Douglas Partners

Geotechnics | Environment | Groundwater

Report on Preliminary Geotechnical Investigation

Proposed UNSW D14 Building
High Street, Kensington

Prepared for
University of New South Wales
(Developer and Applicant)

UNSW SYDNEY

Lendlease
(Design and Construct Partner)

lendlease

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Report on Preliminary Geotechnical Investigation
Proposed UNSW D14 Building
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1. Introduction

This report presents the results of a preliminary geotechnical investigation undertaken by Douglas Partners Pty Ltd (DP) for the proposed development of the UNSW D14 Building at The University of New South Wales, High Street, Kensington. The investigation was commissioned in an email dated 19 June 2018 by Tania Costa of University of New South Wales (UNSW) and was undertaken in accordance with DPs proposal SYD180599, Revision 1, dated 18 June 2018. DP also completed a contamination assessment for the site (Ref: 86457.01), which is reported separately.

The proposed development involves the demolition of the existing D14 Building to allow the construction of a seven-storey building with split ground floor levels ranging between RL 31.5 m (Lower Ground) and RL 34.05 m (Upper Ground). The proposed floor levels step-up the hillside with about 0.5 – 1.5 m of cut and fill anticipated to achieve the proposed floor levels. Localised excavations for services such as the underground water tank and lift pit over-runs are anticipated to be 2 - 3 m below proposed floor levels and located near the central area of the building. Retaining walls are expected between floor levels as well as for buried services and lift pits.

The field work for the geotechnical investigation was undertaken in conjunction with the investigation for the contamination assessment and included the drilling of three rock-cored boreholes, three shallow augered-boreholes, installation of two groundwater monitoring wells, piezocone penetration testing (CPTu) at four of the borehole locations and laboratory testing of selected samples. The details of the field work are presented in this report, together with comments on groundwater, excavation, shoring, vibrations, subgrade preparation, foundations, soil aggressivity, pavements and seismic design.

2. Site Description

The site is located on a hillside within the UNSW Campus and is currently occupied by the University Hall (D14 Building), with pavements and landscaped areas surrounding the building. A Heritage Conservation Area encroaches within the site boundary, with large fig trees within the area. Multistorey buildings, footpaths, roads and landscaped areas are located around the site perimeter.

The ground surface slopes down towards the west and to a lesser extent to the north. The ground level ranges between about RL 35 m and RL 30 m relative to Australian height datum (AHD).

3. Regional Geology

Reference to the Sydney 1:100 000 Series Geological Sheet indicates that the site is underlain by Quaternary aged sediments comprising aeolian sand (deposited by transgressive dunes) overlying Hawkesbury Sandstone. The sandstone typically comprises medium to coarse grained quartz sandstone with some shale bands or lenses. The regional geology has been confirmed by previous investigations.

4. Previous Investigations

DP has previously completed investigations including boreholes, cone penetration tests (CPTs) and groundwater monitoring wells for the High Street Housing Project (currently known as UNSW Village B10 Buildings). The following DP reports were reviewed:

- Preliminary Geotechnical Investigation for High Street Housing Project (Project 44301, dated 2006);
- Preliminary Contamination Assessment for High Street Housing Project (Project 44301-2, dated October 2006);
- Additional Geotechnical Investigation for High Street Housing Project (Report 44301.C, dated November 2007); and
- Phase 2 Contamination Assessment for High Street Housing Project (Report 44301.04-1, dated April 2008).

Another consultant's report was provided to DP by UNSW for a site located to the east of the subject site (Ref: Geotechnical and Environmental Report for Basser and Goldstein Colleges, by Coffey Geotechnical Pty Ltd, dated September 2010) (Coffey). One borehole (BG-8) from the Coffey report is located close to the eastern site boundary of the subject site.

The relevant boreholes and CPTs from the above reports include CPT110, CPT113 and CPT213, and boreholes (BH) BH113A/B and BH116 from the DP reports and BHBG-8 from the Coffey report. The approximate locations of these previous CPTs and boreholes are shown on the test location plan (Appendix B, Drawing 1). Summary logs are shown on the interpreted geotechnical cross sections (Appendix B, Drawings 2 and 3) and detailed logs are presented in Appendix E.

