Douglas Partners
Geotechnics / Environment / Groundwater

Report on
Geotechnical and Waste Classification Investigation

Proposed Aged Care Facility
Morpeth Road, Morpeth

Prepared for
Lend Lease (Retirement Living)

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

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1. Introduction

This report presents the results of a geotechnical and waste classification investigation undertaken for a proposed aged care facility at Morpeth Road, Morpeth. The investigation was commissioned in an email dated 23 February 2016 by Bruce Gould of Lend Lease (Retirement Living) and was undertaken in accordance with Douglas Partners' proposal NCL160058 dated 3 February 2016.

It is understood that the development of the site will include demolition of a number of buildings and retention of others followed by development of the aged care facility within the area surrounding Closebourne House.

A geotechnical investigation and waste classification assessment was required to provide comment on the following:

Geotechnical

- Subsurface conditions within the proposed aged care facility footprint;
- Comments on excavatability;
- Pavement design for internal pavements;
- Geotechnical suitability of materials for re-use;
- Temporary and permanent batter slopes; and
- Suitable footings for proposed development.

Contamination (Waste Classification)

- Assess the materials’ suitability to be characterised as ENM or VENM; and
- Waste classification of the materials for off-site disposal.

The investigation included the drilling of eight boreholes, the excavation of two test pits and laboratory testing of selected samples. The details of the field work are presented in this report, together with comments and recommendations on the issues listed above.

For the purposes of the investigation the client provided DP with a copy of conceptual architectural plans drawn by Jackson Teece, dated 4 February 2016 as well as a plan showing the location of the existing buildings at the site. This plan is provided in Appendix D as Drawing 1 and provides guidance on the names and ages of the existing buildings.

2. Previous DP Reports

DP has undertaken a number of previous investigations at or near the site, including the following:

- Project 31995.02, dated August 2009 (Ref 1). This investigation included excavation of a number of test pits in areas surrounding the proposed aged care facility. Conditions encountered generally included filling to up to 0.8 m depth, underlain by silty sand and then stiff to very stiff sandy clay. Bedrock was encountered within some of the pits at depths of about 1.2 m to greater than 2 m. This investigation included limited testing chemical testing on samples of filling which were encountered in pits located close to the proposed aged care development footprint;
- Project 81251.05, Report on Geotechnical Investigation and Waste Classification Assessment, Proposed Closebourne Estate, Stage 5, Morpeth Road, Morpeth" dated March 2105 (Ref 2). This investigation included the excavation of 15 test pits within Stage 5 of the development, located approximately 350 m to the south-west of the site.

3. Site Description, Regional Geology and Acid Sulfate Soil Mapping

The site is located within Closebourne Estate at Morpeth, which is situated along Morpeth Road approximately 500 m west of Tank Street, Morpeth. The proposed aged care will be located to the east of the existing Closebourne House (refer Drawing 1).

A number of existing buildings are located within the proposed aged care facility footprint (refer Figure 1).

Figure 1: Aerial image of site with approximate aged care footprint (sourced from Google Earth)

The majority of the buildings are of single storey construction (with the exception of Closebourne House which is two storey) with either timber, sandstone block or masonry walls (refer Figures 2 to 7). A former netball court is located to the south-east of the buildings.

Figure 2: Side view of Closebourne House

Figure 3: Sandstone block construction

Figure 4: Existing timber buildings

Figure 5: Dining Hall building

Figure 6: View of the Bishop Tyrell Lodge

Figure 7: View looking north from former Netball Court

The ground slopes within the site generally fall to the south at less than 5°. Reference to the statewide digital mapping indicates that ground surface levels across the site vary from about RL 28 m AHD in the north-western corner to about RL 22 m AHD in the south-eastern corner.

The areas around the buildings are generally either landscaped or grass covered.

Reference to the Geological Survey of New South Wales, Statewide geodatabase, 1:250,000 scale or better geology maps indicate that the site is underlain by the Tomago Coal Measures of Late Permian age. The main rock units of the Tomago Coal Measures generally comprise siltstone, sandstone, coal, tuff, claystone, conglomerate and minor clay.

Reference to the NSW acid sulfate soil risk maps indicate no known occurrence of acid sulfate soils at the site.

4. Field Work Methods

The field work was undertaken on 9 and 10 March 2016 and comprised the following:

- Drilling of eight (8) bores (Bores 201 to 208); and
- Excavation of two test pits (Pit 209 and 210).

The bores were drilled to depths ranging from of between 0.75 m and 4.08 m using a 4WD truck mounted rig. The bores incorporated SPT testing at regular depth intervals.

Two of the bores (Bores 207 and 208) were drilled using a combination of auger and diamond tipped NMLC coring methods. These bores were drilled to 7.0 m and 8.0 m respectively.

The remainder of the bores (Bores 201 to 206) were drilled using a continuous push tube sampling rig and taken to depths ranging from 2.5 m to 3.0 m

Pits 209 and 210 were excavated using an excavator fitted with a 450mm wide bucket with teeth and were taken to depths of 1.5 m and 2.5 m respectively.

It is recommended that the location and elevation of the bores and pits are picked up by the project surveyor.

The subsurface conditions encountered in the test bores and pits were logged by a geotechnical engineer, who also retrieved regular samples for identification and laboratory testing purposes. Pocket penetrometer tests were undertaken at selected depths and locations. Point load testing of the rock core was also undertaken in the cored boreholes. Photos of the recovered core are provided in Plate 1 of Appendix B.

Field work for the preliminary waste classification testing was undertaken concurrently with the geotechnical assessment and comprised collection of soil samples for waste classification testing from selected boreholes drilled as part of the geotechnical assessment.

Samples were collected and selected for laboratory analysis based on material type, visual or olfactory evidence of possible contamination and requirements of the NSW EPA Excavated Natural Material Resource Recovery Order (Ref 3).

The general sampling procedure for chemical testing comprised:

- Decontamination of all sampling equipment (if used) using a 3% solution of phosphate free detergent (Decon 90) and tap water prior to collecting each sample;
- The use of new disposable gloves for each sampling event;
- Transfer of samples into laboratory-prepared jars and capping immediately;
- Collection of replicate samples for Quality Assurance / Quality Control (QA / QC) purposes;
- Labelling of sample containers with individual and unique identification, including project number, sample location and sample depth;
- Placement of the sample jars and replicate sample bags into a cooled, insulated and sealed container with ice for transport to the laboratory; and

The process of obtaining samples and their transportation, storage and delivery to laboratories for analysis was documented on a DP standard C-O-C. Copies of completed forms are contained in Appendix C.

Replicate samples collected in zip-lock bags were screened for the presence of volatile organic compounds (VOCs), using a calibrated MiniRAE Lite photo-ionisation detector (PID) with a 10.6 eV lamp, calibrated to 100 ppm Isobutylene. The PID is capable of detecting over 300 VOCs.

Information on quality assurance and quality control, including analysis of replicate samples are included in Appendix C.

Drawing 2 attached in Appendix D, shows the approximate test locations.

5. Field Work Results

5.1 Subsurface Conditions

Detailed borehole and test pit logs are provided in Appendix B and should be read in conjunction with the notes about this report, which explain the descriptive terms and classification methods used on the logs.

The following is a summary of the conditions encountered:

FILLING	Generally comprising sand or silty sand with occasional coal fragments or slag. Slag was encountered in Bore 202 while coal fragments were present in Bore 206.
SILTY SAND or SAND	Generally to depths of less than 1 m (with the exception of Bore 202) and comprising loose, occasionally medium dense brown or dark brown, occasionally grey silty sand or sand.
SANDY CLAY or CLAY	Stiff to very stiff, brown sandy clay, becoming hard with depth.
SANDSTONE	Initially very low to low strength grey mottled brown sandstone, becoming medium strength in Bore 208 from 7.44 m depth.

Table 1, below, summarises the subsurface conditions encountered in the bores and pits.

Table 1: Summary of Subsurface Conditions

Unit	Material Type	Bores/Pits Where Encountered	Depth to Top of Layer (m)	Depth to Bottom of Layer (m)
1	FILLING	202, 205, 206 and 208	0.0	0.2 – 0.9
2	SILTY SAND or SAND	All bores	0 – 0.9	0.5 – 2.2
3	SANDY CLAY	All bores	0.5 – 2.2	1.5 – 3.1
4	BEDROCK	201, 207, 208	2.5 – 3.1	END of BORE

Free groundwater was observed in Bores 203 and 204 at 0.7 m depth which is possibly a localised perched water table within the sand . No free groundwater was encountered in the remaining bores or pits, however the introduction of drilling fluids from about 3 m in Bores 207 and 208 precluded further groundwater observations. It is noted that groundwater levels are transient and can vary with factors such as soil permeability and climatic conditions.

The results of subsurface investigation indicated the absence of visual or olfactory evidence of gross contamination at the locations tested.

5.2 Contaminant Observations

Surface filling was observed at a number of locations across the site. Materials observed within the surficial filling was predominantly granular pavement material (roads and gravel landscaped areas).

Observations of potential contamination during field work for the current assessment and previous investigations are summarised below in Table 2:

Table 2: Potential Contamination Observations During Field Work

Potential Contaminant Observation	Test Pit or Bore / Depth
Slag	Bore 202 (0.15 – 0.4 m)
Asphalt	Bore 206 (0.0 – 0.05 m)
Coal Fragments	Bore 206 (0.05 – 0.2 m)
Glass Bottles / Aluminium Cans	Pit 135 (0 – 0.8 m) [Previous investigation]

The results of PID screening on soil samples are shown on the test pit logs in Appendix B. PID screening generally suggested the absence of gross volatile hydrocarbon impact, with all results less than the PID detection limit of 1 ppm.

There was no visual or olfactory evidence (i.e. staining or odours) to suggest the presence of gross contamination within the soils investigated.

6. Laboratory Testing

6.1 Geotechnical Laboratory Testing

Laboratory testing for the geotechnical assessment was undertaken on a selection of samples and comprised of two CBR and standard compaction tests together with three shrink-swell tests.

Laboratory test results are presented in Appendix C and are summarised in Table 3 along with pertinent results from previous investigations.

Table 3: Results of Current and Previous CBR / Compaction and Shrink Swell

Bore	Depth (m)	Description	FMC (%)	SOMC (%)	SMDD (t/m^3)	CBR (%)	Iss (% per ΔpF)
209	0.4 – 0.6	Sandy Silt	8.7	11.5	1.90	20	-
209	0.9 – 1.0	Silty Clay	14.2	12.0	1.90	7.0	-
201	1.45 – 1.72	Sandy Clay	19.3	-	-	-	1.4
203	1.3 – 1.7	Sandy Clay	27.3	-	-	-	3.4
205	1.45 – 1.7	Sandy Clay	29.2	-	-	-	3.1
Previous Investigations at Closebourne Village							
202	0.15-0.5	Sandy Clay	20.8	22.0	1.62	7	-
205	0.5-0.7	Silty Sand	7.5	11.5	1.93	30	-
206	0.6-1.03	Sandy Clay	16.1	-	-	-	1.7
209	0.85-1.24	Sandy Clay	12.8	-	-	-	-
214	0.6-1.0	Sandy Clay	15.7	-	-	-	-
115	0.8-1.1	Sandy Clay / Clayey Sand	23.7	-	-	-	1.8
118	0.65-0.8	Sandy Clay	24.2	22.5	1.60	4	-
121	0.7-1.1	Sandy Clay	30.6	-	-	-	1.9
3	0.45-0.75	Silty Clay	19.6	20.0	1.62	4.5	1.4
9	0.20-0.55	Clay	27.6	25.0	1.49	1.0	4.4
134	0.65 – 0.8	Sandy Clay	32.2	28.5	1.43	1.5	-

Notes to Table 3:
FMC – Field Moisture content
SOMC – Optimum Moisture Content (Standard)
CBR – Californian Bearing Ratio
SMDD – Maximum Dry Density (Standard)
LS – Linear Shrinkage
Iss – Shrink Swell Index
LL – Liquid Limit
PL – Plastic Limit
PI – Plasticity Index

6.2 Chemical Laboratory Testing

Laboratory testing for the ENM and waste classification assessment was undertaken by Envirolab, a National Association of Testing Authorities, Australia (NATA) registered laboratory. Analytical Methods used are shown on the laboratory sheets in Appendix C.

A total of 12 soil samples was selected for analysis for the assessment.

The soil samples were tested for the following potential contaminants / analytes with reference to the ENM exemption (Ref 3):

- Metals: Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb); Mercury (Hg), Nickel (Ni), Zinc (Zn);
- Total Recoverable Hydrocarbons (TRH);
- Benzene, Toluene, Ethyl Benzene, Xylene (BTEX);
- Polycyclic Aromatic Hydrocarbons (PAH);
- Polychlorinated Biphenyls (PCBs); and
- Organochlorine (OC) and Organophosphate (OP) Pesticides.

6.3 Chemical Laboratory Testing Results

The results of chemical analysis undertaken on the soils are presented in the laboratory report sheets in Appendix C, and are summarised in Table 4 below.

Table 4: Results of Chemical Testing

Bore	Depth (m)	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn	TRH				BTEX				Total Positive PAH	B(a)P	Total PCB	Total OPP	Total OCP	Aldrin + Dieldrin	Chlordane	DDT	Heptachlor
										C_6 - C_9	C_{10} - C_{14}	C_{15} - C_{28}	C_{29} - C_{36}	Benzene	Toluene	Ethyl Benzene	Xylene									
202	0.2-0.5	5	<0.4	9	5	40	<0.1	5	51	<25	<50	<100	<100	<0.2	<0.5	<1	<3	NIL (+)VE	<0.05	<0.7	<1.2	<2	<0.2	<0.1	<0.1	<0.1
202	1.0-1.2	<4	<0.4	6	1	5	<0.1	2	5	<25	<50	<100	<100	<0.2	<0.5	<1	<3	NIL (+)VE	<0.05	<0.7	<1.2	<2	<0.2	<0.1	<0.1	<0.1
205	0.1-0.25	<4	<0.4	6	3	14	<0.1	1	19	<25	<50	<100	<100	<0.2	<0.5	<1	<3	2.7	0.1	<0.7	<1.2	<2	<0.2	<0.1	<0.1	<0.1
205	0.3-0.5	<4	<0.4	6	3	40	<0.1	2	61	<25	<50	<100	<100	<0.2	<0.5	<1	<3	NIL (+)VE	<0.05	<0.7	<1.2	<2	<0.2	<0.1	<0.1	<0.1
206	0.05-0.2	22	<0.4	3	13	19	0.2	5	26	<25	54	550	290	<0.2	<0.5	<1	<3	2.1	<0.05	<0.7	<1.2	<2	<0.2	<0.1	<0.1	<0.1
206	0.2-0.5	<4	<0.4	7	2	5	<0.1	2	9	<25	<50	<100	<100	<0.2	<0.5	<1	<3	NIL (+)VE	<0.05	<0.7	<1.2	<2	<0.2	<0.1	<0.1	<0.1
208	0.2-0.4	5	<0.4	11	9	23	<0.1	5	47	<25	<50	<100	<100	<0.2	<0.5	<1	<3	4.5	0.5	<0.7	<1.2	<2	<0.2	<0.1	<0.1	<0.1
208	1.0-1.1	<4	<0.4	10	6	15	<0.1	4	45	<25	<50	<100	<100	<0.2	<0.5	<1	<3	0.22	<0.05	<0.7	<1.2	<2	<0.2	<0.1	<0.1	<0.1
203	0.2-0.4	<4	<0.4	8	1	4	<0.1	2	6	<25	<50	<100	<100	<0.2	<0.5	<1	<3	NIL (+)VE	<0.05	<0.7	<1.2	<2	<0.2	<0.1	<0.1	<0.1
207	0.2-0.4	<4	<0.4	9	1	5	<0.1	2	4	<25	<50	<100	<100	<0.2	<0.5	<1	<3	NIL (+)VE	<0.05	<0.7	<1.2	<2	<0.2	<0.1	<0.1	<0.1
201	0.4-0.6	<4	<0.4	7	<1	3	<0.1	2	2	NT	NT	NT	NT	NT	NT	NT	NT	NIL (+)VE	<0.05	NT	NT	NT	NT	NT	0	0
203	0.7-0.9	<4	<0.4	9	<1	3	<0.1	2	2	<25	<50	<100	<100	<0.2	<0.5	<1	<3	NIL (+)VE	<0.05	<0.7	<1.2	<2	<0.2	<0.1	<0.1	<0.1
Laboratory PQL		4	0.4	1	1	1	0.1	1	1	25	50	100	100	0.2	0.5	1	3	1.55	0.05	0.1 ea	0.1 ea	0.1 ea	0.1 ea	0.1	0.1	0.1
General Solid Waste (CT1)		100	20	100	NC	100	4	40	NC	650 SCC1	10000 total SCC1			10	288	600	80	200	0.8	50	250	250	NC	NC	NC	NC
Restricted Solid Waste (CT2)		400	80	400	NC	400	16	160	NC	2600 SCC2	40000 total SCC2			40	1152	2400	200	800	3.2	50	1000	1000	NC	NC	NC	NC
ENM Order (2014)		40	1	150	200	100	1	60	300	NC	500			0.5	65	25	NC	40	1	NC	NC	NC	NC	NC	NC	NC

Notes to Table:

All results in mg/kg on a dry w eight basis

CT - Concentration Threshold

NA - Not Applicable

NC - No Criteria

NT - Not Tested

PID - Photoionisation Detector

PQL - Practical Quantitation Limits

156	Italicised results exceed NSW EPA General Solid Waste criteria w ithout leachability (TCLP) testing
<u>156</u>	Bold, italicised and underlined results exceed Restricted Solid Waste criteria w ithout TCLP testing
▨	Shaded cells indicate concentrations above maximum criteria for ENM classification

7. Proposed Development

It is understood that the proposed development includes the construction of a new aged care facility at the site. The facility will be located to the east of the existing Closebourne House and will be arranged in a near square arrangement around a central courtyard area. Two levels of units will be contained within the facility along with a lower parking level.

At this stage, only preliminary concept architectural plans have been provided to DP. Figure 8, below, is an extract from the concept drawing provided by the client.

Figure 8: Conceptual design of aged care facility

The exact depth of excavation is not known at this stage, but the maximum depth of excavation is understood to be in the order of 4 m.

Column loads are understood to be in the order of 1000 kN working loads.

A new pavement will be constructed in the south-western area of the site to provide vehicular access to the lower ground floor parking area.

8. Geotechnical Comments

8.1 Excavation Conditions

Based on information provided by the client, it is understood that excavation of up to 4 m depth will be required for the development. Based on the results of the investigation, it is considered that excavation of the filling, topsoil, sands and clays (Units 1 to 3) would be generally achievable using conventional machinery such as a hydraulic excavator.

Extremely low strength sandstone, as encountered in Bores 201, 207 and 208 from about 2.5 m depth, should also be readily excavated using an hydraulic excavator, although low strength or better sandstone may require medium ripping with a D9 dozer, ripping attachments and / or rock hammer. Heavy ripping with a D9L or bigger dozer could be required depending on rock discontinuities.

It is important to note that excavatability of rock is dependent not only on rock strength, but also on the presence, orientation and extent of discontinuities such as jointing / bedding and fracturing of the rock, the presence of favourable and adverse bedding planes, presence of groundwater and other factors. For example, low strength rock with few discontinuities may be more difficult to excavate than highly fractured, high strength rock.

Contractors should be responsible for selection of excavation equipment based on the proposed excavation depths and equipment capabilities, together with the anticipated conditions.

Due to the historically important structures in the area vibrations should be monitored and kept below the legal guidelines during construction, which may put restrictions on equipment such as pneumatic or hydraulic hammering.

8.2 Excavation Batters

Maximum excavation depths will be approximately 4 m. Based on the conditions encountered in the bores, it is expected that it would be practicable to allow for battering of excavations at some locations. Ongoing inspection of the excavation face during construction will be necessary to assess the continuity and degree of fracturing of the bedrock, although the batter slopes outlined in Table 5 below are suggested for preliminary design purposes.

Table 5: Suggested Preliminary Safe Batter Slopes

Material	Safe Batter Slope (H:V)	
	Short Term Temporary	Long Term Permanent
Filling and clay	1.5:1	2:1
Extremely low and very low strength rock	0.75:1	1:1
Low strength or stronger rock	0.25:1*	0.5:1*

Notes to Table 5:

* - subject to further detailed inspection by an engineering geologist during construction.

Previous experience with the rocks of the Tomago Coal Measures suggests that the discontinuities are generally strata bound (i.e. not vertically continuous). However, adoption of the batter slopes for low, medium and high strength rock shown in Table 5 must be accompanied by geological inspection to assess any adverse jointing which could give rise to localised instability such as block fallout or wedge failure. The support of these locally unstable blocks and wedges, or extremely low and very low strength bands, can then provided by in-situ stabilisation techniques utilising dowelled mesh, rock bolts and sprayed concrete.

If excavation faces are protected from weathering by overhead construction and sprayed concrete facing, the short term temporary safe batter slopes shown in Table 5 may be incorporated into the permanent excavation construction, as long as unstable blocks are pinned or anchored to the slope.

8.3 Excavation Support

Where support is to be provided to adjoining structures or services, which may be the case along the western boundary of the site, in proximity of the existing heritage buildings, the use of engineered retaining systems is suggested to increase the stability of the upper soil and weathered rock profile at these locations during construction.

8.3.1 Construction

It is considered likely that a suitable construction system would incorporate bored soldier piles pre-drilled on the perimeter of the excavation, at 2.5 m to 3.0 m centres to provide restraint and anchorage points for tie back anchors. Infill panels between the soldier piles are progressively provided by reinforced sprayed concrete as the excavation reaches critical levels for the installation of tie back anchors.

Based on the conditions encountered in the bores, it is expected that the residual clay and weathered rock exposed between the soldier piles over the depth of anchoring will be self-supporting for the short term. Some additional stabilisation measures may be required to support the silty sand which was encountered to depths of up to 0.9 m in some bores. Adverse jointing can sometimes give rise to localised instability in the exposed rock, which may require some stabilisation works prior to shotcreting. It is suggested that regular inspections of the exposed faces be made by an engineering geologist or geotechnical engineer at 2 m depth increments as the excavation progresses.