The general subsurface conditions encountered in the nearby (previous) tests are summarised as follows:

- **Filling** – pavement materials including brick, concrete, asphaltic concrete and roadbase underlain by predominantly sandy filling with inclusions of gravel and slag extending to depths of between 0.2 m to 1.8 m;
- **Natural Sand** – predominantly medium dense and dense, fine to medium grained sand, with some loose sand expected in the top 1 m to 3 m, and very dense sand layers at depth. The sand extended to approximate depths of between 6 m and 17 m near the north-eastern and north-western corners of the subject site, respectively. Some tests terminated in sand at shallower depths;

- **Bedrock** – top of extremely low to low strength sandstone below 5.8 m (RL 29.1 m) near the north-eastern corner of the site (in BHBG-8), increasing in depth towards the west to 17.0 m (RL 16.4 m) near the central area of the northern site boundary (in BH113A) of the subject site.

  Near the north-western corner of the site, CPT110 encountered cone tip refusal at a depth of about 16.7 m (RL 15.1 m), possibly on the top of weathered bedrock or within very dense sand.

  Medium then high strength sandstone with occasional extremely low strength rock and clay seams were encountered below 7.8 m (RL 27.1 m) near the north-eastern corner of the site (in BHBG-8) and below 18.5 m (RL 14.9 m) near the central area of the northern site boundary (in BH113A). The boreholes were discontinued in high strength sandstone at depths of 22.1 m and 10.0 m in BH113A and BHBG-8, respectively.

In 2006, groundwater was measured at a depth of 8.9 m (RL 24.5 m) within a groundwater monitoring well in BH113B. A water level was observed at a depth of 1.2 m (RL 33.1 m) in BH116 whilst auger drilling.

5. Field Work Methods

The current field work included:

- Drilling of two boreholes (BH1 and BH2) to 3 m depth using an excavator with a 150 mm diameter auger attachment.
- Drilling of two boreholes (BH3 and BH3A) to refusal at a depth of 0.2 m and 0.5 m, respectively, with a hand auger;
- Drilling of three rock-cored boreholes (BH4, BH5 and BH6) using a truck-mounted drilling rig. The boreholes were initially drilled using solid flight augers and then rotary methods through soils to the approximate top of rock. Standard penetration tests (SPTs) were undertaken to collect samples for laboratory testing. The boreholes were then extended into the bedrock to depths of 16.8 m, 11.68 m, and 12.05 m, respectively using NMLC- sized (50 mm diameter) diamond core drilling equipment.
- Installation, development and measurement of two groundwater monitoring wells in boreholes BH4 and BH6.
- Four piezocone penetration tests (CPTu1, CPTu4, CPTu5 and CPTu6) to refusal at depths of 13.62 m, 10.36 m, 5.44 m and 5.8 m respectively. No pore pressure dissipation tests were undertaken on account of the soil profile being unsuitable.
- Two dynamic cone penetration tests (DCP2 and DCP3A) to a depth of 1.2 m or prior refusal,
- Coordination of the drilling and logging of the boreholes by an experienced engineer; and
- Core photography and point load testing of the rock cores.

Coordinates and surface levels for test locations 1, 2, and 4 were determined using a differential global positioning system (DGPS) receiver. Due to heavy vegetation and interference from buildings the DGPS could not be used for tests 3, 3A, 5 and 6. As such, the surface levels at these test locations were estimated from the Underground Services location plan provided by UNSW (DWG No: K-SS-2017-030, Rev A, Dated 27/10/2017) or the Plan of Building D14 at UNSW prepared by Project

Surveyors (DWG No: B04216-1, Dated 14/6/2018), and coordinates estimated from geographic information system (GIS) software. The surface levels at test locations are considered to be accurate to 0.1 - 0.2 m, with spatial co-ordinates accurate to about 1 m. The test locations are shown on Drawing 1 in Appendix B.

6. Field Work Results

The subsurface conditions encountered within the current borehole locations are described on the borehole logs included in Appendix C, together with core photographs and notes defining classification methods and terms used to describe the soils and rocks. The results of the piezocone penetration tests (CPTu) are also included within Appendix C. The inferred soil stratification and density based on the measured friction ratio and cone resistance are shown on each of the CPTu results sheets.

The current tests indicate that the subsurface profile includes:

Pavements Brick pavers in BH3. A thin layer of asphaltic concrete (0.05 m to 0.1 m) in BH5 and BH6.

Filling BH3 and BH3A were terminated in filling at a depth of 0.2 m and 0.5 m respectively, all other boreholes encountered filling to between 0.5 m to 0.8 m depth. The filling generally included varying proportions of sand and gravel, a piece of slag was encountered in borehole 4.

Natural Sand In all boreholes apart from BH3 and BH3A (which were terminated in filling). The sand was typically medium dense and dense. Loose and loose to medium dense sand was encountered to a depth of 3.5 m and 4 m in BH4 and BH6, respectively. Very dense sand was encountered inferred from a depth of 8.4 m in CPTu1 and encountered from a depth of 8.65 m in BH4.