Soldier piles are normally drilled with a minimum “toe in” below the base of the excavation in order to provide lateral restraint, with the depth of “toe in” dictated by the retained height and passive resistance of the rock in which the “toe in” is developed.

8.3.2 Design

It is suggested that design of retaining structures be based on an average bulk unit weight for the retained material of 22 kN/m^3. Cantilevered support should be designed on a triangular earth pressure distribution and anchored or propped support should be designed on a trapezoidal earth pressure distribution (increasing linearly from zero pressure to full pressure over the upper 0.25H, then decreasing linearly to zero pressure over the lowest 0.25H – where H is the retained height in metres). The earth pressure coefficients to be adopted for design will be dependent upon the nature and strength of the retained materials, as shown in Table 6 below.

Table 6: Preliminary Active Earth Pressure Coefficients for Retaining Wall Design

Retained Material	Long Term Earth Pressure Coefficient
Filling and clays	0.35
Extremely low and very low strength sandstone	0.25
Low and medium strength sandstone	0.1*

Notes to Table 6:
* - subject to further investigation

Additional pressures should be allowed for where surcharging of the wall system results from the proximity of the proposed structure itself near changes in excavation level, to reduce the risk of damage occurring to these structures. To increase the wall stiffness and thereby reduce lateral (inward) wall deflection, the active earth pressure coefficients shown in Table 6 should be increased by 50% to represent the "at rest" condition. Further, allowance should be made in the wall design for estimated footing loads.

The parameters given above are based on the provision of full drainage behind the retaining walls.

The calculation of the ultimate lateral capacity of piles embedded below the bulk excavation should be based on ultimate lateral resistance pressures given in Table 7 below. Design should incorporate an appropriate factor of safety, and the capacity developed within the first or upper 0.5 m of bulk excavation level should be disregarded in the calculation of lateral capacity.

Table 7: Ultimate Lateral Resistance Pressure for Retaining Wall Design

Material	Ultimate Lateral Resistance (kPa)
Extremely low to very low strength sandstone	1000
Low strength sandstone	2500
Medium strength sandstone	4500

8.3.3 Anchoring

It is likely that the soldier piles may be designed as cantilevers in the shallower sections of the excavation where support to adjoining structures is not required, but where excavation depths exceed 2 m to 3 m or where structures adjoin the excavation, anchoring may be required.

The use of inclined prestressed tie-back anchors is suggested as one method of anchoring support with minimal deflection. Anchors need only be of temporary construction if permanent support will be provided by the building itself. They should be designed to have a free length equal to their height above the base of the excavation or base of retaining system (with a minimum of 3 m), and after installation they should be check stressed to 125% of the nominal working load and locked off at 60% of working load up until the anchors are decommissioned. For those anchors supporting piles adjacent to the neighbouring and retained structures, lock off values should be 90% of working load. Regular checks should be made to ensure that load is maintained in the anchors and not lost due to creep effects.

The design of bond lengths for anchors should be based on a maximum allowable grout to rock bond stress of 200 kPa where anchors have a minimum 3 m bond length and derive their capacity in very low strength sandstone. It may be more appropriate for estimation of maximum allowable bond stress to be made by the contractor installing anchors, at the time of construction, as bond stress achieved often depends on installation techniques and contractor expertise. Regardless of who performs anchor design, all anchors should be stress tested to the satisfaction of the geotechnical designer.

8.4 Excavation Vibration

It would be prudent to allow dilapidation surveys to be carried out and the nearby heritage buildings and existing services to document their condition prior to commencement of all work.

As a guide, the damage threshold due to vibration is dependent on the quality of the building foundations and construction of the building as well as the wavelength of the vibration and the source distance. The heritage buildings may be as sensitive to vibration, or more sensitive to vibration, than their occupants. It should be noted that humans are very sensitive to vibration and it may therefore be beneficial to carry out vibration monitoring to confirm vibration levels during site works. A sensitive structure criterion is therefore indicated and the vector sum peak velocity (VSPPV) is proposed as the control parameter. It is recommended that a Provision allowed vibration limit of 5.0 mm/sec (VSPPV) be set, at foundation level of the potentially affected buildings.

8.5 Site Classification

Site classification of foundation soil reactivity provides an indication of the propensity of the ground surface to move with seasonal variation in moisture. The site classification is based on procedures presented in AS 2870-2011 (Ref 4), the typical soil profiles revealed in the pits, and the results of laboratory testing.

Due to the presence of uncontrolled filling greater than 0.4 m depth in some of the bores, the existing buildings on the site, which will potentially lead to adverse soil moisture conditions, and the proposed extent of excavation, the site would be classified **Class P** in accordance with the procedures outlined in AS2870.

The results of shrink-swell testing from samples taken from the bores within the proposed building footprint returned I_{ss} values ranging from 1.4 to 3.1% per ΔpF. Previous investigation for Stage 5 of Closebourne Village returned I_{ss} values ranging from 1.7 to 1.9% per ΔpF, while samples of silty clay and clay soils retrieved from adjacent areas (Morpeth House Heritage Estate to the west and Lend Lease subdivision to the south) returned I_{ss} values ranging from 2.0 to 5.5% per ΔpF.

The results of the shrink swell testing indicated that the soils have a moderate to high propensity for volume change with variations in moisture content.

Articulation joints should be provided within masonry walls in accordance with TN61 (Ref 5) in order to reduce the effects of differential movement.

It should be noted that this classification is dependent on proper site maintenance, which should be carried out in accordance with CSIRO Sheet BTF 18 in Appendix A and Appendix B of AS 2870-2011 (Ref 4).

8.6 Shallow Foundations

The conditions anticipated at bulk excavation level are anticipated to vary from silty sand and sandy clay to extremely low to very low strength sandstone bedrock.

Depending upon the final design of the building, rock may be encountered in some areas, particularly beneath the lower ground floor level and in areas of greatest excavation, such as along the northern perimeter. It may therefore be prudent to deepen all footings such that they all footings for the structure found on rock to reduce the effects of differential movement.

The recommended maximum allowable bearing pressures for the encountered soil types are presented in Table 8 below:

Table 8: Allowable Bearing Pressure

Founding Strata	**Maximum Allowable Bearing Pressure (kPa)**
Stiff Clay and medium dense silty sand	100
Very stiff to hard clay	200
Extremely low strength rock or better	700

If bored piles are required in localised areas, they should be founded on rock and the bearing pressure presented above in Table 8, above, may be used in design. For such footing arrangements, it is important that slab panels are not supported on the “uncontrolled” filling but suspended between ground beams / edge beams / strips. This is to avoid potential for cracking due to differential settlement.

Groundwater was not encountered during the present investigation and was only encountered in one location (Pit 113) at 1.2 m depth during the previous investigation. Hence it is anticipated that footing excavations should remain dry during excavation provided surface water is excluded.

Bored piles should be poured immediately after footing excavation to reduce the risk of hole collapse or softening from rain events or groundwater. Care should be taken to ensure the base of the bored pile holes are cleaned and free of all loose debris and water at the time of placing concrete. Accordingly, pier hole inspections are recommended during construction to confirm adequate bearing.

8.7 Piles

8.7.1 Geotechnical Strength Reduction Factor

In the current Piling Code, released in November 2009 (Ref 6), the design geotechnical strength of a pile ($R_{d,g}$) is the ultimate geotechnical strength ($R_{d,ug}$) multiplied by the geotechnical strength reduction factor (ϕ_g), such that:

$$R_{d,g} = \phi_g . R_{d,ug}$$

The calculated value $R_{d,g}$ must equal or exceed the structural design action effect E_d.

Selection of the geotechnical strength reduction factor (ϕ_g) is based on a series of individual risk ratings (IRR) which are weighted and lead to an average risk rating (ARR). The individual risk ratings and final value of ϕ_g depend on the following factors:

- Site: the type, quantity and quality of testing;
- Design: design methods and parameter selection;
- Installation: construction control and monitoring;
- Pile testing regime; testing benefit factor based on percentage of piles tested and the type of testing; and
- Redundancy: whether other piles can take up load if a given pile settles or fails.

Using the methodology outlined in the piling code and the supplementary site data retrieved during the present investigation, an average risk rating of 2.48 (Low Category) has been assessed. A geotechnical strength reduction factor, ϕ_g, of 0.56 is applicable for low redundancy in the design of the piles. In the event that pile integrity testing will not be undertaken as part of the conformance testing for the project, it is recommended that a ϕ_g of 0.4 is used.

The above assessment assumes that no static or high-strain dynamic testing of installed piles will be undertaken. The ϕ_g could be increased if such testing is carried out.

It is however pointed out that the final ϕ_g will depend on the piling contractor chosen and the experience of the pile designers. The strength reduction factors should be checked when this information is available.

8.7.2 Pile Design Parameters

Concrete bored piles would be suitable for the support of the proposed building, founded within the sandstone bedrock.

Table 9, provides the ultimate limit state end bearing pressures and shaft adhesion values for piles socketed into the sandstone bedrock. For calculation of serviceability geotechnical strength, the capacity can be calculated using the serviceability end bearing values and ultimate shaft adhesion values within the rock units. In the serviceability case, these values do not need to be factored. It is recommended that deflection under load is checked and compared to serviceability deflection limits.

Table 9: Design Pressures for Founding Strata

Strata	Ultimate End Bearing Pressure (kPa)	Ultimate Shaft Adhesion (kPa)	Serviceability/Max Allowable End Bearing (kPa)
Extremely low strength rock	2000	150	700
Low strength or stronger rock	8000	500	2500

Notes to Table 9:

Ultimate Values occur at large settlements (> 5% of minimum footing diameter).

Shaft adhesion values based on a shaft roughness of R2 or better.

Serviceability / Max Allowable end bearing to cause settlement of < 1% of minimum footing dimension or pile diameter.

AS 2159 – 2009 requires that the contribution of the shaft from finished surface to 1.5 times pile diameter or 1 m (whichever is greater) shall be ignored.

Piles should be installed by experienced operators, using suitably sized piling rigs, monitoring equipment and supervision.

For piles in tension, the shaft adhesion parameters should be reduced to 75% of the values in Table 9.

Piles that are constructed in a manner that does not enable inspection or checking of the pile socket, or those that are likely to have an increased amount of smear over the length of the socket, should be designed based on parameters that are 20% lower than those given in Table 9.

Piles may need to be drilled by a cleaning bucket auger rig. Light Pengo-type rigs or pendulum borers may reach refusal on strata with inadequate bearing capacity. It should be noted that the parameters given in Table 9 are for clean rock sockets (with an R2 roughness rating) and bases only. Specific cleaning buckets and grooving tools should be used in pile construction, together with suitable inspection or verification methods.

Settlement of piles is expected to be up to about 5% of the pile diameter for the serviceability pressures provided above.

In the event that piles are adopted for the support of the proposed structure it is recommended that prior to construction a series of trial pile excavations are undertaken across the footprint of the building to determine the depth to the design foundation strata.

8.7.3 Pile Testing

Section 8 of AS2159 – 2009 (Ref 6) outlines the pile load testing requirements. Clause 8.2.4 of AS2159 states that where the basic geotechnical strength reduction factor is greater than 0.4, testing shall be performed to verify the integrity of pile shafts. Assessment of pile shaft integrity may be by high-strain dynamic pile testing or other methods of integrity testing. Seismic integrity testing may be suitable in this instance. It is recommended that a percentage of piles are tested as outlined in AS2159 (Ref 6).

It is also recommended that comprehensive inspections and monitoring be undertaken during the installation of piles, including but not necessarily limited to geotechnical inspection during installation to record the depth of pile, the conditions encountered at the toe of the pile and review of any pile installation data acquired during drilling.

8.8 Pavements

8.8.1 Design Traffic

No specific traffic data has been provided for the proposed pavement. In the absence of such information, 1×10^4 ESA (Equivalent Standard Axles) has been adopted based on the assumption that the pavement will be trafficked by vehicles with a gross weight of less than 4 tonnes. For the rigid pavement, a design traffic loading of 1×10^{-3} HVAG (Heavy Vehicle Axle Groups) has been adopted.

If the traffic loading is to be significantly different from this value, the pavement thickness design should be reviewed.

8.8.2 Subgrade Conditions

The results of laboratory testing on samples of the clay and silt soils from within the pits excavated at the site returned soaked CBR values of 7% and 20%. Previous testing of similar clay soils in the adjacent areas returned soaked CBR values ranging from 1% to 7%.

Along the proposed access pavement, located to in the south-western area of the site, it is anticipated that sandy clay will be exposed at subgrade level, for which a design CBR of 3% is suggested.

8.8.3 Pavement Thickness Design

It is understood that a flexible pavement will be constructed for the access pavement to the lower ground parking and circular loop to the front entrance of the facility (refer Drawing 2).

A rigid (concrete) pavement will be constructed for the lower ground floor parking area. Table 10, below provides a flexible pavement thickness design for the access pavement.

Table 10: Pavement Thickness Design (based on 1 x 10^4 ESA)

Layer	Thickness (mm)
Design Subgrade CBR – Natural Clay	3%
2 Coat Spray Seal(1)	-
Basecourse	100
Subbase	200
Select Subgrade(2)	-
Total	300

Notes to Table 10:

Where asphalt is to be used as a wearing course a 7 mm or 10 mm prime seal should be placed over the basecourse and the thickness of the asphalt can be deducted from the subbase layer

Select material (possibly up to 0.3 m thick) may be required dependent on clay subgrade moisture conditions at the time of excavation

Based on the procedures outlined in Austroads (Ref 7) the following rigid pavement thickness design, shown in Table 11 is suggested.

Table 11: Rigid Pavement Thickness Design

Design CBR (%)	Design Traffic Loading (HVAGs)	Pavement Thickness (mm)	Layer Component	
			Concrete Base (mm)	Unbound Subbase (mm)
3	1 x 10^3	250	125	125

Notes to Table 11

This pavement thickness design is based on the absence of concrete shoulders, a concrete flexural strength of at least 4 MPa and a design project load safety factor of 1.05.

The rigid pavement thickness given in Table 11 is based on a compressive strength of at least 32 MPa. Steel reinforcing and joint detail for the concrete pavement should be designed by the civil engineer for the project based on the procedures in Austroads.

8.8.4 Subgrade Preparation

Pavement subgrade preparation measures should include:

- Excavation to nominal subgrade level;
- Removal of any existing filling and assessment of the suitability of sandy silt to remain in place, as it is susceptible to softening with increases in moisture content;
- Rolling of the exposed subgrade with at least six passes of a minimum 10 tonne deadweight vibratory roller, with a final pass undertaken at slow speed with careful visual inspection by a geotechnical engineer to allow the detection of any soft or compressible zones, or areas requiring removal and replacement (such as sandy silt);
- The inspection may be accompanied by dynamic penetrometer testing at close spacings (say 10 m intervals);
- In the event that sections of exposed materials are deemed unsuitable to remain in place, additional excavation and replacement with approved filling will be required;
- Compaction of the exposed natural soils or existing filling deemed suitable to act as subgrade to a minimum dry density of 100% Standard in accordance with AS3798-2007 (Ref 10);
- Any subgrade replacement filling should consist of material with a soaked CBR of greater than 5% and should be placed in horizontal layers of less than 250 mm loose thickness with each layer compacted to at least 100% Standard dry density ratio with moisture contents maintained within the range of 4% dry of optimum moisture content (OMC) for Standard compaction to OMC.
- Compaction testing of all engineering filling and prepared subgrade surfaces should be carried out with sufficient density testing to justify that it is well compacted. AS3798 (Ref 10) provides information regarding suitable testing regimes during placement.
- The pavement thickness design presented in this report is dependent upon satisfactory subgrade preparation and the provision and continuing maintenance of adequate surface and subsurface drainage.

8.8.5 Material Quality and Compaction Requirements

Table 12, below, presents the material quality and compaction requirements for the respective pavement layers.

Table 12: Material Quality and Compaction Requirements

Layer	Material Quality	Compaction
Concrete Base	Minimum 32 MPa 28 day compressive strength	-
Subbase	Conform to RTA Spec. 3051 of basecourse quality and minimum soaked CBR 80%	Minimum 98% Modified Compaction (AS 1289 5.2.1) or RTA R73
Basecourse	CBR ≥ 80%, PI ≤ 6%, Grading in accordance with RMS 3051	Compact to at least 98% dry density ratio Modified (AS 1289.5.2.1, Ref 7).
Select Subgrade (if required)	Soaked CBR ≥ 5%.	Compact to 100% dry density ratio Standard (AS 1289.5.1.1, Ref 7).
Subgrade	Minimum Soaked CBR 3%	Minimum 100% Standard dry density (AS 1289.5.1.1)

8.8.6 Pavement Drainage

The vehicular pavement design provided above depends on the provision of adequate surface and subsoil drainage to maintain the subgrade as close to the optimum moisture content as possible and to ensure that the pavement layers do not become saturated.

Subsoil drainage should be installed at least 0.5 m below subgrade level adjacent to pavements. Preparation of subgrade surfaces should be such that adequate crossfalls for surface drainage are achieved across the final pavement.

The select subgrade, if required, should be a well-graded material which is suitable for placement over wet clay soils, and which requires minimal working / rolling to achieve compaction. Thus coarse material is not expected to be suitable. The maximum particle size of the select should be half the layer thickness.

9. Waste Classification Assessment

9.1 Scope of Works

The purpose of the investigation was to provide waste classification for the subsurface materials / spoil generated during excavation in order to assess off-site disposal/re-use options, with reference to the NSW EPA “Waste Classification Guidelines” (Ref 11).

The assessment comprised the following:

- Brief review of historical aerial photos and previous DP investigations;
- Site walkover by a senior engineer from DP;
- Boreholes and test pits within the proposed development area;
- Collection of soil samples from the boreholes and pits;

- Laboratory analysis of selected soil samples for a range of potential organic and inorganic contaminants; and
- Preparation of this report.

9.2 Site Walkover and Historical Review

The observations made during the site walkover which are pertinent to the waste classification of the soils to be excavated at the site are discussed below:

- The site contains a number of existing buildings, paved areas and landscaped gardens;
- The surrounding area is predominantly cleared areas; and
- The ground surface generally falls to the south, towards wetlands located about 500 m to 1 km from the site.

9.3 Review of Historical Aerial Photos

A historical aerial photo review was undertaken by DP. The following historical aerial photos were reviewed for the assessment.

Table 13: Aerial Photo Review

Year	Approximate Scale	Black and White/Colour
1958	1:30,000	B & W
1984	1:40,000	B & W
1987	1:16,000	Colour
2007	Not to scale	Google Image
2013	Not to scale	Google Image
2015	Not to scale	Google Image

1958 Aerial Photograph

- Closebourne House, Closebourne Chapel, The Registry and The Dining Hall appear to be present in the photo, although the quality of the photo is poor;
- The site is surrounded by cleared paddocks; and
- Brush Box Tree Avenue is visible to the east.

1984 Aerial Photograph

- The 1984 photo is of very poor quality and not much of the site development can be determined;
- Closebourne House is visible in the photo; and
- The surrounding areas are similar to 1958.

1987 Aerial Photograph

- All buildings which were present on site during the investigation appear within this photo; and
- An additional structure, understood to be a pool, is located to the north of Brush Box Tree Avenue.

2007 Aerial Photograph

- Similar to 1987 photo.

2013 Aerial Photograph

- Similar to 2007 photo.

2015 Aerial Photograph

- Similar to 2007 photo, however the pool appears to have been removed.

It is noted that data obtained from aerial photos was limited due to the relatively small scale and poor resolutions.

9.4 EPA Register Searches

A review of the NSW EPA public registers indicated the following:

- The site is not on the NSW EPA Contaminated Land Management Register;
- The site is not on the list of contaminated sites notified to NSW EPA; and
- The site is not on the Protection of the Environment Operations Act list for licences, notices etc.

9.5 Review of Previous DP Investigations

DP has undertaken several previous investigations at the site, including contamination assessment (Ref 1). The pertinent results of these investigations is discussed in Section 3 and further summarised below.

The report concluded that the potential for gross contamination on the site was low and that the site was considered suitable for residential development provided a hazardous materials assessment is undertaken by a qualified consultant on buildings to be demolished as part of redevelopment, with appropriate demolition and disposal of hazardous materials (e.g. asbestos cladding) by a licensed contractor. DP has been engaged to carry out Hazardous Material Assessments of the buildings present within the aged care facility footprint.

A number of potential sources of contamination were identified within the greater sites, with the closest pits to the aged care facility (Pits 133 and 135) containing trace brick fragments and trace glass bottles and aluminium cans in the filling, which was encountered to depths of up to 0.8 m. Pit 135 was located adjacent to the former netball court within the south-eastern corner of the proposed aged care facility. This area appears to have been created by the importation of filling. The targeted investigation indicated the absence of gross contamination.

9.6 Assessment Criteria

Results of the chemical analyses were compared to the following NSW EPA recommended guidelines.

- NSW EPA, Waste Classification Guidelines, Part 1: Classifying Waste, November 2014 (Ref 11); and
- NSW EPA, “Resource Recovery Order under Part 9, Clause 93 of the Protection of the Environment Operations (Waste) Regulation 2014, The Excavated Natural Material Order 2014”, November 2014.

9.7 Comments

Generally no visible or olfactory signs of contamination were observed in the fill materials that overlie the natural soil although it is noted that a number of bores (Bores 202 and 206 during the current investigation and Pit135 during previous investigation) encountered filling which included either glass bottles, bricks, slag or coal fragments, as outlined in Table 2 of Section 5.2.

Chemical testing was undertaken on samples from these bores and pits, with results summarised in Table 4. The results indicate that the contaminant concentrations were within the General Solid Waste criteria (without leachability testing).

The results of chemical testing were also compared against the Excavated Natural Material Order 2014 (Ref 3) and were all below the maximum and average permissible concentrations in the ENM order with the exception of the sample of filling from 0.05 m to 0.2 m depth in Bore 206 returned a total recoverable hydrocarbon concentration of 894 mg/kg which is above the maximum permissible value of 500 mg/kg in the ENM order.

The natural soils tested were below the adopted background values (ENM guideline values).

In summary, based on the site historical information, site investigations and laboratory results, the following waste classifications are provided:

Existing Filling

- The existing filling is generally classified as General Soil Waste (non-putrescible) for disposal to landfill. It is noted, however, that a number of areas of the filling contained potential contaminants, such as bricks and ash. This may be indicative of material which has been sourced from off-site locations which presents a risk of introduction of contaminants to the site owing to poor segregation practices and unknown activities on the source site. It is recommended that during construction an inspection regime should be implemented to identify any areas of filling which may warrant further assessment. The inspection regime should include the following:
    - Stripping of the overlying filling over the excavation area;
    - Inspection of the exposed soils by a geo-environmental engineer to assess for the presence of material which may affect the waste classification;
    - Supplementary laboratory testing of soil in the event that differing conditions are encountered; and

    - Regular inspections and testing during construction to ensure that the excavated materials are appropriately handled and that material different to those encountered during the investigation are assessed, if encountered. It is envisaged that a site instruction would be issued to the contractor at the completion of each inspection that would identify the classification of the material encountered in the exposed section of excavation and any treatment or handling procedures required. It is noted that there are several old buildings which appear to have been demolished within areas of the site. In the event that poor demolition building practices have occurred there is a risk of asbestos within the surficial soils which would alter the waste classification.
- The existing filling in the area around Bores 202 and 208, which contained significant inclusions of anthropogenic inclusions, does not comply with the ENM exemption.

Natural Soils and Bedrock

- The silty sand, underlying clay and bedrock is considered to be suitable for classification as Virgin Excavated Natural Material (VENM) and are suitable from a contamination standpoint, for off-site re-use;
- The use of the natural residual clays and underlying bedrock as Virgin Excavated Natural Material (VENM) would be contingent on prior acceptance by the receptor site/relevant authority to receive the material. The natural soils and bedrock should not be mixed/cross contaminated with non-VENM materials (e.g. overlying filling, topsoil or anthropogenic inclusions). During construction an inspection regime should include the following:
    - Stripping of the overlying filling over the excavation area;
    - Inspection of the exposed soils by a geo-environmental engineer to assess for the presence of material which may affect the VENM classification;
    - Supplementary laboratory testing of soil in the event that differing conditions are encountered; and
    - Regular inspections and testing during construction to ensure that the excavated materials are appropriately handled and that material different to those encountered during the investigation are assessed, if encountered. It is envisaged that a site instruction would be issued to the contractor at the completion of each inspection that would identify the classification of the material encountered in the exposed section of excavation and any treatment or handling procedures required.

10. References

1. Douglas Partners Pty Ltd, “Report on Geotechnical and Contamination Assessment, Morpeth House Heritage Estate, Morpeth Road, Morpeth”, Project 31995.02, dated August 2009.
2. Douglas Partners Pty Ltd, “Report on Geotechnical Investigation and Waste Classification Assessment, Proposed Closebourne Estate, Stage 5, Morpeth Road, Morpeth”, Project 81251.05, dated March 2015.
3. NSW EPA, “Resource Recovery Order under Part 9, Clause 93 of the Protection of the Environment Operations (Waste) Regulation 2014, The Excavated Natural Material Order 2014”, November 2014.

4. Australian Standard AS2870-2011, 'Residential Slabs and Footings', April 2011, Standards Australia
5. Cement Concrete & Aggregates Australia, Technical Note 61 “Articulated Walling”, August 2008.
6. Australian Standard AS2159-2009, "Piling - Design and Installation".
7. Austroads, "Guide to Pavement Technology Part 2: Pavement Structural Design", Austroads AGPT02, 12 February 2012.
8. Roads and Maritime Services, “RMS QA Specification 3051, Granular Base and Subbase Materials for Surfaced Road Pavements”, dated April 2011 and subsequent editions.
9. Australian Standard AS 1289.5.2.1-2003, “Methods of testing soils for engineering purposes”, Standards Australia.
10. Australian Standard AS3798-2007, "Guidelines on Earthworks for Commercial & Residential Developments", Standards Australia, March 2007.
11. NSW EPA, “Waste Classification Guidelines – Part 1: Classifying Waste, November 2014”.

11. Limitations

Douglas Partners (DP) has prepared this report for the proposed aged care facility at Closebourne Village, Morpeth in accordance with DP’s proposal NCL160058 dated 3 February 2016 and acceptance received from Mr Bruce Gould of Lend Lease dated 23 February 2016. The work was carried out under a consulting agreement between Lend Lease Retirement Living and DP. This report is provided for the exclusive use of Lend Lease Retirement Living for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP’s field testing has been completed.

DP’s advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The scope for work for this investigation included limited assessment of surface or sub-surface materials for contaminants. Should evidence of filling of unknown origin be noted in the report, and in particular the presence of building demolition materials, it should be recognised that there may be some risk that such filling may contain contaminants and hazardous building materials.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical / environmental components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

About This Report
Sampling Methods
Soil Descriptions
Symbols and Abbreviations
Rock Descriptions
CSIRO Sheet BTF 18

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

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This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Soil Descriptions

Douglas Partners

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

Symbols & Abbreviations

Douglas Partners

Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core Drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

July 2010

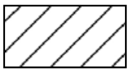
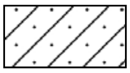
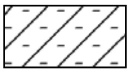
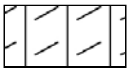
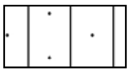
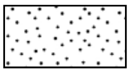
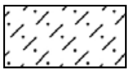
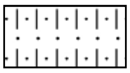
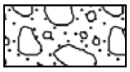
Symbols & Abbreviations

Graphic Symbols for Soil and Rock

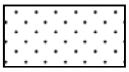
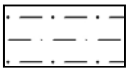
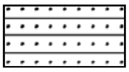
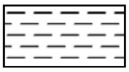
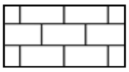
General

■	Asphalt
	Road base
	Concrete
	Filling

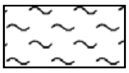
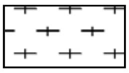
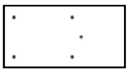
Soils

	Topsoil
	Peat
	Clay
	Silty clay
	Sandy clay
	Gravelly clay
	Shaly clay
	Silt
	Clayey silt
	Sandy silt
	Sand
	Clayey sand
	Silty sand
	Gravel
	Sandy gravel
	Cobbles, boulders
	Talus

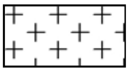
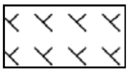
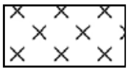
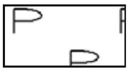
Sedimentary Rocks

	Boulder conglomerate
	Conglomerate
	Conglomeratic sandstone
	Sandstone
	Siltstone
	Laminite
	Mudstone, claystone, shale
■	Coal
	Limestone

Metamorphic Rocks

	Slate, phyllite, schist
	Gneiss
	Quartzite

Igneous Rocks

	Granite
	Dolerite, basalt, andesite
	Dacite, epidote
	Tuff, breccia
	Porphyry

Rock Descriptions

Rock Strength

Rock strength is defined by the Point Load Strength Index ($Is_{(50)}$) and refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects. The test procedure is described by Australian Standard 4133.4.1 - 1993. The terms used to describe rock strength are as follows:

Term	Abbreviation	Point Load Index $Is_{(50)}$ MPa	Approx Unconfined Compressive Strength MPa*
Extremely low	EL	<0.03	<0.6
Very low	VL	0.03 - 0.1	0.6 - 2
Low	L	0.1 - 0.3	2 - 6
Medium	M	0.3 - 1.0	6 - 20
High	H	1 - 3	20 - 60
Very high	VH	3 - 10	60 - 200
Extremely high	EH	>10	>200

* Assumes a ratio of 20:1 for UCS to $Is_{(50)}$

Degree of Weathering

The degree of weathering of rock is classified as follows:

Term	Abbreviation	Description
Extremely weathered	EW	Rock substance has soil properties, i.e. it can be remoulded and classified as a soil but the texture of the original rock is still evident.
Highly weathered	HW	Limonite staining or bleaching affects whole of rock substance and other signs of decomposition are evident. Porosity and strength may be altered as a result of iron leaching or deposition. Colour and strength of original fresh rock is not recognisable
Moderately weathered	MW	Staining and discolouration of rock substance has taken place
Slightly weathered	SW	Rock substance is slightly discoloured but shows little or no change of strength from fresh rock
Fresh stained	Fs	Rock substance unaffected by weathering but staining visible along defects
Fresh	Fr	No signs of decomposition or staining

Degree of Fracturing

The following classification applies to the spacing of natural fractures in diamond drill cores. It includes bedding plane partings, joints and other defects, but excludes drilling breaks.

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	Core lengths of 20-40 mm with some fragments
Fractured	Core lengths of 40-200 mm with some shorter and longer sections
Slightly Fractured	Core lengths of 200-1000 mm with some shorter and loner sections
Unbroken	Core lengths mostly > 1000 mm

Rock Descriptions

Rock Quality Designation

The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

$$\text{RQD \%} = \frac{\text{cumulative length of 'sound' core sections} \geq 100\text{ mm long}}{\text{total drilled length of section being assessed}}$$

where 'sound' rock is assessed to be rock of low strength or better. The RQD applies only to natural fractures. If the core is broken by drilling or handling (i.e. drilling breaks) then the broken pieces are fitted back together and are not included in the calculation of RQD.

Stratification Spacing

For sedimentary rocks the following terms may be used to describe the spacing of bedding partings:

Term	Separation of Stratification Planes
Thinly laminated	< 6 mm
Laminated	6 mm to 20 mm
Very thinly bedded	20 mm to 60 mm
Thinly bedded	60 mm to 0.2 m
Medium bedded	0.2 m to 0.6 m
Thickly bedded	0.6 m to 2 m
Very thickly bedded	> 2 m

Foundation Maintenance and Footing Performance: A Homeowner's Guide

CSIRO
PUBLISHING
BTF 18-2011
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 2870-2011, 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, which may experience only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes

Notes

1. Where controlled fill has been used, the site may be classified A to E according to the type of fill used.
2. Filled sites. Class P is used for sites which include soft fills, such as clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soil subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise.
3. Where deep-seated moisture changes exist on sites at depths of 3 m or greater, further classification is needed for Classes M to E (M-D, H1-D, H2-D and E-D).

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.

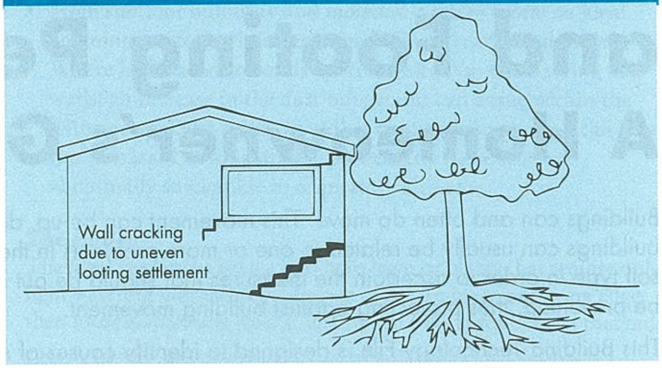
Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends 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.

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.

Trees can cause shrinkage and damage



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 causes 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 2870-2011.

AS 2870-2011 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

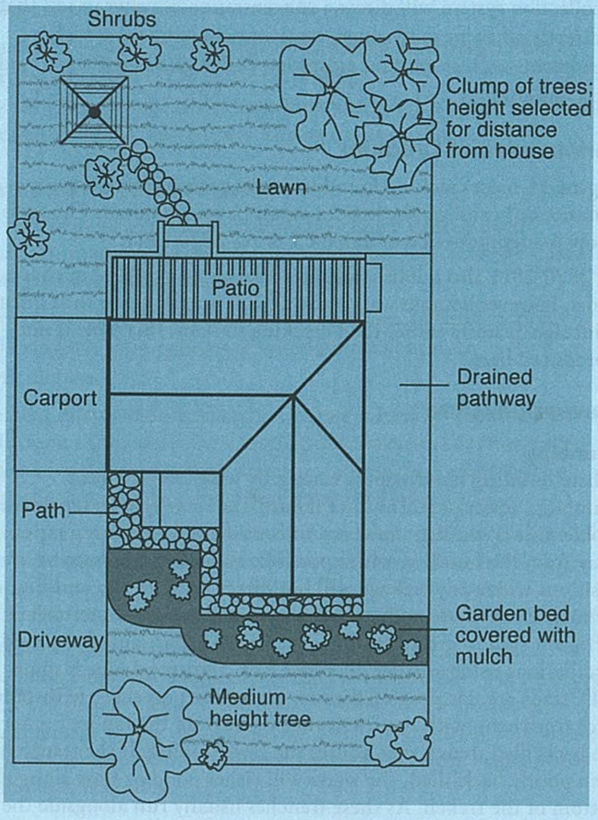
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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 should

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 depends on number of cracks	4

Gardens for a reactive site



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

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

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

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

Condensation

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

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

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

The garden

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

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

Existing trees

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

Information on trees, plants and shrubs

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

Excavation

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

Remediation

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

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

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

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Appendix B

Borehole Logs 201 to 208 – Current Investigations
Test Pits 209 and 210 – Current Investigation
Test Pit 135 – Previous Investigation
Results of Dynamic Penetrometer Tests
Plate 1 – Core Photos

BOREHOLE LOG

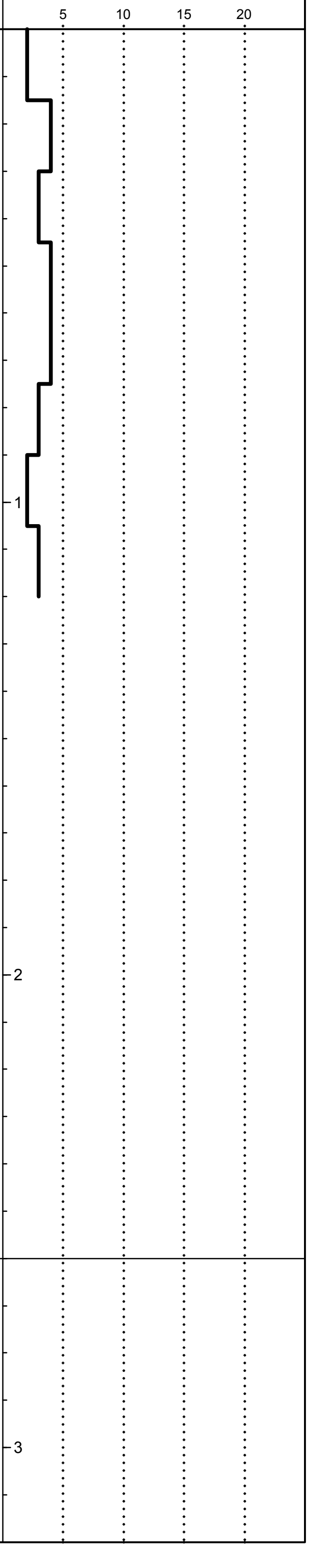
CLIENT: Lend Lease (Retirement Living)
PROJECT: Proposed Aged Care
LOCATION: Morpeth Road, Morpeth

SURFACE LEVEL: --
EASTING: 370858
NORTHING: 6378109
DIP/AZIMUTH: 90°/--

BORE No: 201
PROJECT No: 81251.10
DATE: 9/3/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water
	0.1	TOPSOIL - Generally comprising grey/brown, fine to medium grained silty sand topsoil, grass covered, with some rootlets					
		SILTY SAND - Loose, orange/grey, fine grained silty sand, humid					
			D	0.4 0.6	E		
		From 0.6m, light brown with trace clay					
		From 0.8m, wet	D	0.8 1.0	E		
1	1.0	SANDY CLAY - Stiff to very stiff, brown, fine to medium grained sandy clay, M>Wp					
		From 1.2m, red mottled grey		1.3		pp = 340-360	
			U	1.45 1.72	50	pp >600	
				1.9		pp = 380-410	
2			D	2.0			
				2.2		pp = 220-290	
		From 2.4m, rock like structure					
	2.5	SANDSTONE - Extremely low strength, extremely weathered, brown/grey, fine to medium grained sandstone	D	2.5 2.6			
	2.6	Bore discontinued at 2.6m , refusal					
3							

Dynamic Penetrometer Test (blows per 150mm)



RIG: Push Tube Rig **DRILLER:** Misikic **LOGGED:** Misikic **CASING:** N/A
TYPE OF BORING: 60mm diameter pushtube to 1.50m, from 1.5m to 2.6m, 35mm diameter pushtube
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

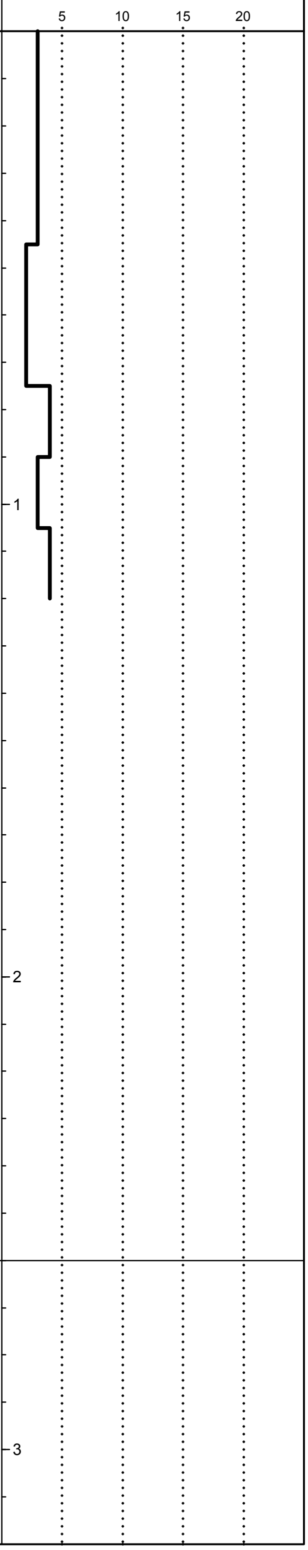
CLIENT: Lend Lease (Retirement Living)
PROJECT: Proposed Aged Care
LOCATION: Morpeth Road, Morpeth

SURFACE LEVEL: --
EASTING: 370851
NORTHING: 6378061
DIP/AZIMUTH: 90°/--

BORE No: 202
PROJECT No: 81251.10
DATE: 9/3/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		FILLING - Generally comprising dark grey, fine to medium grained silty sand, with gravel up to 20mm, grass covered, with some rootlets					
	0.15	FILLING - Generally comprising brown, fine to medium grained silty sand From 0.15m to 0.4m, some slag up to 20mm	D	0.2 0.4	E		
	0.9	SILTY SAND - Loose, brown, fine grained silty sand, with trace clay, humid	D	1.0 1.2	E		
		From 1.9m, brown, wet	D	1.9			
	2.2	SANDY CLAY - Stiff, brown, fine to medium grained sandy clay, M>Wp		2.25		pp = 240-280	
	2.3	CLAY - Stiff, brown clay, M>Wp		2.4		pp = 220-260	
	2.5	SANDY CLAY - Brown mottled red, fine to medium grained sandy clay (rock structure)		2.55		pp >600	
	2.6	Bore discontinued at 2.6m , limit of investigation					

Dynamic Penetrometer Test (blows per 150mm)



RIG: Push Tube Rig **DRILLER:** Misikic **LOGGED:** Misikic **CASING:** N/A
TYPE OF BORING: 60mm diameter pushtube to 1.50m, from 1.5m to 2.6m, 35mm diameter pushtube
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

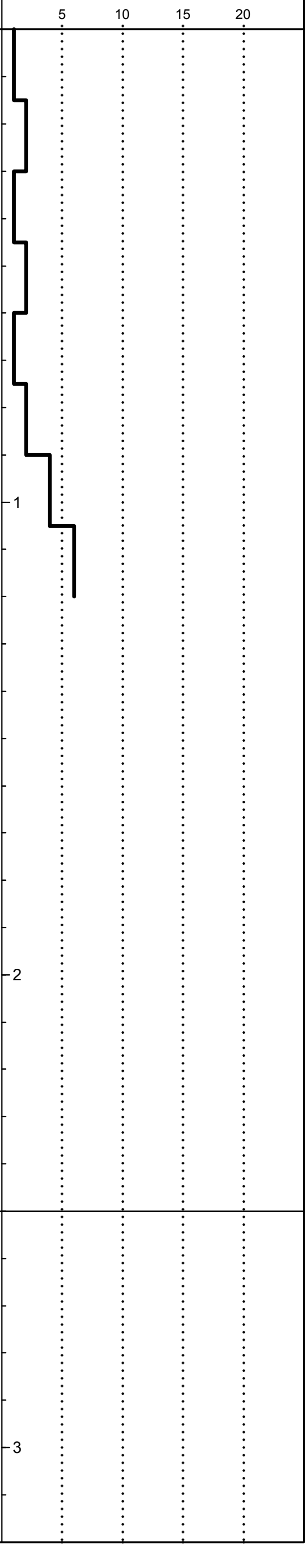
CLIENT: Lend Lease (Retirement Living)
PROJECT: Proposed Aged Care
LOCATION: Morpeth Road, Morpeth

SURFACE LEVEL: --
EASTING: 370863
NORTHING: 6378029
DIP/AZIMUTH: 90°/--

BORE No: 203
PROJECT No: 81251.10
DATE: 9/3/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - Generally comprising dark grey, fine to medium grained sandy clay topsoil, grass covered, M>Wp					
	0.2	SILTY SAND - Grey, fine to medium grained silty sand, humid	D	0.2 0.4	E		
	0.5	SAND - Loose, light grey, fine to medium grained sand, wet	D	0.7 0.9	E		▼ 09-03-16
1	1.0	SANDY CLAY - Stiff, brown/grey, fine to medium grained sandy clay, M>Wp		1.2		pp = 300-350	
			50	1.3 1.7		pp = 250-280	
2		From 2.2m, rock like structure		2.2		pp >600	
			D	2.4 2.6			
	2.5	Bore discontinued at 2.5m , limit of investigation					
3							