Extremely Low to Low Strength Sandstone In BH4, BH5 and BH6 at a depth of 10.7 m, 5.4 m and 5.83 m respectively and inferred at the termination of CPTu1 at a depth of 13.62 m. The sandstone transitioned to medium or high strength sandstone below this veneer at between 0.1 m (BH4 and BH5) to 0.82 m (BH6) below the top of rock.

Medium and High Strength Sandstone Medium then high strength sandstone in BH4, BH5 and BH6 from a depth of 10.8 m, 5.5 m and 6.71 m respectively, which were all terminated in fresh, unbroken, high strength sandstone.

Free groundwater was observed in BH6 at a depth of 5.8 m during augering of the borehole, free groundwater was not observed during augering of any other borehole. A summary of the measured groundwater levels within the two monitoring wells is provided in Table 1

Table 1: Summary of Groundwater Measurements

Borehole	Date Purged	Surface Level (m AHD)	5 August 2018 (depth m)	5 August 2018 (RL, m AHD)
BH4	27 July 2018	30.2	7.4	22.8
BH6	27 Jul 2018	34.7	5.9	28.8

It should be noted that groundwater levels vary over time due to climatic, anthropogenic and other factors.

7. Laboratory Testing

Four soil samples were analysed in a NATA-accredited laboratory for measurement of electrical conductivity, pH, chloride and sulphate ion concentrations in order to assess aggressivity of the site soils to buried concrete and steel, in accordance with AS 2159 – 2009 – Piling: Design and Installation. The laboratory results are included in Appendix D, with the results summarised in Table 2.

Table 2: Chemical Analysis Test Results for Soil Samples

Borehole	Depth (m)	Strata Description	pH	Conductivity (µS/cm)	Cl (mg/kg)	SO_4 (mg/kg)	Resistivity[1] (ohm.m)
BH2	0.4	Filling	7.1	18	<10	<10	560
BH4	8.5	Sand	7.2	25	20	<10	400
BH5	4	Sand	7.0	9	<10	<10	1,100
BH6	1	Sand	5.8	26	10	22	390

Notes: 1. Resistivity by calculation from conductivity.
Cl = Chloride ion concentration, SO4 = Sulphate ion concentration.

Two bulk soil samples were tested for California bearing ratio (CBR). The detailed test results are included in Appendix D and are summarised in Table 3.

Table 3: CBR Test Results

Borehole.	Depth (m)	Strata Description	WF (%)	MDD (t/m^3)	OMC (%)	CBR (%)
BH1	0.7 – 1.0	Sand	6	1.66	16.5	17
BH2	0.8 – 1.1	Sand	3.6	1.65	16.5	13

Notes: WF = Field moisture content, MDD = Maximum dry density, OMC = Optimum moisture content,
CBR = California bearing ratio

Nineteen (19) axial point load tests were undertaken on the returned rock core samples for assessment of rock strength. The results of the point load strength tests are shown on the borehole logs and range between 0.4 MPa (medium strength) and 1.5 MPa (high strength).

8. Comments

8.1 Proposed Development

The proposed development involves the demolition of the existing D14 Building to allow the construction of a seven-storey building with split ground floor levels ranging between RL 31.5 m (Lower Ground) and RL 34.05 m (Upper Ground). The proposed floor levels step-up the hillside with about 0.5 – 1.5 m of cut and fill anticipated to achieve the proposed floor levels. Localised excavations for services such as the underground water tank and lift pit over-runs are anticipated to be 2 - 3 m below proposed floor levels and located near the central area of the building. Retaining walls are expected between floor levels as well as for buried services and lift pits.

No column loads were available at the time of this report, but based on the proposed size of the building and a normal column spacing and floor loading, working loads in the order of 5000 - 6000 kN are anticipated.

The approximate site boundary and future building envelope for the proposed development are shown on Drawing 1 in Appendix B.

8.2 Geotechnical Model

Two geotechnical cross-sections (Interpreted Geotechnical Cross-Sections A-A' and B-B'), showing the interpreted subsurface profile between selected boreholes, are presented on Drawings 2 and 3 in Appendix B. The sections show interpreted geotechnical units of soil and rock, together with the proposed ground floor levels as a guide. It should be noted that the interpreted boundaries shown on the sections are accurate only at the borehole locations and layers shown diagrammatically on the drawings are inferred only. Bands of lower / higher strength rock and looser / denser sand should be expected within the generalised layers. Similarly, the ground surface is accurate only at the borehole locations.