Dynamic Penetrometer Test
(blows per 150mm)



RIG: Push Tube Rig **DRILLER:** Misikic **LOGGED:** Misikic **CASING:** N/A
TYPE OF BORING: 60mm diameter pushtube to 1.50m, from 1.5m to 2.6m, 35mm diameter pushtube
WATER OBSERVATIONS: Free groundwater observed at 0.7m
REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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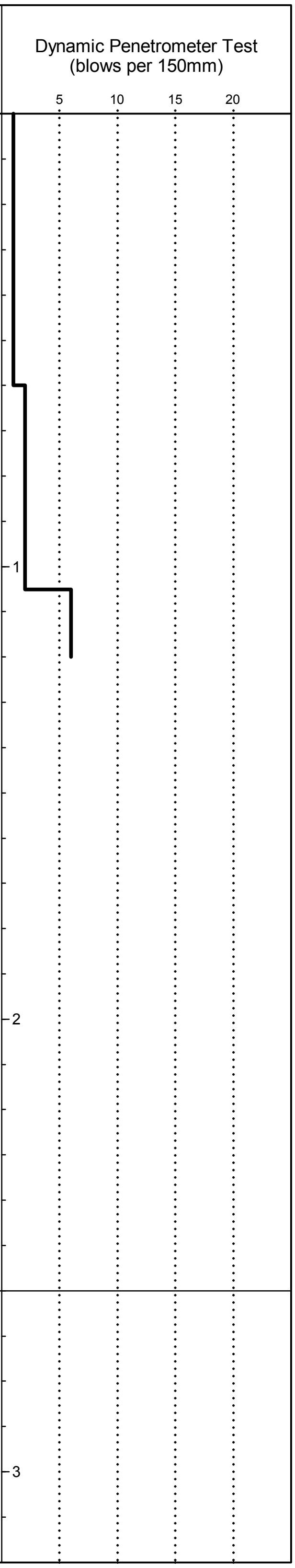
BOREHOLE LOG

CLIENT: Lend Lease (Retirement Living)
PROJECT: Proposed Aged Care
LOCATION: Morpeth Road, Morpeth

SURFACE LEVEL: --
EASTING: 370804
NORTHING: 6378040
DIP/AZIMUTH: 90°/--

BORE No: 204
PROJECT No: 81251.10
DATE: 9/3/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		TOPSOIL - Generally comprising dark grey, fine to medium grained sandy clay, grass covered, with some rootlets, M>Wp						
	0.1	SANDY CLAY - Soft to firm, dark grey, fine to medium grained sandy clay, with trace rootlets, M>Wp						
	0.4	SAND - Loose, light grey, fine to medium grained sand, wet						
				D	0.5 0.7			
		From 0.9m, with trace clay						
	1.2	SANDY CLAY - Stiff, brown, fine to medium grained sandy clay, M>Wp						
					1.4		pp = 100-130	
		From 1.5m to 1.65m, cemented clayey sand		D	1.5 1.65			
					1.8		pp = 160-190	
				D	2.2 2.4			
		From 2.5m, rock like structure			2.5		pp = 370-460	
	2.6	Bore discontinued at 2.6m , limit of investigation						



RIG: Push Tube Rig **DRILLER:** Misikic **LOGGED:** Misikic **CASING:** N/A
TYPE OF BORING: 60mm diameter pushtube to 1.50m, from 1.5m to 2.6m, 35mm diameter pushtube
WATER OBSERVATIONS: Free groundwater observed at 0.7m
REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

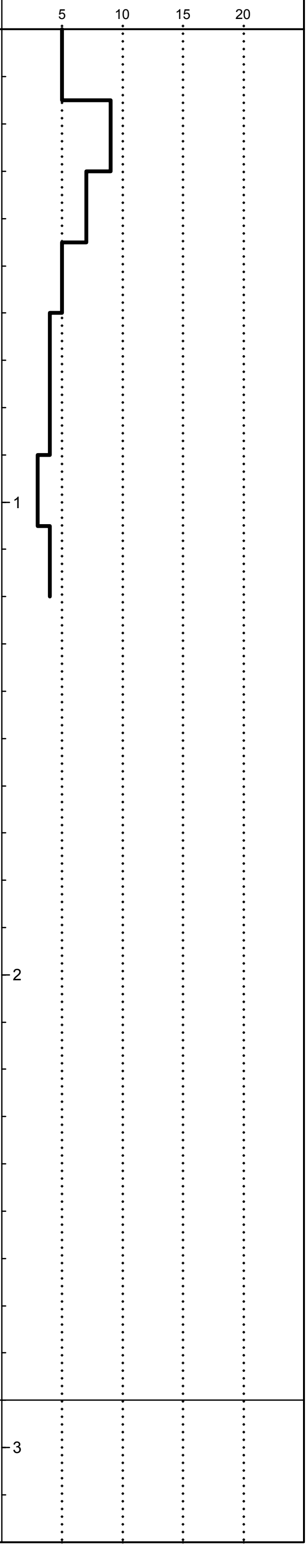
CLIENT: Lend Lease (Retirement Living)
PROJECT: Proposed Aged Care
LOCATION: Morpeth Road, Morpeth

SURFACE LEVEL: --
EASTING: 370821
NORTHING: 6378073
DIP/AZIMUTH: 90°/--

BORE No: 205
PROJECT No: 81251.10
DATE: 9/3/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		FILLING - Generally comprising light grey, fine to medium grey silty sand, grass covered						
		From 0.15m, sandstone fragments, very low to low strength, extremely to highly weathered		D	0.1 0.25	E		
	0.25	SILTY SAND - Medium dense, dark grey, fine to medium grained, silty sand, humid		D	0.3 0.5	E		
		From 0.9m, with trace clay						
	1							
	1.2	SANDY CLAY -Stiff to very stiff, brown, fine to medium grained sandy clay, M>Wp			1.2		pp = 410-490	
				U	1.45 1.7	50	pp = 420-440	
		From 1.7m, rock structure with very low strength, extremely weathered sandstone fragments			1.8		pp = 460-490	
				D	1.8 2.0			
	2							
					2.3		pp = 210-260	
					2.8		pp = 460-470	
	2.9	Bore discontinued at 2.9m , limit of investigation						
	3							

Dynamic Penetrometer Test
(blows per 150mm)



RIG: Push Tube Rig **DRILLER:** Misikic **LOGGED:** Misikic **CASING:** N/A

TYPE OF BORING: 60mm diameter pushtube to 1.50m, from 1.5m to 2.9m, 35mm diameter pushtube

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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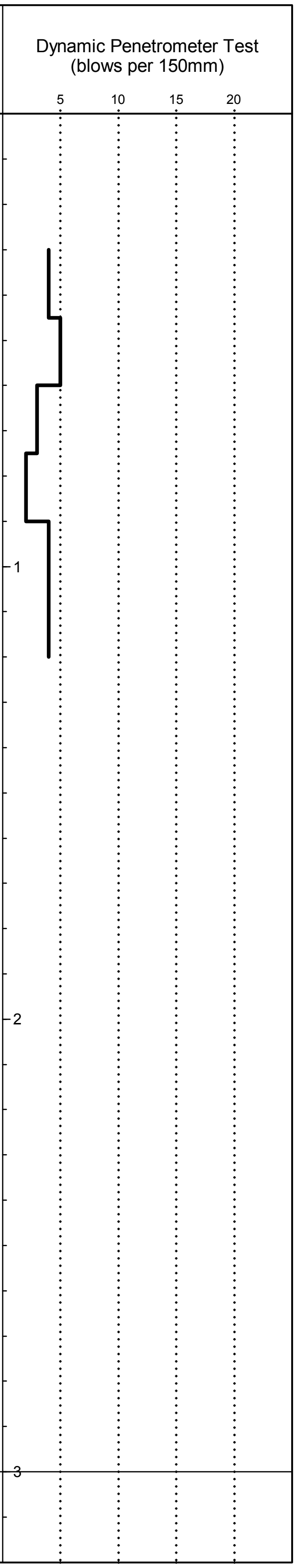
BOREHOLE LOG

CLIENT: Lend Lease (Retirement Living)
PROJECT: Proposed Aged Care
LOCATION: Morpeth Road, Morpeth

SURFACE LEVEL: --
EASTING: 370797
NORTHING: 6378099
DIP/AZIMUTH: 90°/--

BORE No: 206
PROJECT No: 81251.10
DATE: 9/3/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing Type	Sampling & In Situ Testing Depth	Sampling & In Situ Testing Sample	Sampling & In Situ Testing Results & Comments	Water
	0.05	ASPHALT						
	0.2	FILLING - Generally comprising black coal filling, with abundant silty sand		D	0.05 0.2	E		
	0.5	SILTY SAND - Medium dense, brown, fine to medium grained silty sand, humid		D	0.2 0.5	E		
		SANDY CLAY - Stiff, brown, fine to medium grained sandy clay, M>Wp						
1					1.3 1.4		pp = 160-180	
		From 1.4m, grey mottled red iron staining						
				D	1.6			
2					2.0		pp = 200-350	
				D	2.6			
					2.7		pp = 260-280	
3	3.0	Bore discontinued at 3.0m , limit of investigation						



RIG: Push Tube Rig **DRILLER:** Misikic **LOGGED:** Misikic **CASING:** N/A
TYPE OF BORING: 60mm diameter pushtube to 1.50m, from 1.5m to 3.6m, 35mm diameter pushtube
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

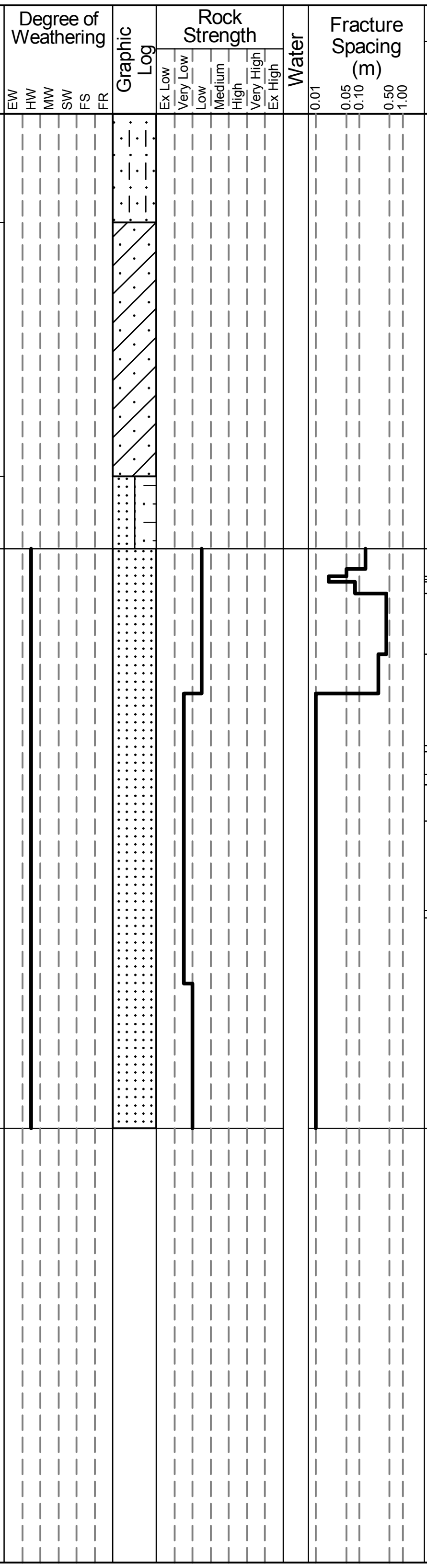
BOREHOLE LOG

CLIENT: Lend Lease (Retirement Living)
PROJECT: Proposed Aged Care
LOCATION: Morpeth Road, Morpeth

SURFACE LEVEL: --
EASTING: 370806
NORTHING: 6378140
DIP/AZIMUTH: 90°/--

BORE No: 207
PROJECT No: 81251.10
DATE: 10/3/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata
	0.0	SILTY SAND - Loose, brown, fine grained silty sand, grass covered, humid
	0.75	SANDY CLAY - Stiff, brown, fine grained sandy clay, M<Wp From 1.6m, hard, rock properties
	2.5	SANDSTONE/SILTSTONE - Extremely low strength, extremely weathered, grey/brown, fine to medium grained sandstone and siltstone
	3.0	SANDSTONE - Low strength, highly weathered, grey mottled brown, fine to medium grained sandstone, slightly fractured
	7.0	Bore discontinued at 7.0m , limit of investigation



Discontinuities (B - Bedding J - Joint S - Shear F - Fault)

- 3.14m: P, sh-20°, iv, ro, fe
- 3.19m: P, sh-20°, iv, ro, fe
- 3.21m: P, sh-20°, iv, ro, fe
- 3.23m: P, sh-20°, iv, ro, fe
- 3.31m: P, sh-20°, iv, ro, fe
- 3.73m: J, 10°, pl, ro, clay veneer
- 4.36m: J, 20°, ir, ro, clean
- 4.4m: J, 20°, ir, ro, clean
- 4.56m: P, sh-10°, ir, ro, clean
- 4.63m: P, sh-10°, ir, ro, clean
- 4.88m: P, sh-10°, ir, ro, clean
- 5.5m: P, sh-10°, ir, ro, clean
- 5.55m: J, 20°, ir, ro, clean

Sampling & In Situ Testing

Type	Core Rec. %	RQD %	Test Results & Comments
D			
D			
S			pp >600 10,13,17 N = 30
S			25/40mm,-,- refusal
C	100	83	
C	100	0	
C	100	0	

RIG: Hengen 114 **DRILLER:** Sawyer **LOGGED:** Misikic **CASING:** HQ to 2.7m
TYPE OF BORING: Solid flight auger to 2.6m, rotary from 2.6m to 3.0m, NMLC coring from 3.0m to 7.0m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

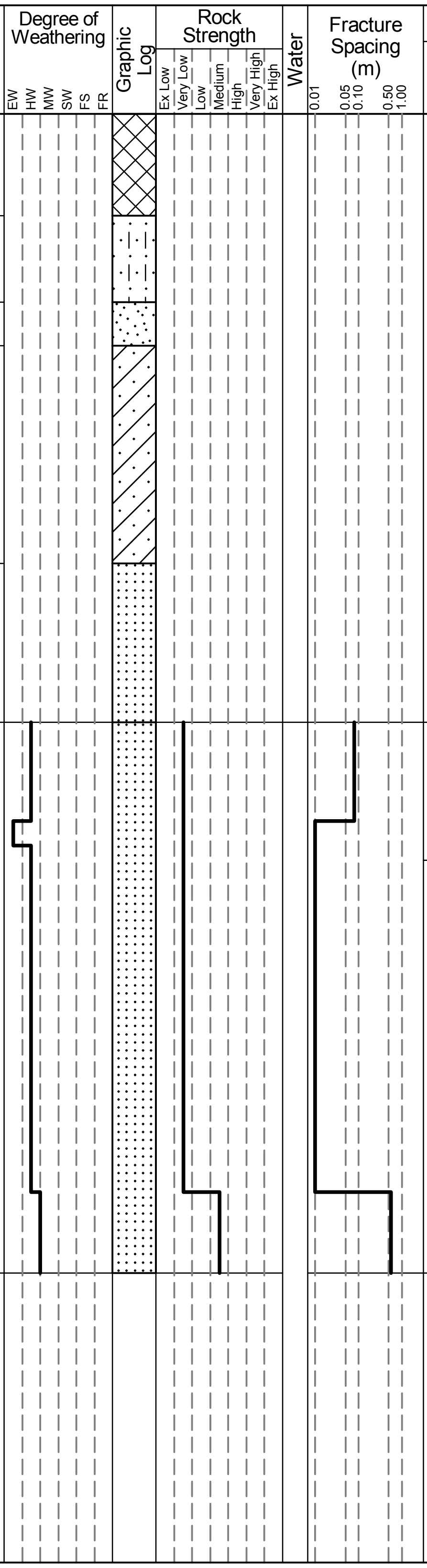
BOREHOLE LOG

CLIENT: Lend Lease (Retirement Living)
PROJECT: Proposed Aged Care
LOCATION: Morpeth Road, Morpeth

SURFACE LEVEL: --
EASTING: 370782
NORTHING: 6378075
DIP/AZIMUTH: 90°/--

BORE No: 208
PROJECT No: 81251.10
DATE: 10/3/2016
SHEET 1 OF 1

Depth (m)	Description of Strata	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
	FILLING - Generally comprising dark brown, fine to medium grained silty sand filling, with some gravel up to 20mm, grass covered		D			
0.7	SILTY SAND - Loose, dark grey, fine to medium grained silty sand, with trace clay and gravel up to 3mm, humid		D S			3,5,5 N = 10
1.3	SAND - Loose, brown, fine to medium grained sand, moist		D			
1.6	SANDY CLAY - Stiff, brown, fine to medium grained sandy clay, M>Wp					
	From 2.6m, very stiff to hard		S			11,12,19 N = 31
3.1	SANDSTONE - Extremely low to very low, extremely to highly weathered, grey mottled red, fine to medium grained sandstone		S			16,24,25/110mm refusal
4.2	At 4.2m, start coring SANDSTONE - Very low strength, highly weathered, grey mottled red/orange, fine to medium grained, slightly fractured sandstone	From 4.88m to 5.05m, fragmented 5.15m: P, sh, ir, ro, clean	C	100	0	
			C	100	0	
	From 7.44m, medium strength	7.2m: P, sh, ir, ro, clean 7.44m: P, sh, ir, ro, fe	C	100	70	
8.0	Bore discontinued at 8.0m , limit of investigation	8m: J, 70°, pl, ro, fe				



RIG: Hengen 114 **DRILLER:** Sawyer **LOGGED:** Misikic **CASING:**

TYPE OF BORING: Solid flight auger to 2.5m, rotary from 2.5m to 3.8m, NMLC coring from 4.2m to 7.0m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

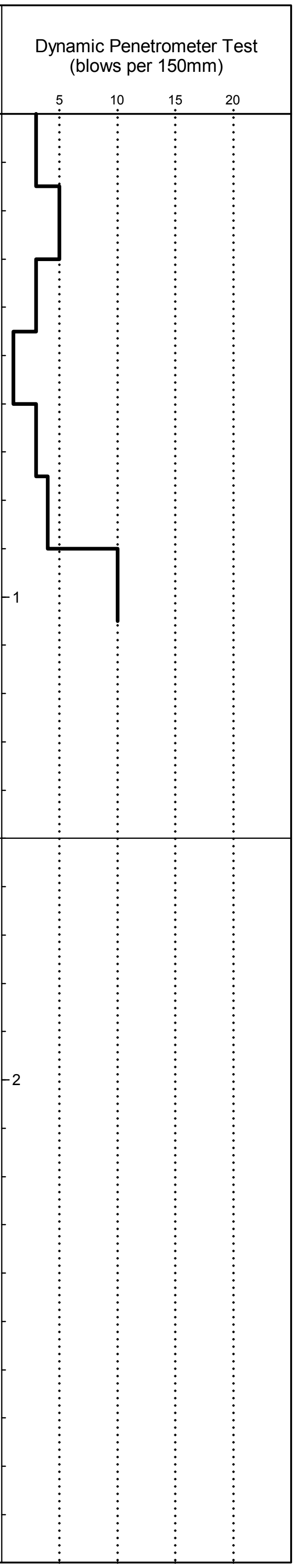
TEST PIT LOG

CLIENT: Lend Lease (Retirement Living)
PROJECT: Proposed Aged Care
LOCATION: Morpeth Road, Morpeth

SURFACE LEVEL: --
EASTING: 370740
NORTHING: 6378054

PIT No: 209
PROJECT No: 81251.10
DATE: 10/3/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments
		TOPSOIL - Generally cmprising dark brown silty sand topsoil with abundant rootlets				
	0.15	SILTY SAND - Loose to medium dense, dark brown, fine to medium grained silty sand	B D	0.4 0.5		
	0.6	SAND - Medium dense, brown, fine to medium grained sand with some clay, moist to wet	D	0.6 0.8		
	0.9	SANDY CLAY - Very stiff, brown, fine to medium grained sandy clay From 1.3m, trace iron staining	B D	0.9 1.0		
	1.5	Pit discontinued at 1.5m , limit of investigation				



RIG: 3tonne Excavator with 450mm bucket

LOGGED: Fulham

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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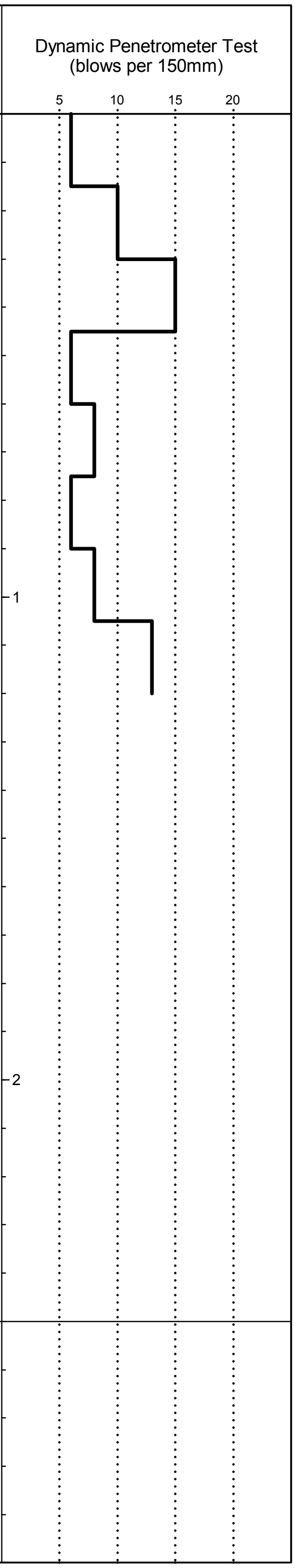
TEST PIT LOG

CLIENT: Lend Lease (Retirement Living)
PROJECT: Proposed Aged Care
LOCATION: Morpeth Road, Morpeth

SURFACE LEVEL: --
EASTING: 370752
NORTHING: 6378042

PIT No: 210
PROJECT No: 81251.10
DATE: 10/3/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		SILTY SAND - Medium dense to dense, dark brown, fine to medium grained silty sand with some rootlets within the top 100mm	D	0.2			
	0.5	SAND - Medium dense, brown, fine to medium grained sand with some clay, moist From 0.7m, clay content increasing with depth	B D	0.5 0.6 0.7			
1	1.0	SANDY CLAY - Very stiff to hard, brown mottled grey and red, fine to medium grained sandy clay, M>Wp					
2							
	2.5	Pit discontinued at 2.5m , limit of investigation					



RIG: 3tonne Excavator with 450mm bucket **LOGGED:** Fulham **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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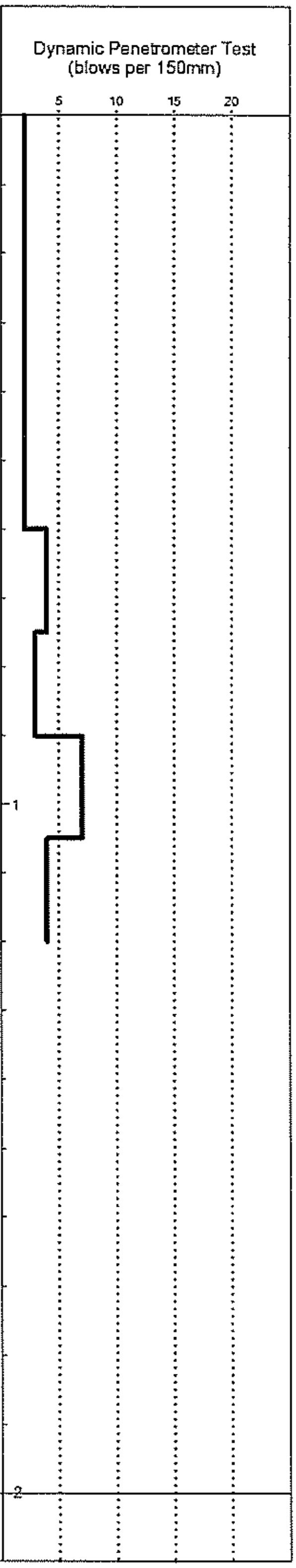
TEST PIT LOG

CLIENT: Morpeth House Pty Ltd
PROJECT: Morpeth House Estate
LOCATION: Morpeth Road, Morpeth

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: 135
PROJECT No: 31995.02
DATE: 11 May 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing Type	Sampling & In Situ Testing Depth	Sampling & In Situ Testing Sample	Sampling & In Situ Testing Results & Comments	Water
		FILLING - Generally comprising loose brown/grey fine to medium grained silty sand topsoil filling, trace rootlets, glass bottles, dry to moist		D, PID	0.1		<1 ppm	
	0.25	FILLING - Generally comprising loose brown/grey fine to medium grained silty sand filling, with trace glass bottles, aluminium cans, loose gravel, dry to moist		D, PID	0.5		<1 ppm	
	0.8	SILTY SAND - Medium dense dark brown/grey fine to medium grained silty sand, dry to moist						
1								
	1.6	SAND - Very loose light brown/grey fine to medium grained silty sand, dry to moist						▷
	1.7	SANDY CLAY - Stiff brown mottled orange/red/grey fine to medium grained sandy clay, M>Wp		B, pp	1.7		300 - 400 kPa	
2	2.0	Pit discontinued at 2.0m, limit of investigation						



RIG: Case 580 Super LE backhoe, 300mm bucket with teeth

LOGGED: Cairnes

WATER OBSERVATIONS: Seepage observed at 1.6m to 1.7m

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date:

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Results of Dynamic Penetrometer Tests

Client Lend Lease (Retirement)
Project Proposed Aged Care
Location Morpeth Road, Morpeth

Project No. 81251.10
Date 09/03/16
Page No. 1 of 1

Test Location	201	202	203	204	205	206				
RL of Test (AHD)										
Depth (m)	**Penetration Resistance** Blows/150 mm									
0 - 0.15	2	3	1	1	5	-				
0.15 - 0.30	4	3	2	1	9	-				
0.30 - 0.45	3	3	1	1	7	4				
0.45 - 0.60	4	2	2	1	5	5				
0.60 - 0.75	4	2	1	2	4	3				
0.75 - 0.90	3	4	2	2	4	2				
0.90 - 1.05	2	3	4	2	3	4				
1.05 - 1.20	3	4	6	6	4	4				
1.20 - 1.35										
1.35 - 1.50										
1.50 - 1.65										
1.65 - 1.80										
1.80 - 1.95										
1.95 - 2.10										
2.10 - 2.25										
2.25 - 2.40										
2.40 - 2.55										
2.55 - 2.70										
2.70 - 2.85										
2.85 - 3.00										
3.00 - 3.15										
3.15 - 3.30										
3.30 - 3.45										
3.45 - 3.60										

Test Method AS 1289.6.3.2, Cone Penetrometer ☑
AS 1289.6.3.3, Sand Penetrometer ☐

Tested By MM
Checked By MPG

Remarks Ref = Refusal, 24/110 indicates 25 blows for 110 mm penetration

DOUGLAS PARTNERS PTY LTD

Proposed Aged Care, Closebourne, MORPETH

BORE 207 PROJECT 81251.10 2016

3.00 m – 7.00 m

DOUGLAS PARTNERS PTY LTD

Proposed Aged Care, Closebourne, MORPETH

BORE 208 PROJECT 81251.10 2016

4.20 m – 8.00 m

Douglas Partners
Geotechnics / Environment / Groundwater

Core Photoplates

Proposed Aged Care, Closebourne

Morpeth Road, Morpeth

CLIENT: Lend Lease (Retirement Living)

PROJECT:	81251.10
PLATE No:	1
REV:	A
DATE:	11-Apr-16

Appendix C

Laboratory Test Results
Chain of Custody Sheets

12 Ashley Street, Chatswood, NSW 2067
tel: +61 2 9910 6200

email: sydney@envirolab.com.au
envirolab.com.au

Envirolab Services Pty Ltd - Sydney | ABN 37 112 535 645

CERTIFICATE OF ANALYSIS 143383

Client:

Douglas Partners Newcastle
Box 324 Hunter Region Mail Centre
Newcastle
NSW 2310

Attention: Michael Gawn

Sample log in details:

Your Reference:	**81251.10, Morpeth**
No. of samples:	12 soils
Date samples received / completed instructions received	16/03/16 / 16/03/16

Analysis Details:

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	23/03/16 / 18/03/16
Date of Preliminary Report:	Not Issued

NATA accreditation number 2901. This document shall not be reproduced except in full.
Accredited for compliance with ISO/IEC 17025. **Tests not covered by NATA are denoted with *.**

Results Approved By:

Jacinta Hurst
Laboratory Manager

ACCREDITED FOR TECHNICAL COMPETENCE

vTRH(C6-C10)/BTEXN in Soil						
Our Reference:	UNITS	143383-1	143383-2	143383-3	143383-4	143383-5
Your Reference	--------------	202	202	205	205	206
Depth	------------	0.2-0.5	1.0-1.2	0.1-0.25	0.3-0.5	0.05-0.2
Type of sample		soil	soil	soil	soil	soil
Date extracted	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Date analysed	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
TRH C_6 - C_9	mg/kg	<25	<25	<25	<25	<25
TRH C_6 - C_{10}	mg/kg	<25	<25	<25	<25	<25
vTPH C_6 - C_{10} less BTEX (F1)	mg/kg	<25	<25	<25	<25	<25
Benzene	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	mg/kg	<1	<1	<1	<1	<1
m+p-xylene	mg/kg	<2	<2	<2	<2	<2
o-Xylene	mg/kg	<1	<1	<1	<1	<1
naphthalene	mg/kg	<1	<1	<1	<1	<1
Surrogate aaa-Trifluorotoluene	%	100	98	97	97	97

vTRH(C6-C10)/BTEXN in Soil						
Our Reference:	UNITS	143383-6	143383-7	143383-8	143383-9	143383-10
Your Reference	--------------	206	208	208	203	207
Depth	------------	0.2-0.5	0.2-0.4	1.0-1.1	0.2-0.4	0.2-0.4
Type of sample		soil	soil	soil	soil	soil
Date extracted	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Date analysed	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
TRH C_6 - C_9	mg/kg	<25	<25	<25	<25	<25
TRH C_6 - C_{10}	mg/kg	<25	<25	<25	<25	<25
vTPH C_6 - C_{10} less BTEX (F1)	mg/kg	<25	<25	<25	<25	<25
Benzene	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	mg/kg	<1	<1	<1	<1	<1
m+p-xylene	mg/kg	<2	<2	<2	<2	<2
o-Xylene	mg/kg	<1	<1	<1	<1	<1
naphthalene	mg/kg	<1	<1	<1	<1	<1
Surrogate aaa-Trifluorotoluene	%	98	98	93	92	101

vTRH(C6-C10)/BTEXN in Soil		
Our Reference:	UNITS	143383-12
Your Reference	------------- -	203
Depth	------------	0.7-0.9
Type of sample		soil
Date extracted	-	17/03/2016
Date analysed	-	17/03/2016
TRH C_6 - C_9	mg/kg	<25
TRH C_6 - C_{10}	mg/kg	<25
vTPH C_6 - C_{10} less BTEX (F1)	mg/kg	<25
Benzene	mg/kg	<0.2
Toluene	mg/kg	<0.5
Ethylbenzene	mg/kg	<1
m+p-xylene	mg/kg	<2
o-Xylene	mg/kg	<1
naphthalene	mg/kg	<1
Surrogate aaa-Trifluorotoluene	%	97

svTRH (C10-C40) in Soil						
Our Reference:	UNITS	143383-1	143383-2	143383-3	143383-4	143383-5
Your Reference	------------- -	202	202	205	205	206
Depth	------------	0.2-0.5	1.0-1.2	0.1-0.25	0.3-0.5	0.05-0.2
Type of sample		soil	soil	soil	soil	soil
Date extracted	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Date analysed	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
TRHC$_{10}$ - C$_{14}$	mg/kg	<50	<50	<50	<50	54
TRHC$_{15}$ - C$_{28}$	mg/kg	<100	<100	<100	<100	550
TRHC$_{29}$ - C$_{36}$	mg/kg	<100	<100	<100	<100	290
TRH>C$_{10}$-C$_{16}$	mg/kg	<50	<50	<50	<50	110
TRH>C$_{10}$ - C$_{16}$ less Naphthalene (F2)	mg/kg	<50	<50	<50	<50	110
TRH>C$_{16}$-C$_{34}$	mg/kg	<100	<100	<100	<100	710
TRH>C$_{34}$-C$_{40}$	mg/kg	<100	<100	<100	<100	180
Surrogate o-Terphenyl	%	84	82	83	80	107

svTRH (C10-C40) in Soil						
Our Reference:	UNITS	143383-6	143383-7	143383-8	143383-9	143383-10
Your Reference	------------- -	206	208	208	203	207
Depth	------------	0.2-0.5	0.2-0.4	1.0-1.1	0.2-0.4	0.2-0.4
Type of sample		soil	soil	soil	soil	soil
Date extracted	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Date analysed	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
TRHC$_{10}$ - C$_{14}$	mg/kg	<50	<50	<50	<50	<50
TRHC$_{15}$ - C$_{28}$	mg/kg	<100	<100	<100	<100	<100
TRHC$_{29}$ - C$_{36}$	mg/kg	<100	<100	<100	<100	<100
TRH>C$_{10}$-C$_{16}$	mg/kg	<50	<50	<50	<50	<50
TRH>C$_{10}$ - C$_{16}$ less Naphthalene (F2)	mg/kg	<50	<50	<50	<50	<50
TRH>C$_{16}$-C$_{34}$	mg/kg	<100	<100	<100	<100	<100
TRH>C$_{34}$-C$_{40}$	mg/kg	<100	<100	<100	<100	<100
Surrogate o-Terphenyl	%	78	82	80	80	81

svTRH (C10-C40) in Soil		
Our Reference:	UNITS	143383-12
Your Reference	------------ -	203
Depth	------------	0.7-0.9
Type of sample		soil
Date extracted	-	17/03/2016
Date analysed	-	17/03/2016
TRHC $_{10}$ - C $_{14}$	mg/kg	<50
TRHC $_{15}$ - C $_{28}$	mg/kg	<100
TRHC $_{29}$ - C $_{36}$	mg/kg	<100
TRH>C $_{10}$-C $_{16}$	mg/kg	<50
TRH>C $_{10}$ - C $_{16}$ less Naphthalene (F2)	mg/kg	<50
TRH>C $_{16}$-C $_{34}$	mg/kg	<100
TRH>C $_{34}$-C $_{40}$	mg/kg	<100
Surrogate o-Terphenyl	%	79

PAHs in Soil						
Our Reference:	UNITS	143383-1	143383-2	143383-3	143383-4	143383-5
Your Reference	-------------	202	202	205	205	206
Depth	------------	0.2-0.5	1.0-1.2	0.1-0.25	0.3-0.5	0.05-0.2
Type of sample		soil	soil	soil	soil	soil
Date extracted	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Date analysed	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Naphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	mg/kg	<0.1	<0.1	0.2	<0.1	0.7
Anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	mg/kg	<0.1	<0.1	0.6	<0.1	0.4
Pyrene	mg/kg	<0.1	<0.1	0.5	<0.1	0.4
Benzo(a)anthracene	mg/kg	<0.1	<0.1	0.2	<0.1	0.3
Chrysene	mg/kg	<0.1	<0.1	0.3	<0.1	0.3
Benzo(b,j+k)fluoranthene	mg/kg	<0.2	<0.2	0.3	<0.2	<0.2
Benzo(a)pyrene	mg/kg	<0.05	<0.05	0.1	<0.05	<0.05
Indeno(1,2,3-c,d)pyrene	mg/kg	<0.1	<0.1	0.3	<0.1	<0.1
Dibenzo(a,h)anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	mg/kg	<0.1	<0.1	0.3	<0.1	<0.1
Benzo(a)pyrene TEQ calc (zero)	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ calc(half)	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Total Positive PAHs	mg/kg	NIL (+)VE	NIL (+)VE	2.7	NIL (+)VE	2.1
Surrogate p-Terphenyl-d14	%	92	88	93	93	90

PAHs in Soil Our Reference: Your Reference Depth Type of sample	UNITS ------------- ------------	143383-6 206 0.2-0.5 soil	143383-7 208 0.2-0.4 soil	143383-8 208 1.0-1.1 soil	143383-9 203 0.2-0.4 soil	143383-10 207 0.2-0.4 soil
Date extracted	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Date analysed	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Naphthalene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	mg/kg	<0.1	0.5	<0.1	<0.1	<0.1
Pyrene	mg/kg	<0.1	0.4	<0.1	<0.1	<0.1
Benzo(a)anthracene	mg/kg	<0.1	0.5	<0.1	<0.1	<0.1
Chrysene	mg/kg	<0.1	0.5	<0.1	<0.1	<0.1
Benzo(b,j+k)fluoranthene	mg/kg	<0.2	0.8	<0.2	<0.2	<0.2
Benzo(a)pyrene	mg/kg	<0.05	0.5	<0.05	<0.05	<0.05
Indeno(1,2,3-c,d)pyrene	mg/kg	<0.1	0.7	0.1	<0.1	<0.1
Dibenzo(a,h)anthracene	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	mg/kg	<0.1	0.7	0.1	<0.1	<0.1
Benzo(a)pyrene TEQ calc (zero)	mg/kg	<0.5	0.7	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ calc(half)	mg/kg	<0.5	0.7	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	<0.5	0.8	<0.5	<0.5	<0.5
Total Positive PAHs	mg/kg	NIL (+)VE	4.5	0.22	NIL (+)VE	NIL (+)VE
Surrogate p-Terphenyl-d14	%	91	93	90	106	81

PAHs in Soil			
Our Reference:	UNITS	143383-11	143383-12
Your Reference	------------- -	201	203
Depth	------------	0.4-0.6	0.7-0.9
Type of sample		soil	soil
Date extracted	-	17/03/2016	17/03/2016
Date analysed	-	17/03/2016	17/03/2016
Naphthalene	mg/kg	<0.1	<0.1
Acenaphthylene	mg/kg	<0.1	<0.1
Acenaphthene	mg/kg	<0.1	<0.1
Fluorene	mg/kg	<0.1	<0.1
Phenanthrene	mg/kg	<0.1	<0.1
Anthracene	mg/kg	<0.1	<0.1
Fluoranthene	mg/kg	<0.1	<0.1
Pyrene	mg/kg	<0.1	<0.1
Benzo(a)anthracene	mg/kg	<0.1	<0.1
Chrysene	mg/kg	<0.1	<0.1
Benzo(b,j+k)fluoranthene	mg/kg	<0.2	<0.2
Benzo(a)pyrene	mg/kg	<0.05	<0.05
Indeno(1,2,3-c,d)pyrene	mg/kg	<0.1	<0.1
Dibenzo(a,h)anthracene	mg/kg	<0.1	<0.1
Benzo(g,h,i)perylene	mg/kg	<0.1	<0.1
Benzo(a)pyrene TEQ calc (zero)	mg/kg	<0.5	<0.5
Benzo(a)pyrene TEQ calc(half)	mg/kg	<0.5	<0.5
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	<0.5	<0.5
Total Positive PAHs	mg/kg	NIL (+)VE	NIL (+)VE
Surrogate p-Terphenyl-d14	%	94	102

Organochlorine Pesticides in soil Our Reference: Your Reference Depth Type of sample	UNITS ------------- ------------	143383-1 202 0.2-0.5 soil	143383-2 202 1.0-1.2 soil	143383-3 205 0.1-0.25 soil	143383-4 205 0.3-0.5 soil	143383-5 206 0.05-0.2 soil
Date extracted	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Date analysed	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
HCB	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
beta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
delta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor Epoxide	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-Chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan I	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDE	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Dieldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDD	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan II	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDT	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin Aldehyde	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan Sulphate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Methoxychlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate TCMX	%	95	113	96	108	83

Organochlorine Pesticides in soil						
Our Reference:	UNITS	143383-6	143383-7	143383-8	143383-9	143383-10
Your Reference	-------------	206	208	208	203	207
Depth	------------	0.2-0.5	0.2-0.4	1.0-1.1	0.2-0.4	0.2-0.4
Type of sample		soil	soil	soil	soil	soil
Date extracted	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Date analysed	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
HCB	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
beta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
delta-BHC	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Heptachlor Epoxide	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
gamma-Chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
alpha-chlordane	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan I	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDE	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Dieldrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDD	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan II	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
pp-DDT	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin Aldehyde	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Endosulfan Sulphate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Methoxychlor	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate TCMX	%	93	98	108	88	95

Organochlorine Pesticides in soil Our Reference: Your Reference Depth Type of sample	UNITS ------------- ------------	143383-12 203 0.7-0.9 soil
Date extracted	-	17/03/2016
Date analysed	-	17/03/2016
HCB	mg/kg	<0.1
alpha-BHC	mg/kg	<0.1
gamma-BHC	mg/kg	<0.1
beta-BHC	mg/kg	<0.1
Heptachlor	mg/kg	<0.1
delta-BHC	mg/kg	<0.1
Aldrin	mg/kg	<0.1
Heptachlor Epoxide	mg/kg	<0.1
gamma-Chlordane	mg/kg	<0.1
alpha-chlordane	mg/kg	<0.1
Endosulfan I	mg/kg	<0.1
pp-DDE	mg/kg	<0.1
Dieldrin	mg/kg	<0.1
Endrin	mg/kg	<0.1
pp-DDD	mg/kg	<0.1
Endosulfan II	mg/kg	<0.1
pp-DDT	mg/kg	<0.1
Endrin Aldehyde	mg/kg	<0.1
Endosulfan Sulphate	mg/kg	<0.1
Methoxychlor	mg/kg	<0.1
Surrogate TCMX	%	95

Organophosphorus Pesticides Our Reference: Your Reference Depth Type of sample	UNITS ------------ - ------------	143383-1 202 0.2-0.5 soil	143383-2 202 1.0-1.2 soil	143383-3 205 0.1-0.25 soil	143383-4 205 0.3-0.5 soil	143383-5 206 0.05-0.2 soil
Date extracted	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Date analysed	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Azinphos-methyl (Guthion)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Bromophos-ethyl	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chlorpyriphos	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chlorpyriphos-methyl	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Diazinon	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Dichlorvos	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Dimethoate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Ethion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fenitrothion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Malathion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Parathion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Ronnel	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate TCMX	%	95	113	96	108	83

Organophosphorus Pesticides Our Reference: Your Reference Depth Type of sample	UNITS ------------ - ------------	143383-6 206 0.2-0.5 soil	143383-7 208 0.2-0.4 soil	143383-8 208 1.0-1.1 soil	143383-9 203 0.2-0.4 soil	143383-10 207 0.2-0.4 soil
Date extracted	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Date analysed	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Azinphos-methyl (Guthion)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Bromophos-ethyl	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chlorpyriphos	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chlorpyriphos-methyl	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Diazinon	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Dichlorvos	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Dimethoate	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Ethion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Fenitrothion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Malathion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Parathion	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Ronnel	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate TCMX	%	93	95	108	88	95

Organophosphorus Pesticides		
Our Reference:	UNITS	143383-12
Your Reference	------------- -	203
Depth	------------	0.7-0.9
Type of sample		soil
Date extracted	-	17/03/2016
Date analysed	-	17/03/2016
Azinphos-methyl (Guthion)	mg/kg	<0.1
Bromophos-ethyl	mg/kg	<0.1
Chlorpyriphos	mg/kg	<0.1
Chlorpyriphos-methyl	mg/kg	<0.1
Diazinon	mg/kg	<0.1
Dichlorvos	mg/kg	<0.1
Dimethoate	mg/kg	<0.1
Ethion	mg/kg	<0.1
Fenitrothion	mg/kg	<0.1
Malathion	mg/kg	<0.1
Parathion	mg/kg	<0.1
Ronnel	mg/kg	<0.1
Surrogate TCMX	%	95

PCBs in Soil						
Our Reference:	UNITS	143383-1	143383-2	143383-3	143383-4	143383-5
Your Reference	-------------	202	202	205	205	206
Depth	------------	0.2-0.5	1.0-1.2	0.1-0.25	0.3-0.5	0.05-0.2
Type of sample		soil	soil	soil	soil	soil
Date extracted	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Date analysed	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Aroclor 1016	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1221	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1232	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1242	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1248	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1254	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1260	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate TCLMX	%	95	113	96	108	83

PCBs in Soil						
Our Reference:	UNITS	143383-6	143383-7	143383-8	143383-9	143383-10
Your Reference	-------------	206	208	208	203	207
Depth	------------	0.2-0.5	0.2-0.4	1.0-1.1	0.2-0.4	0.2-0.4
Type of sample		soil	soil	soil	soil	soil
Date extracted	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Date analysed	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Aroclor 1016	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1221	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1232	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1242	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1248	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1254	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Aroclor 1260	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate TCLMX	%	93	95	108	88	95

PCBs in Soil		
Our Reference:	UNITS	143383-12
Your Reference	-------------	203
Depth	------------	0.7-0.9
Type of sample		soil
Date extracted	-	17/03/2016
Date analysed	-	17/03/2016
Aroclor 1016	mg/kg	<0.1
Aroclor 1221	mg/kg	<0.1
Aroclor 1232	mg/kg	<0.1
Aroclor 1242	mg/kg	<0.1
Aroclor 1248	mg/kg	<0.1
Aroclor 1254	mg/kg	<0.1
Aroclor 1260	mg/kg	<0.1
Surrogate TCLMX	%	95

Acid Extractable metals in soil						
Our Reference:	UNITS	143383-1	143383-2	143383-3	143383-4	143383-5
Your Reference	-------------	202	202	205	205	206
Depth	------------	0.2-0.5	1.0-1.2	0.1-0.25	0.3-0.5	0.05-0.2
Type of sample		soil	soil	soil	soil	soil
Date prepared	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Date analysed	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Arsenic	mg/kg	5	<4	<4	<4	22
Cadmium	mg/kg	<0.4	<0.4	<0.4	<0.4	<0.4
Chromium	mg/kg	9	6	6	6	3
Copper	mg/kg	5	1	3	3	13
Lead	mg/kg	40	5	14	40	19
Mercury	mg/kg	<0.1	<0.1	<0.1	<0.1	0.2
Nickel	mg/kg	5	2	1	2	5
Zinc	mg/kg	51	5	19	61	26

Acid Extractable metals in soil						
Our Reference:	UNITS	143383-6	143383-7	143383-8	143383-9	143383-10
Your Reference	-------------	206	208	208	203	207
Depth	------------	0.2-0.5	0.2-0.4	1.0-1.1	0.2-0.4	0.2-0.4
Type of sample		soil	soil	soil	soil	soil
Date prepared	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Date analysed	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Arsenic	mg/kg	<4	5	<4	<4	<4
Cadmium	mg/kg	<0.4	<0.4	<0.4	<0.4	<0.4
Chromium	mg/kg	7	11	10	8	9
Copper	mg/kg	2	9	6	1	1
Lead	mg/kg	5	23	15	4	5
Mercury	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	mg/kg	2	5	4	2	2
Zinc	mg/kg	9	47	45	6	4

Acid Extractable metals in soil			
Our Reference:	UNITS	143383-11	143383-12
Your Reference	-------------	201	203
Depth	------------	0.4-0.6	0.7-0.9
Type of sample		soil	soil
Date prepared	-	17/03/2016	17/03/2016
Date analysed	-	17/03/2016	17/03/2016
Arsenic	mg/kg	<4	<4
Cadmium	mg/kg	<0.4	<0.4
Chromium	mg/kg	7	9
Copper	mg/kg	<1	<1
Lead	mg/kg	3	3
Mercury	mg/kg	<0.1	<0.1
Nickel	mg/kg	2	2
Zinc	mg/kg	2	2

Moisture Our Reference: Your Reference Depth Type of sample	UNITS ------------- ------------	143383-1 202 0.2-0.5 soil	143383-2 202 1.0-1.2 soil	143383-3 205 0.1-0.25 soil	143383-4 205 0.3-0.5 soil	143383-5 206 0.05-0.2 soil
Date prepared	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Date analysed	-	18/03/2016	18/03/2016	18/03/2016	18/03/2016	18/03/2016
Moisture	%	4.7	7.2	13	7.9	12

Moisture Our Reference: Your Reference Depth Type of sample	UNITS ------------- ------------	143383-6 206 0.2-0.5 soil	143383-7 208 0.2-0.4 soil	143383-8 208 1.0-1.1 soil	143383-9 203 0.2-0.4 soil	143383-10 207 0.2-0.4 soil
Date prepared	-	17/03/2016	17/03/2016	17/03/2016	17/03/2016	17/03/2016
Date analysed	-	18/03/2016	18/03/2016	18/03/2016	18/03/2016	18/03/2016
Moisture	%	8.2	6.1	9.9	14	4.4

Moisture Our Reference: Your Reference Depth Type of sample	UNITS ------------- ------------	143383-11 201 0.4-0.6 soil	143383-12 203 0.7-0.9 soil
Date prepared	-	17/03/2016	17/03/2016
Date analysed	-	18/03/2016	18/03/2016
Moisture	%	9.1	13

Method ID	Methodology Summary
Org-016	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater.
Org-014	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS.
Org-003	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis.
Org-012	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013. For soil results:- 1. 'TEQ PQL' values are assuming all contributing PAHs reported as <PQL are actually at the PQL. This is the most conservative approach and can give false positive TEQs given that PAHs that contribute to the TEQ calculation may not be present. 2. 'TEQ zero' values are assuming all contributing PAHs reported as <PQL are zero. This is the least conservative approach and is more susceptible to false negative TEQs when PAHs that contribute to the TEQ calculation are present but below PQL. 3. 'TEQ half PQL' values are assuming all contributing PAHs reported as <PQL are half the stipulated PQL. Hence a mid-point between the most and least conservative approaches above. Note, the Total +ve PAHs PQL is reflective of the lowest individual PQL and is therefore" Total +ve PAHs" is simply a sum of the positive individual PAHs.
Org-005	Soil samples are extracted with dichloromethane/acetone and waters with dichloromethane and analysed by GC with dual ECD's.
Org-008	Soil samples are extracted with dichloromethane/acetone and waters with dichloromethane and analysed by GC with dual ECD's.
Org-006	Soil samples are extracted with dichloromethane/acetone and waters with dichloromethane and analysed by GC-ECD.
Metals-020 ICP-AES	Determination of various metals by ICP-AES.
Metals-021 CV-AAS	Determination of Mercury by Cold Vapour AAS.
Inorg-008	Moisture content determined by heating at 105+/-5 deg C for a minimum of 12 hours.

QUALITY CONTROL vTRH(C6-C10)/BTEXN in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			17/03/2016	143383-1	17/03/2016 || 17/03/2016	LCS-2	17/03/2016
Date analysed	-			17/03/2016	143383-1	17/03/2016 || 17/03/2016	LCS-2	17/03/2016
TRHC$_6$ - C$_9$	mg/kg	25	Org-016	<25	143383-1	<25 || <25	LCS-2	96%
TRHC$_6$ - C$_{10}$	mg/kg	25	Org-016	<25	143383-1	<25 || <25	LCS-2	96%
Benzene	mg/kg	0.2	Org-016	<0.2	143383-1	<0.2 || <0.2	LCS-2	93%
Toluene	mg/kg	0.5	Org-016	<0.5	143383-1	<0.5 || <0.5	LCS-2	87%
Ethylbenzene	mg/kg	1	Org-016	<1	143383-1	<1 || <1	LCS-2	95%
m+p-xylene	mg/kg	2	Org-016	<2	143383-1	<2 || <2	LCS-2	103%
o-Xylene	mg/kg	1	Org-016	<1	143383-1	<1 || <1	LCS-2	98%
naphthalene	mg/kg	1	Org-014	<1	143383-1	<1 || <1	[NR]	[NR]
Surrogate aaa-Trifluorotoluene	%		Org-016	97	143383-1	100 || 94 || RPD: 6	LCS-2	94%

QUALITY CONTROL svTRH (C10-C40) in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			17/03/2016	143383-1	17/03/2016 || 17/03/2016	LCS-2	17/03/2016
Date analysed	-			17/03/2016	143383-1	17/03/2016 || 17/03/2016	LCS-2	17/03/2016
TRHC$_{10}$ - C$_{14}$	mg/kg	50	Org-003	<50	143383-1	<50 || <50	LCS-2	106%
TRHC$_{15}$ - C$_{28}$	mg/kg	100	Org-003	<100	143383-1	<100 || <100	LCS-2	99%
TRHC$_{29}$ - C$_{36}$	mg/kg	100	Org-003	<100	143383-1	<100 || <100	LCS-2	88%
TRH>C$_{10}$-C$_{16}$	mg/kg	50	Org-003	<50	143383-1	<50 || <50	LCS-2	106%
TRH>C$_{16}$-C$_{34}$	mg/kg	100	Org-003	<100	143383-1	<100 || <100	LCS-2	99%
TRH>C$_{34}$-C$_{40}$	mg/kg	100	Org-003	<100	143383-1	<100 || <100	LCS-2	88%
Surrogate o-Terphenyl	%		Org-003	85	143383-1	84 || 84 || RPD: 0	LCS-2	93%

QUALITY CONTROL PAHs in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			17/03/2016	143383-1	17/03/2016 || 17/03/2016	LCS-2	17/03/2016
Date analysed	-			17/03/2016	143383-1	17/03/2016 || 17/03/2016	LCS-2	17/03/2016
Naphthalene	mg/kg	0.1	Org-012	<0.1	143383-1	<0.1 || <0.1	LCS-2	97%
Acenaphthylene	mg/kg	0.1	Org-012	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Acenaphthene	mg/kg	0.1	Org-012	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Fluorene	mg/kg	0.1	Org-012	<0.1	143383-1	<0.1 || <0.1	LCS-2	104%
Phenanthrene	mg/kg	0.1	Org-012	<0.1	143383-1	<0.1 || <0.1	LCS-2	113%
Anthracene	mg/kg	0.1	Org-012	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Fluoranthene	mg/kg	0.1	Org-012	<0.1	143383-1	<0.1 || <0.1	LCS-2	93%
Pyrene	mg/kg	0.1	Org-012	<0.1	143383-1	<0.1 || <0.1	LCS-2	96%
Benzo(a)anthracene	mg/kg	0.1	Org-012	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Chrysene	mg/kg	0.1	Org-012	<0.1	143383-1	<0.1 || <0.1	LCS-2	98%
Benzo(b,j +k)fluoranthene	mg/kg	0.2	Org-012	<0.2	143383-1	<0.2 || <0.2	[NR]	[NR]

QUALITY CONTROL PAHs in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Benzo(a)pyrene	mg/kg	0.05	Org-012	<0.05	143383-1	<0.05 || <0.05	LCS-2	92%
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	Org-012	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Dibenzo(a,h)anthracene	mg/kg	0.1	Org-012	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Benzo(g,h,i)perylene	mg/kg	0.1	Org-012	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Surrogate p-Terphenyl-d14	%		Org-012	94	143383-1	92 || 91 || RPD: 1	LCS-2	106%

QUALITY CONTROL Organochlorine Pesticides in soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			17/03/2016	143383-1	17/03/2016 || 17/03/2016	LCS-2	17/03/2016
Date analysed	-			17/03/2016	143383-1	17/03/2016 || 17/03/2016	LCS-2	17/03/2016
HCB	mg/kg	0.1	Org-005	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
alpha-BHC	mg/kg	0.1	Org-005	<0.1	143383-1	<0.1 || <0.1	LCS-2	94%
gamma-BHC	mg/kg	0.1	Org-005	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
beta-BHC	mg/kg	0.1	Org-005	<0.1	143383-1	<0.1 || <0.1	LCS-2	93%
Heptachlor	mg/kg	0.1	Org-005	<0.1	143383-1	<0.1 || <0.1	LCS-2	111%
delta-BHC	mg/kg	0.1	Org-005	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Aldrin	mg/kg	0.1	Org-005	<0.1	143383-1	<0.1 || <0.1	LCS-2	105%
Heptachlor Epoxide	mg/kg	0.1	Org-005	<0.1	143383-1	<0.1 || <0.1	LCS-2	103%
gamma-Chlordane	mg/kg	0.1	Org-005	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
alpha-chlordane	mg/kg	0.1	Org-005	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Endosulfan I	mg/kg	0.1	Org-005	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
pp-DDE	mg/kg	0.1	Org-005	<0.1	143383-1	<0.1 || <0.1	LCS-2	100%
Dieldrin	mg/kg	0.1	Org-005	<0.1	143383-1	<0.1 || <0.1	LCS-2	107%
Endrin	mg/kg	0.1	Org-005	<0.1	143383-1	<0.1 || <0.1	LCS-2	108%
pp-DDD	mg/kg	0.1	Org-005	<0.1	143383-1	<0.1 || <0.1	LCS-2	100%
Endosulfan II	mg/kg	0.1	Org-005	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
pp-DDT	mg/kg	0.1	Org-005	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Endrin Aldehyde	mg/kg	0.1	Org-005	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Endosulfan Sulphate	mg/kg	0.1	Org-005	<0.1	143383-1	<0.1 || <0.1	LCS-2	100%
Methoxychlor	mg/kg	0.1	Org-005	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Surrogate TCMX	%		Org-005	95	143383-1	95 || 101 || RPD: 6	LCS-2	112%

QUALITY CONTROL Organophosphorus Pesticides	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			17/03/2016	143383-1	17/03/2016 || 17/03/2016	LCS-2	17/03/2016
Date analysed	-			17/03/2016	143383-1	17/03/2016 || 17/03/2016	LCS-2	17/03/2016
Azinphos-methyl (Guthion)	mg/kg	0.1	Org-008	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Bromophos-ethyl	mg/kg	0.1	Org-008	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Chlorpyriphos	mg/kg	0.1	Org-008	<0.1	143383-1	<0.1 || <0.1	LCS-2	99%
Chlorpyriphos-methyl	mg/kg	0.1	Org-008	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Diazinon	mg/kg	0.1	Org-008	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Dichlorvos	mg/kg	0.1	Org-008	<0.1	143383-1	<0.1 || <0.1	LCS-2	83%
Dimethoate	mg/kg	0.1	Org-008	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Ethion	mg/kg	0.1	Org-008	<0.1	143383-1	<0.1 || <0.1	LCS-2	96%
Fenitrothion	mg/kg	0.1	Org-008	<0.1	143383-1	<0.1 || <0.1	LCS-2	89%
Malathion	mg/kg	0.1	Org-008	<0.1	143383-1	<0.1 || <0.1	LCS-2	79%
Parathion	mg/kg	0.1	Org-008	<0.1	143383-1	<0.1 || <0.1	LCS-2	103%
Ronnel	mg/kg	0.1	Org-008	<0.1	143383-1	<0.1 || <0.1	LCS-2	108%
Surrogate TCMX	%		Org-008	95	143383-1	95 || 101 || RPD: 6	LCS-2	94%

QUALITY CONTROL PCBs in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			17/03/2016	143383-1	17/03/2016 || 17/03/2016	LCS-2	17/03/2016
Date analysed	-			17/03/2016	143383-1	17/03/2016 || 17/03/2016	LCS-2	17/03/2016
Aroclor 1016	mg/kg	0.1	Org-006	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Aroclor 1221	mg/kg	0.1	Org-006	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Aroclor 1232	mg/kg	0.1	Org-006	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Aroclor 1242	mg/kg	0.1	Org-006	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Aroclor 1248	mg/kg	0.1	Org-006	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Aroclor 1254	mg/kg	0.1	Org-006	<0.1	143383-1	<0.1 || <0.1	LCS-2	100%
Aroclor 1260	mg/kg	0.1	Org-006	<0.1	143383-1	<0.1 || <0.1	[NR]	[NR]
Surrogate TCLMX	%		Org-006	95	143383-1	95 || 101 || RPD: 6	LCS-2	94%

QUALITY CONTROL Acid Extractable metals in soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			17/03/2016	143383-1	17/03/2016 || 17/03/2016	LCS-3	17/03/2016
Date analysed	-			17/03/2016	143383-1	17/03/2016 || 17/03/2016	LCS-3	17/03/2016
Arsenic	mg/kg	4	Metals-020 ICP-AES	<4	143383-1	5 || 4 || RPD: 22	LCS-3	107%
Cadmium	mg/kg	0.4	Metals-020 ICP-AES	<0.4	143383-1	<0.4 || <0.4	LCS-3	106%
Chromium	mg/kg	1	Metals-020 ICP-AES	<1	143383-1	9 || 8 || RPD: 12	LCS-3	107%
Copper	mg/kg	1	Metals-020 ICP-AES	<1	143383-1	5 || 6 || RPD: 18	LCS-3	108%
Lead	mg/kg	1	Metals-020 ICP-AES	<1	143383-1	40 || 40 || RPD: 0	LCS-3	103%
Mercury	mg/kg	0.1	Metals-021 CV-AAS	<0.1	143383-1	<0.1 || <0.1	LCS-3	94%
Nickel	mg/kg	1	Metals-020 ICP-AES	<1	143383-1	5 || 5 || RPD: 0	LCS-3	99%
Zinc	mg/kg	1	Metals-020 ICP-AES	<1	143383-1	51 || 45 || RPD: 12	LCS-3	99%

QUALITY CONTROL vTRH(C6-C10)/BTEXN in Soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date extracted	-	143383-12	17/03/2016 || 17/03/2016	143383-2	17/03/2016
Date analysed	-	143383-12	17/03/2016 || 17/03/2016	143383-2	17/03/2016
TRHC $_6$ - C $_9$	mg/kg	143383-12	<25 || <25	143383-2	102%
TRHC $_6$ - C $_{10}$	mg/kg	143383-12	<25 || <25	143383-2	102%
Benzene	mg/kg	143383-12	<0.2 || <0.2	143383-2	97%
Toluene	mg/kg	143383-12	<0.5 || <0.5	143383-2	90%
Ethylbenzene	mg/kg	143383-12	<1 || <1	143383-2	103%
m+p-xylene	mg/kg	143383-12	<2 || <2	143383-2	111%
o-Xylene	mg/kg	143383-12	<1 || <1	143383-2	107%
naphthalene	mg/kg	143383-12	<1 || <1	[NR]	[NR]
Surrogate aaa-Trifluorotoluene	%	143383-12	97 || 92 || RPD: 5	143383-2	98%

QUALITY CONTROL svTRH (C10-C40) in Soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date extracted	-	143383-12	17/03/2016 || 17/03/2016	143383-2	17/03/2016
Date analysed	-	143383-12	17/03/2016 || 17/03/2016	143383-2	17/03/2016
TRHC $_{10}$ - C $_{14}$	mg/kg	143383-12	<50 || <50	143383-2	100%
TRHC $_{15}$ - C $_{28}$	mg/kg	143383-12	<100 || <100	143383-2	93%
TRHC $_{29}$ - C $_{36}$	mg/kg	143383-12	<100 || <100	143383-2	92%
TRH>C $_{10}$-C $_{16}$	mg/kg	143383-12	<50 || <50	143383-2	100%
TRH>C $_{16}$-C $_{34}$	mg/kg	143383-12	<100 || <100	143383-2	93%
TRH>C $_{34}$-C $_{40}$	mg/kg	143383-12	<100 || <100	143383-2	92%
Surrogate o-Terphenyl	%	143383-12	79 || 79 || RPD: 0	143383-2	82%

QUALITY CONTROL PAHs in Soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date extracted	-	143383-12	17/03/2016 || 17/03/2016	143383-2	17/03/2016
Date analysed	-	143383-12	17/03/2016 || 17/03/2016	143383-2	17/03/2016
Naphthalene	mg/kg	143383-12	<0.1 || <0.1	143383-2	98%
Acenaphthylene	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Acenaphthene	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Fluorene	mg/kg	143383-12	<0.1 || <0.1	143383-2	127%
Phenanthrene	mg/kg	143383-12	<0.1 || <0.1	143383-2	107%
Anthracene	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Fluoranthene	mg/kg	143383-12	<0.1 || <0.1	143383-2	90%
Pyrene	mg/kg	143383-12	<0.1 || <0.1	143383-2	94%
Benzo(a)anthracene	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Chrysene	mg/kg	143383-12	<0.1 || <0.1	143383-2	93%
Benzo(b,j+k)fluoranthene	mg/kg	143383-12	<0.2 || <0.2	[NR]	[NR]
Benzo(a)pyrene	mg/kg	143383-12	<0.05 || <0.05	143383-2	86%
Indeno(1,2,3-c,d)pyrene	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Dibenzo(a,h)anthracene	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Benzo(g,h,i)perylene	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Surrogate p-Terphenyl-d14	%	143383-12	102 || 106 || RPD: 4	143383-2	111%

QUALITY CONTROL Organochlorine Pesticides in soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date extracted	-	143383-12	17/03/2016 || 17/03/2016	143383-2	17/03/2016
Date analysed	-	143383-12	17/03/2016 || 17/03/2016	143383-2	17/03/2016
HCB	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
alpha-BHC	mg/kg	143383-12	<0.1 || <0.1	143383-2	98%
gamma-BHC	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
beta-BHC	mg/kg	143383-12	<0.1 || <0.1	143383-2	94%
Heptachlor	mg/kg	143383-12	<0.1 || <0.1	143383-2	111%
delta-BHC	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Aldrin	mg/kg	143383-12	<0.1 || <0.1	143383-2	106%
Heptachlor Epoxide	mg/kg	143383-12	<0.1 || <0.1	143383-2	103%
gamma-Chlordane	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
alpha-chlordane	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Endosulfan I	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
pp-DDE	mg/kg	143383-12	<0.1 || <0.1	143383-2	103%
Dieldrin	mg/kg	143383-12	<0.1 || <0.1	143383-2	109%
Endrin	mg/kg	143383-12	<0.1 || <0.1	143383-2	108%
pp-DDD	mg/kg	143383-12	<0.1 || <0.1	143383-2	100%
Endosulfan II	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
pp-DDT	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Endrin Aldehyde	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Endosulfan Sulphate	mg/kg	143383-12	<0.1 || <0.1	143383-2	102%
Methoxychlor	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Surrogate TCMX	%	143383-12	95 || 90 || RPD: 5	143383-2	116%

QUALITY CONTROL Organophosphorus Pesticides	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date extracted	-	143383-12	17/03/2016 || 17/03/2016	143383-2	17/03/2016
Date analysed	-	143383-12	17/03/2016 || 17/03/2016	143383-2	17/03/2016
Azinphos-methyl (Guthion)	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Bromophos-ethyl	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Chlorpyriphos	mg/kg	143383-12	<0.1 || <0.1	143383-2	99%
Chlorpyriphos-methyl	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Diazinon	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Dichlorvos	mg/kg	143383-12	<0.1 || <0.1	143383-2	95%
Dimethoate	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Ethion	mg/kg	143383-12	<0.1 || <0.1	143383-2	107%
Fenitrothion	mg/kg	143383-12	<0.1 || <0.1	143383-2	89%
Malathion	mg/kg	143383-12	<0.1 || <0.1	143383-2	75%
Parathion	mg/kg	143383-12	<0.1 || <0.1	143383-2	94%
Ronnel	mg/kg	143383-12	<0.1 || <0.1	143383-2	108%
Surrogate TCMX	%	143383-12	95 || 90 || RPD: 5	143383-2	94%

QUALITY CONTROL PCBs in Soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date extracted	-	143383-12	17/03/2016 || 17/03/2016	143383-2	17/03/2016
Date analysed	-	143383-12	17/03/2016 || 17/03/2016	143383-2	17/03/2016
Aroclor 1016	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Aroclor 1221	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Aroclor 1232	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Aroclor 1242	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Aroclor 1248	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Aroclor 1254	mg/kg	143383-12	<0.1 || <0.1	143383-2	99%
Aroclor 1260	mg/kg	143383-12	<0.1 || <0.1	[NR]	[NR]
Surrogate TCLMX	%	143383-12	95 || 90 || RPD: 5	143383-2	94%

QUALITY CONTROL Acid Extractable metals in soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	143383-12	17/03/2016 || 17/03/2016	143383-2	17/03/2016
Date analysed	-	143383-12	17/03/2016 || 17/03/2016	143383-2	17/03/2016
Arsenic	mg/kg	143383-12	<4 || <4	143383-2	93%
Cadmium	mg/kg	143383-12	<0.4 || <0.4	143383-2	106%
Chromium	mg/kg	143383-12	9 || 12 || RPD: 29	143383-2	106%
Copper	mg/kg	143383-12	<1 || <1	143383-2	108%
Lead	mg/kg	143383-12	3 || 4 || RPD: 29	143383-2	100%
Mercury	mg/kg	143383-12	<0.1 || <0.1	143383-2	89%
Nickel	mg/kg	143383-12	2 || 2 || RPD: 0	143383-2	100%
Zinc	mg/kg	143383-12	2 || 2 || RPD: 0	143383-2	98%

Report Comments:

Asbestos ID was analysed by Approved Identifier:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job

INS: Insufficient sample for this test	PQL: Practical Quantitation Limit	NT: Not tested
NR: Test not required	RPD: Relative Percent Difference	NA: Test not required
<: Less than	>: Greater than	LCS: Laboratory Control Sample

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

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CHAIN OF CUSTODY DESPATCH SHEET (1)

Project: Morpeth, Closebourne, Stage 5, site class and waste class	**To:** Envirolab.
Project No: 81251.10	
DP Contact Person:	**Ph:**
Prior Storage: Esky ☐ Fridge ☑ Shelved ☐	**Attn:** Jacinta Hurst

Do samples contain HBM? Yes ☐ No ☐ (If YES, then handle, transport and store in accordance with FPM HAZID)

Sample			Inorganics								Organics						
Sample ID	Type S-soil W-water	Lab ID	As	Cd	Cr	Cu	Pb	Hg	Zn	Other	Total / GS/MS Phenol	BTEX/ TPH	OCs/ OPs/ PCBs	PAHs	Other	TCLP	Notes
✓ 202/0.2-0.5	S.	1	●	●	●	●	●	●	●	Ni		●	●	●			Combination 6
✓ 202/1.0-1.2	S	2	●	●	●	●	●	●	●	Ni		●	●	●			Combination 6
✓ 205/0.1-0.25	S	3	●	●	●	●	●	●	●	Ni		●	●	●			Combination 6
✓ 205/03-05	S	4	●	●	●	●	●	●	●	Ni		●	●	●			Combination 6
✓ 206/005-02	S.	5	●	●	●	●	●	●	●	Ni		●	●	●			Combination 6
✓ 206/0.2-05	S	6	●	●	●	●	●	●	●	Ni		●	●	●			Combination 6
✓ 208/0.2-0.4	S	7	●	●	●	●	●	●	●	Ni		●	●	●			Combination 6
✓ 208/1.0-1.1	S	8	●	●	●	●	●	●	●	Ni		●	●	●			Combination 6
✓ 203/0.2-0.4	S	9	●	●	●	●	●	●	●	Ni		●	●	●			Combination 6
PQL (S)	mg/kg		0.05	1	5	3	5	0.01	5		0.5/*	*	*	*		-	
PQL (W) (mg/L)	ANZECC PQLs req'd for all water parameters ☐										0.05/*	*	*	*		-	

PQL = practical quantitation limit, *As per Laboratory Method Detection Limit

Total number of samples in container: ....

Date relinquished: ....

Relinquished by (signature) ....

Results required by: ....

☐ 24 hours ☐ 48 hours ☐ 72 hours ☐ Standard

SAMPLES RECEIVED
Please sign and date to acknowledge receipt of samples and return by fax

Signature: PT

Date: 16/3/16 Lab Ref: 143383

Send results to:
Douglas Partners Pty Ltd
Address:

Fax:

ENVIROLAB GROUP
Envirolab Ser
12 Ashley S
Chatswood NSW 2067
Ph: (02) 9910 6200

Job No: 143383

Date Received: 16/3/16
Time Received: 11:00
Received by: PT
Temp: [✓ Cool]/Ambient
Cooling: Ice/[✓ Icepack]
Security: [✓ Intact]/Broken/None

Douglas Partners
Geotechnics / Environment / Groundwater

CHAIN OF CUSTODY DESPATCH SHEET (1)

Project: Morpeth, Closebourne, Stage 5, site class and waste class
Project No: 81251.10
DP Contact Person:
Prior Storage: Esky ☐ Fridge ☑ Shelved ☐

To: Envirolab
Ph:
Attn: Jacinta Hurst

Do samples contain HBM? Yes ☐ No ☐ (If YES, then handle, transport and store in accordance with FPM HAZID)

Sample			Inorganics								Organics							
Sample ID	Type S-soil W-water	Lab ID	As	Cd	Cr	Cu	Pb	Hg	Zn	Other	Total / GS/MS Phenol	BTEX/ TPH	OCs/ OPs/ PCBs	PAHs	Other	TCLP	Notes
/207/0.2-0.4	S	10	●	●	●	●	●	●	●	Ni		●	●	●			Combination 6
/201/0.4-0.6	S	11	●	●	●	●	●	●	●	Ni				●			Combination 6
/203/0.7-0.9	S	12	●	●	●	●	●	●	●	Ni		●	●	●			Combination 6
PQL (S)	mg/kg		0.05	1	5	3	5	0.01	5		0.5/*	*	*	*		-	
PQL (W) (mg/L)	ANZECC PQLs req'd for all water parameters ☐										0.05/*	*	*	*		-	

PQL = practical quantitation limit, *As per Laboratory Method Detection Limit

Total number of samples in container: ....
Date relinquished: ....
Relinquished by (signature) ....
Results required by: ....
☐ 24 hours ☐ 48 hours ☐ 72 hours ☐ Standard

SAMPLES RECEIVED
Please sign and date to acknowledge receipt of samples and return by fax

Signature: PT
Date: 14/3/16 Lab Ref: 143383

Send results to:
Douglas Partners Pty Ltd
Address:

Fax:

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.envirolabservices.com.au

SAMPLE RECEIPT ADVICE

Client Details	
Client	Douglas Partners Newcastle
Attention	Michael Gawn

Sample Login Details	
Your Reference	81251.10, Morpeth
Envirolab Reference	**143383**
Date Sample Received	16/03/2016
Date Instructions Received	16/03/2016
Date Results Expected to be Reported	**23/03/2016**

Sample Condition	
Samples received in appropriate condition for analysis	YES
No. of Samples Provided	12 soils
Turnaround Time Requested	Standard
Temperature on receipt (°C)	9.9
Cooling Method	Ice
Sampling Date Provided	Not Provided on the COC

Comments
Samples will be held for 1 month for water samples and 2 months for soil samples from date of receipt of samples

Please direct any queries to:

Aileen Hie	**Jacinta Hurst**
Phone: 02 9910 6200	Phone: 02 9910 6200
Fax: 02 9910 6201	Fax: 02 9910 6201
Email: ahie@envirolabservices.com.au	Email: jhurst@envirolabservices.com.au

Sample and Testing Details on following page

Sample Id	*vTRH(C6-C10)/BTEXN in Soil*	*svTRH (C10-C40) in Soil*	*PAHs in Soil*	*Organochlorine Pesticides in soil*	*Organophosphorus Pesticides*	*PCBs in Soil*	*Acid Extractable metals in soil*
202-0.2-0.5	✓	✓	✓	✓	✓	✓	✓
202-1.0-1.2	✓	✓	✓	✓	✓	✓	✓
205-0.1-0.25	✓	✓	✓	✓	✓	✓	✓
205-0.3-0.5	✓	✓	✓	✓	✓	✓	✓
206-0.05-0.2	✓	✓	✓	✓	✓	✓	✓
206-0.2-0.5	✓	✓	✓	✓	✓	✓	✓
208-0.2-0.4	✓	✓	✓	✓	✓	✓	✓
208-1.0-1.1	✓	✓	✓	✓	✓	✓	✓
203-0.2-0.4	✓	✓	✓	✓	✓	✓	✓
207-0.2-0.4	✓	✓	✓	✓	✓	✓	✓
201-0.4-0.6			✓				✓
203-0.7-0.9	✓	✓	✓	✓	✓	✓	✓

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Warabrook NSW 2304
PO Box 324
Hunter Region MC NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Result of Shrink-Swell Index Determination

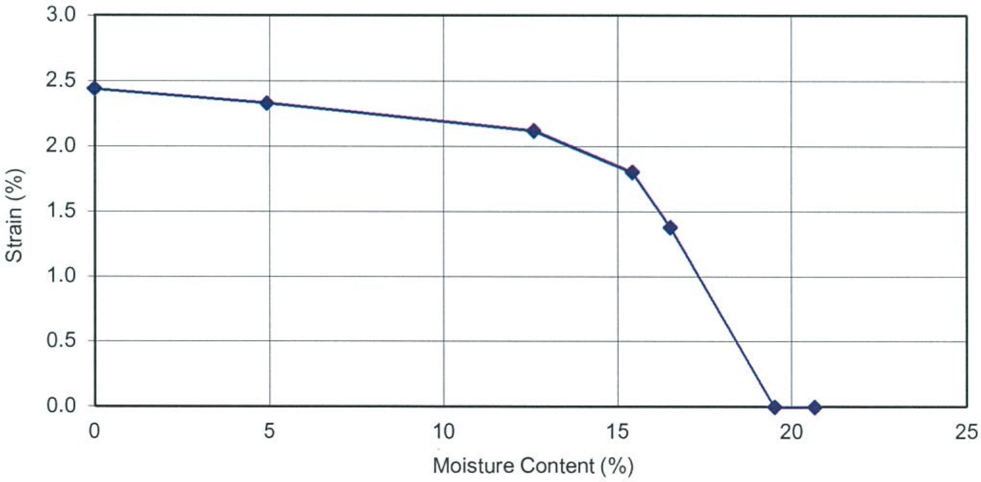
Client :	Lend Lease (Retirement Living)	**Project No. :**	81251.10
		Report No. :	N16-059_1
Project :	Geotechnical & Waste Classification Investigation	**Report Date :**	05.04.2016
		Date Sampled :	09.03.2016
Location :	Proposed Aged Care Facility, Morpeth	**Date of Test:**	16.03.2016
Test Location :	Bore 201		
Depth / Layer :	1.45 - 1.72m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	2.3 %
Shrinkage - oven dried	2.4 %
Significant inert inclusions	0.0 %
Extent of cracking	SC
Extent of soil crumbling	0.0 %
Moisture content of core	19.5 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	>600 kPa
Pocket penetrometer reading at final moisture content	>600 kPa
Initial Moisture Content	19.3 %
Final Moisture Content	20.7 %
Swell under 25kPa	0.0 %



SHRINK-SWELL INDEX Iss 1.4% per Δ pF

Description:	Sandy CLAY - Red grey
Test Method(s):	AS 1289.7.1.1, AS 1289.2.1.1
Sampling Method(s):	Sampled by Newcastle Engineering Department

Extent of Cracking:

UC - Uncracked
SC - Slightly cracked
MC - Moderately cracked
HC - Highly cracked
FR - Fractured

Remarks:

Note that NATA accreditation does not cover
the performance of pocket penetrometer readings

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NATA Accredited Laboratory Number: 828

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Tested:	DR
Checked:	DM

Dave Millard
Laboratory Manager

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Result of Shrink-Swell Index Determination

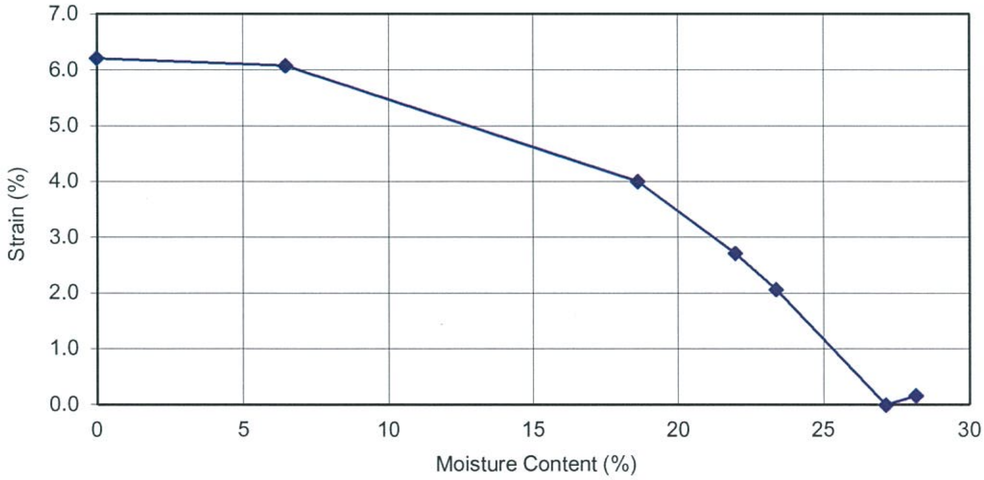
Client :	Lend Lease (Retirement Living)	**Project No. :**	81251.10
		Report No. :	N16-059_2
Project :	Geotechnical & Waste Classification Investigation	**Report Date :**	05.04.2016
		Date Sampled :	09.03.2016
Location :	Proposed Aged Care Facility, Morpeth	**Date of Test:**	16.03.2016
Test Location :	Bore 203		
Depth / Layer :	1.3 - 1.7m	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	6.1 %
Shrinkage - oven dried	6.2 %
Significant inert inclusions	0.0 %
Extent of cracking	SC
Extent of soil crumbling	0.0 %
Moisture content of core	27.1 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	210 kPa
Pocket penetrometer reading at final moisture content	180 kPa
Initial Moisture Content	27.3 %
Final Moisture Content	28.2 %
Swell under 25kPa	-0.2 %



SHRINK-SWELL INDEX Iss 3.4% per Δ pF

Description:	Sandy CLAY - Red brown mottled grey
Test Method(s):	AS 1289.7.1.1, AS 1289.2.1.1
Sampling Method(s):	Sampled by Newcastle Engineering Department

Extent of Cracking:

UC - Uncracked
SC - Slightly cracked
MC - Moderately cracked
HC - Highly cracked
FR - Fractured

Remarks: Slight consolidation

Note that NATA accreditation does not cover
the performance of pocket penetrometer readings

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Checked:	DM

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Laboratory Manager

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Result of Shrink-Swell Index Determination

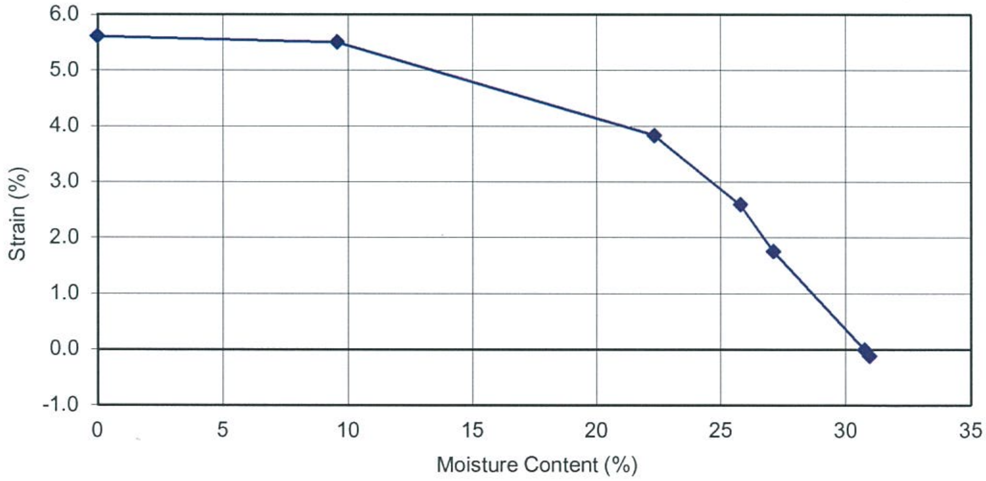
Client : Lend Lease (Retirement Living)
Project No. : 81251.10
Report No. : N16-059_3
Project : Geotechnical & Waste Classification Investigation
Report Date : 05.04.2016
Date Sampled : 09.03.2016
Location : Proposed Aged Care Facility, Morpeth
Date of Test: 16.03.2016
Test Location : Bore 205
Depth / Layer : 1.45 - 1.70m
Page: 1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	5.5 %
Shrinkage - oven dried	5.6 %
Significant inert inclusions	0.0 %
Extent of cracking	SC
Extent of soil crumbling	0.0 %
Moisture content of core	30.8 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	400 kPa
Pocket penetrometer reading at final moisture content	340 kPa
Initial Moisture Content	29.2 %
Final Moisture Content	30.9 %
Swell under 25kPa	0.1 %



SHRINK-SWELL INDEX Iss 3.1% per Δ pF

Description: Sandy CLAY - Brown mottled orange
Test Method(s): AS 1289.7.1.1, AS 1289.2.1.1
Sampling Method(s): Sampled by Newcastle Engineering Department
Extent of Cracking:
UC - Uncracked
SC - Slightly cracked
MC - Moderately cracked
HC - Highly cracked
FR - Fractured

Remarks:

Note that NATA accreditation does not cover
the performance of pocket penetrometer readings

NATA Accredited Laboratory Number: 828

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Tested: DR
Checked: DM

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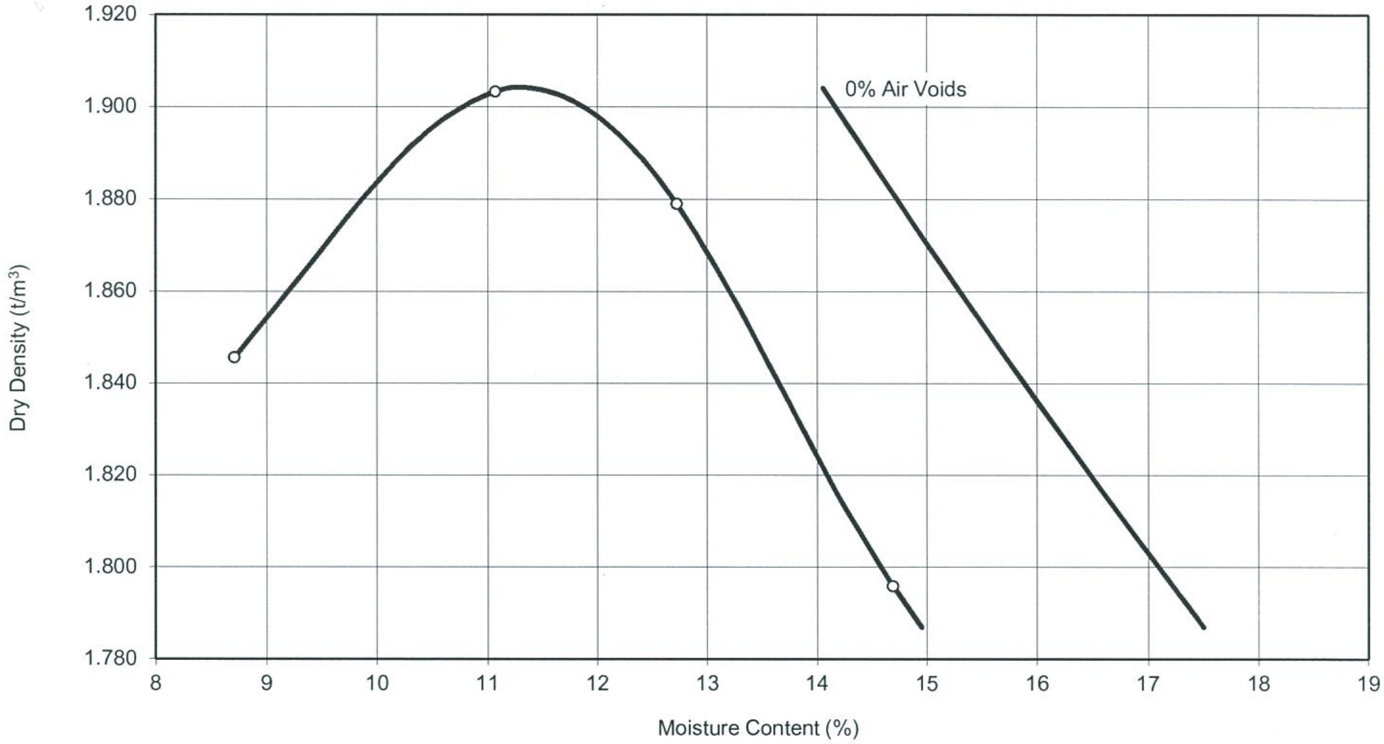
Results of Compaction Test

Client :	Lend Lease (Retirement Living)	**Project No. :**	81251.10
		Report No. :	N16-059_4
Project :	Geotechnical & Waste Classification Investigation	**Report Date :**	05.04.2016
Location :	Proposed Aged Care Facility, Morpeth	**Date of Test:**	21.03.2016
		Page:	1 of 1



Sample Details: **Location:** Pit 209

Depth: 0.4 - 0.6m

Particles > 19mm: 0%

Description: Sandy SILT - Brown

Maximum Dry Density:	**1.90 t/m^3**
Optimum Moisture Content:	**11.5 %**

Remarks:

Test Methods: AS 1289.5.1.1, AS 1289.2.1.1

Sampling Methods: Sampled by DP Engineering Department

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Tested:	AV
Checked:	DM

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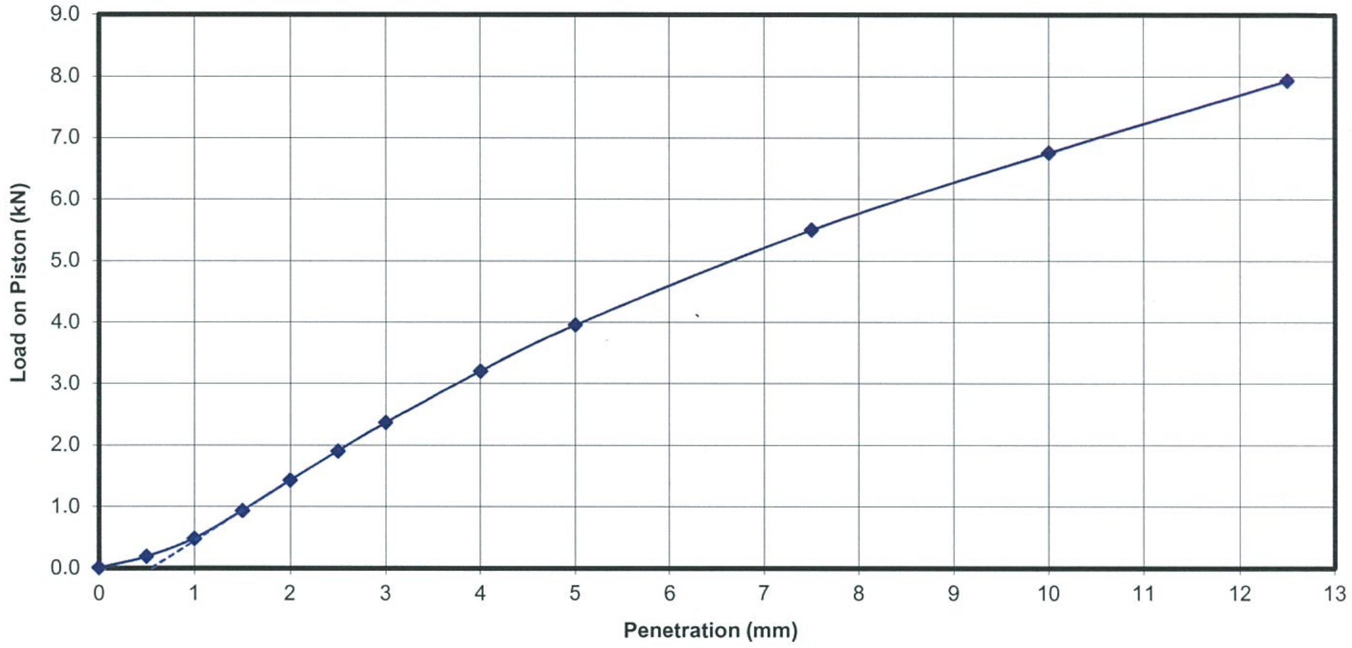
Result of California Bearing Ratio Test

Client :	Lend Lease (Retirement Living)	**Project No. :**	81251.10
		Report No. :	N16-059_5
Project :	Geotechnical & Waste Classification Investigation	**Report Date :**	05.04.2016
		Date Sampled :	09.03.2016
Location :	Proposed Aged Care Facility, Morpeth	**Date of Test:**	04.04.2016
Test Location :	Pit 209		
Depth / Layer :	0.4 - 0.6m	**Page:**	1 of 1



Description: Sandy SILT - Brown

Sampling Method(s): Sampled by DP Engineering Department
Test Method(s): AS 1289.6.1.1, AS 1289.2.1.1

Remarks:

Percentage > 19mm: 0.0%

LEVEL OF COMPACTION: 99.5% of STD MDD
MOISTURE RATIO: 99.5% of STD OMC
SURCHARGE: 4.5 kg
SOAKING PERIOD: 4 days
SWELL: 0.1%

CONDITION		MOISTURE CONTENT %	DRY DENSITY t/m^3
At compaction		11.5	1.89
After soaking		12.9	1.89
After test	Top 30mm of sample	13.5	-
	Remainder of sample	11.8	-
Field values		8.7	-
Standard Compaction	(OMC/MDD)	11.5	1.90

RESULTS		
TYPE	**PENETRATION**	**CBR (%)**
TOP	**5.0mm**	**20**

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ACCREDITED FOR TECHNICAL COMPETENCE

NATA Accredited Laboratory Number: 828

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

Tested:	AV
Checked:	DM

Dave Millard
Laboratory Manager

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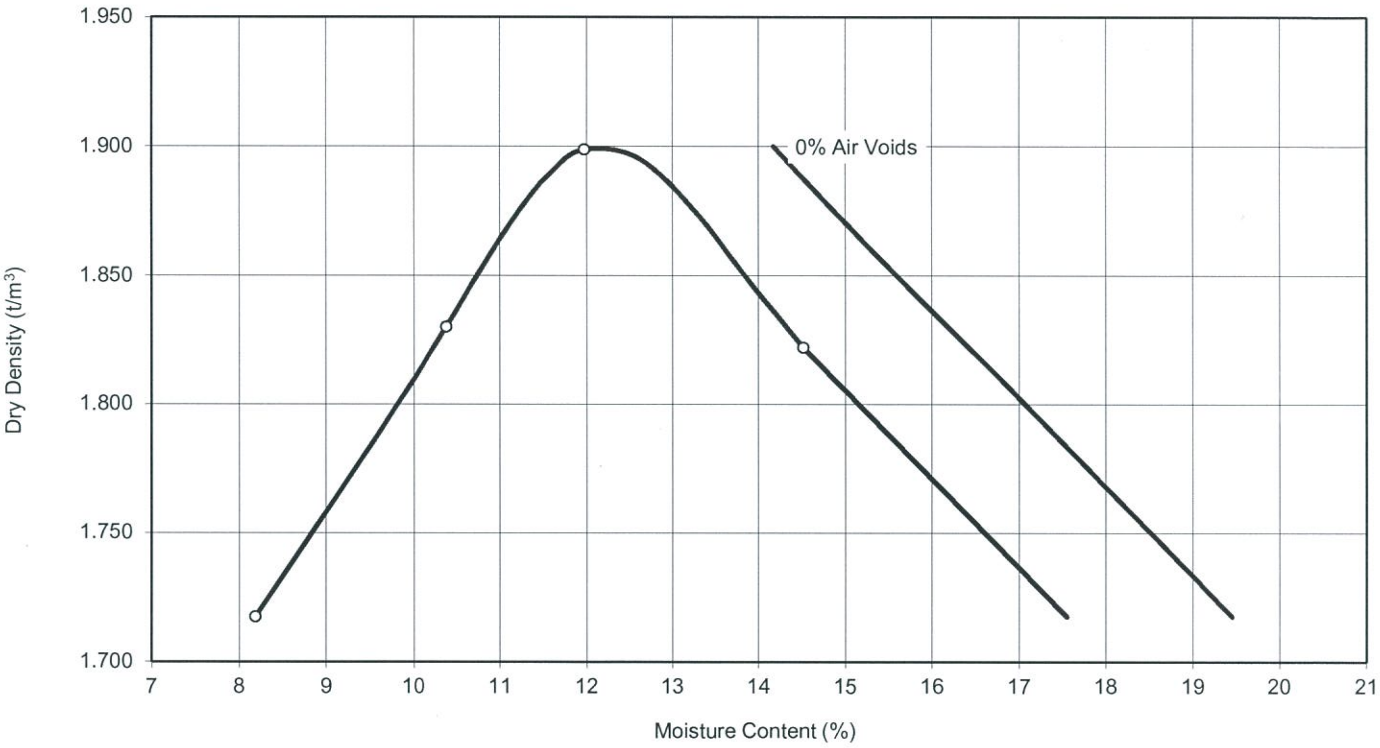
Results of Compaction Test

Client :	Lend Lease (Retirement Living)	**Project No. :**	81251.10
		Report No. :	N16-059_6
Project :	Geotechnical & Waste Classification Investigation	**Report Date :**	05.04.2016
Location :	Proposed Aged Care Facility, Morpeth	**Date of Test:**	21.03.2016
		Page:	1 of 1



Sample Details: **Location:** Pit 209 **Particles > 19mm:** 0%

Depth: 0.9 - 1.0m

Description: Silty CLAY - Light brown

Maximum Dry Density:	**1.90 t/m^3**
Optimum Moisture Content:	**12.0 %**

Remarks:

Test Methods: AS 1289.5.1.1, AS 1289.2.1.1

Sampling Methods: Sampled by DP Engineering Department

Tested: AV
Checked: DM

Dave Millard
Laboratory Manager

Douglas Partners
Geotechnics / Environment / Groundwater

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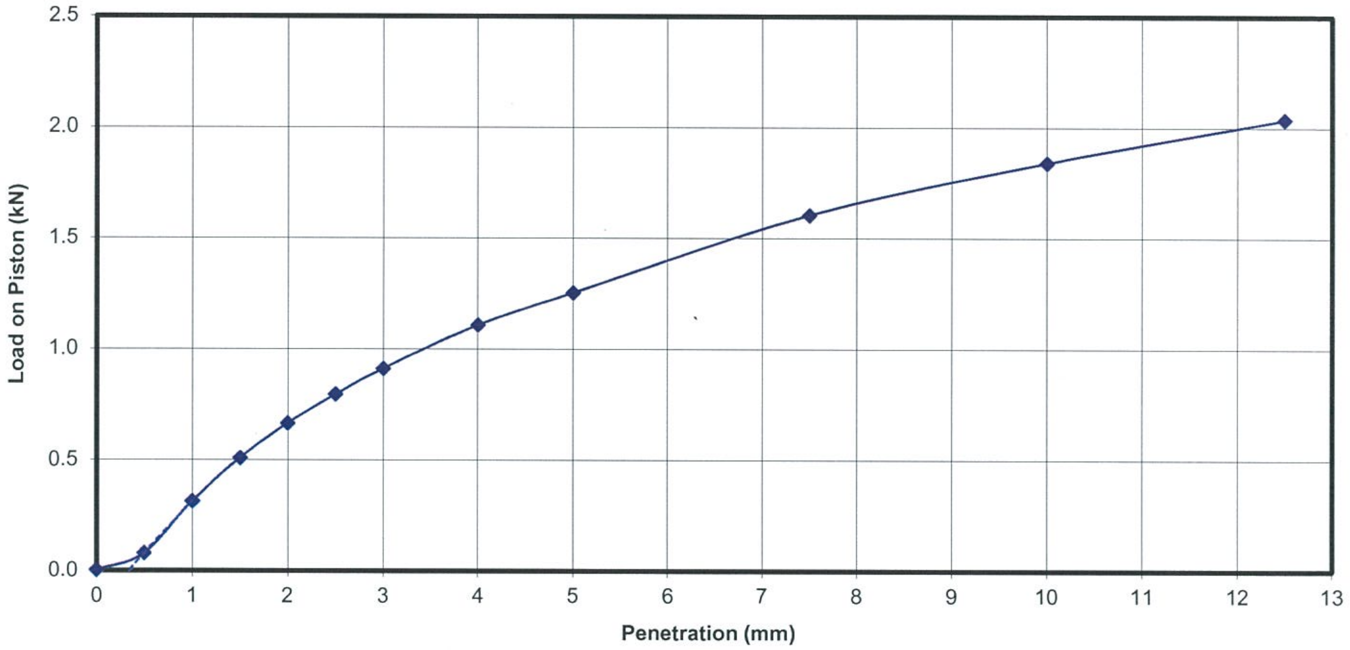
Result of California Bearing Ratio Test

Client : Lend Lease (Retirement Living)
Project : Geotechnical & Waste Classification Investigation
Location : Proposed Aged Care Facility, Morpeth
Test Location : Pit 209
Depth / Layer : 0.9 - 1.0m

Project No. : 81251.10
Report No. : N16-059_7
Report Date : 05.04.2016
Date Sampled : 09.03.2016
Date of Test: 04.04.2016
Page: 1 of 1



Description: Silty CLAY - Light brown

Sampling Method(s): Sampled by DP Engineering Department
Test Method(s): AS 1289.6.1.1, AS 1289.2.1.1

Remarks:

Percentage > 19mm: 0.0%

LEVEL OF COMPACTION: 100.5% of STD MDD
MOISTURE RATIO: 100.5% of STD OMC
SURCHARGE: 4.5 kg
SOAKING PERIOD: 4 days
SWELL: 0.7%

CONDITION		MOISTURE CONTENT %	DRY DENSITY t/m^3
At compaction		12.0	1.90
After soaking		13.2	1.89
After test	Top 30mm of sample	14.8	-
	Remainder of sample	13.2	-
Field values		14.2	-
Standard Compaction	(OMC/MDD)	12.0	1.90

RESULTS		
TYPE	PENETRATION	CBR (%)
TOP	**2.5mm**	**7**

NATA
ACCREDITED FOR TECHNICAL COMPETENCE

NATA Accredited Laboratory Number: 828

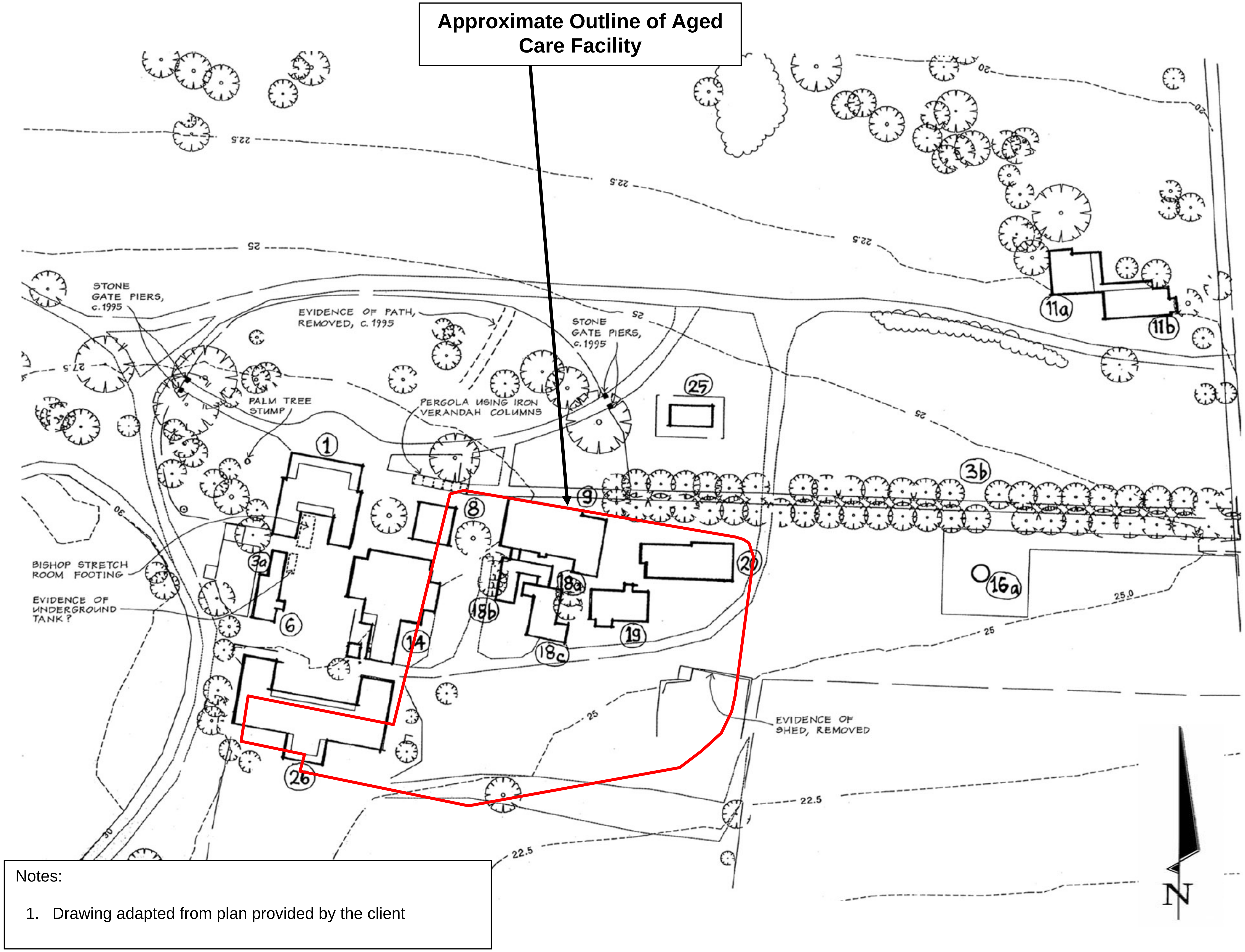
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.
Accredited for compliance with ISO/IEC 17025

Tested: AV
Checked: DM

Dave Millard
Laboratory Manager

Appendix D

Drawing 1 – Plan of Existing Buildings on Site
Drawing 2 – Test Location Plan



LEGEND

1	Closebourne House, c.1829
3a	Closebourne laundry, late 1800s
3b	Brush Box tree avenue, 1891
6	Closebourne Chapel (gymnasium)
8	The Registry, 1946
9	Assembly Hall, 1946
11a	Tank Street Cottage, 1959
11b	Tank Street Cottage, c.1946-47
14	Dining Hall/Kitchen, 1955
16a	Water tower, c.1967-75
18a	Toilet block, c.1940s?
18b	Cintra House , c.1960
18c	Workshop, c.1980
19	Belle Vue House, c.1955
20	Tillimby House, c.1957
25	Pool, c.1970
26	Bishop Tyrrell Lodge, 1982

Notes:

1. Drawing adapted from plan provided by the client

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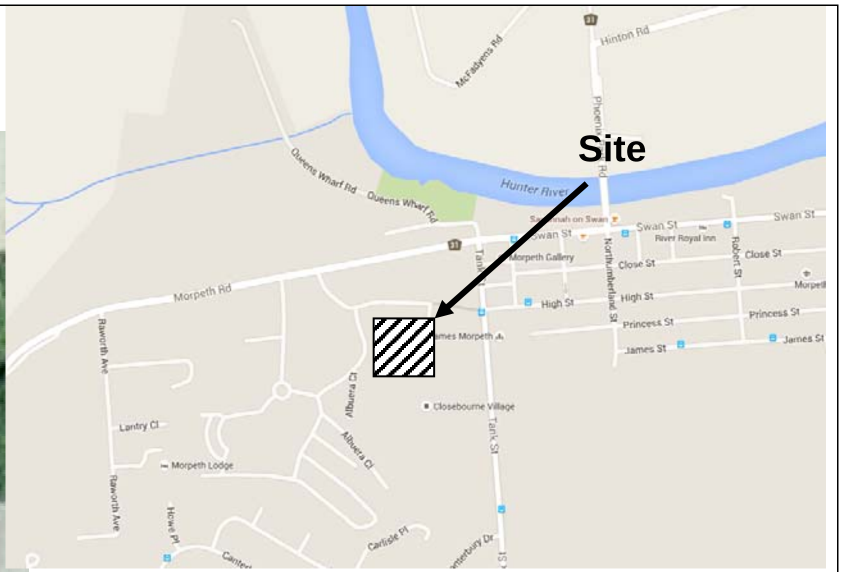
CLIENT:	Lend Lease (Retirement Living)			TITLE:	**Plan of Existing Buildings on Site**	PROJECT No:	81251.10
OFFICE:	Newcastle	DRAWN BY:	MPG		**Proposed Aged Care Facility**	DRAWING No:	1
SCALE:	NTS	DATE:	6.04.2016		**Morpeth Road, Morpeth**	REVISION:	0



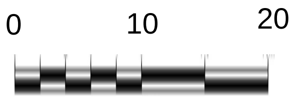
Site Locality

Legend:

◐	Approximate Bore Locations
▚	Approximate Test Pit Locations
🟥	Approximate Pit Location (Previous Investigation - Project 31995.02)

Notes:

1. Drawing adapted from Google earth and client supplied “Aged Care Facility, Closebourne House, Morpeth, NSW”, by Jackson Teece, Project Number 2016013, Drawing Ground Floor, dated 4 February 2016.



~ 1:600 @ A3

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CLIENT:	Lend Lease (Retirement Living)		
OFFICE:	Newcastle	DRAWN BY:	MM
SCALE:	1:600 @A3	DATE:	15.3.16

TITLE: **Test Location Plan**
Proposed Aged Care Facility
Morpeth Road, Morpeth

PROJECT No:	81251.10
DRAWING No:	2
REVISION:	0