Of particular note is the bedrock profile shown on these cross-sections. Based on previous experience at the university and surrounds, the rock surface is commonly stepped in a series of benches and small cliff lines, and thus may not be 'linear' as shown.

It is also noted that the thickness of the 'veneer' of weaker rock varies between zero and up to approximately 2 m based on some of the previous boreholes (refer Cross-Section A-A' on Drawing 2).

8.3 Groundwater

The groundwater level in BH6 was within 0.03 m (i.e. 30 mm) of the top of rock. As such, it is inferred that this water level observed towards the eastern side of the site represents a perched ephemeral water table and not the regional groundwater table.

The groundwater level in BH4 was within the sand at a depth of 7.4 m (RL 22.8 m), and the groundwater was measured at a depth of 8.9 m (RL 24.5 m) in BH113 (Ref 44301). As such, it is inferred that a permanent groundwater table exists within the natural sands towards the west of the site, but is well below the proposed lower ground floor level.

In BH116 (Ref 44301), free groundwater was observed at a depth of 1.2 m (RL 33.1 m). It is considered that this was likely a perched ephemeral water table due to the presence of silty sand directly below this level. It could also represent a broken water service in this vicinity. However, it is recommended that further investigation be carried out to rule out the possibility of a localised, elevated water table above the proposed ground floor level.

Groundwater levels are generally transient and are likely to change with climatic conditions and other factors. It is likely that the groundwater level will temporarily rise during periods of heavy or prolonged rainfall. At the eastern end of the site this ephemeral water would be expected to mostly flow westwards, along the surface of the less permeable bedrock.

Based on the groundwater data available at this stage, it is unlikely that the groundwater table would lie above the proposed ground floor levels and localised excavations for service/lift pits (assuming localised excavations are no deeper than 2 m below proposed ground floor levels). Some minor inflow due to seepage of surface water into subfloors and localised excavations should be expected after rainfall events.

8.4 Excavation Conditions

Excavation for the proposed split floor levels are anticipated to be less than 1 m deep and localised within the central area of the site. Localised excavations for services and lift pits are anticipated to be less than 2 m below the proposed floor levels.

Excavation is expected mainly through the filling and natural sands. Excavation of these materials should be achievable using conventional earthmoving equipment such as tracked hydraulic excavators.

All excavated materials requiring off-site disposal will need to be disposed of in accordance with the provisions of the current legislation and guidelines including the NSW EPA, Waste Classification Guidelines, Part 1: Classifying Waste, November 2014. Further reference should be made to DP's contamination assessment (Ref: 86457.01) in this regard.

8.5 Engineered Fill Construction

It is anticipated that about 0.5 - 1.5 m of engineered fill is required to achieve design subgrade levels for the proposed split ground floor levels. It is noted that the existing hall building floor levels may be closer to the proposed building floor levels, thereby the extent of cut and fill earthworks that is required may be less than anticipated and shown on the Interpreted Geotechnical Cross-Sections A-A' and B-B' in Appendix B (Note: ground surface level is accurate at test location only and is likely to be different in between test locations).

Notwithstanding the above, it will be important to establish a construction methodology that promotes good engineering practice for earthworks and 'well compacted' engineered fill on a sloping site. Typically, construction of working platforms for piling rigs/heavy plant and subgrade preparation for floor slabs on grade commences from the lowest platform/floor level and progresses upslope. It is recommended that overfilling several metres beyond (i.e. downslope) of the lines of the proposed retaining walls between the split levels is undertaken to allow the engineered fill to be later cut back into upper platform/floor level, so as to achieve adequate and uniform compaction throughout and to reduce the risk of disturbance to engineered fill.

The subgrade level for pavements and floor slabs is likely to expose uncontrolled filling and natural sand. The existing filling is assumed to be uncontrolled in the absence of compaction records and should be removed and replaced as engineered filling to a depth that is appropriate for the pavement or structure to be supported.

From a geotechnical perspective, the predominantly sand / gravel filling is considered to be suitable for re-use as engineered filling, provided that it is free of oversize particles (>100 mm) and deleterious material. The suitability of re-using site-won filling and natural soil should also be considered from a contamination perspective (refer to DP's contamination report).

Subgrade preparation measures are recommended up to subgrade level as follows:

- Remove topsoil and filling to at least 0.6 m below the design subgrade level, or to the top of natural sand, whichever is shallower.
- Compact the exposed material, then proof roll the exposed surface using a minimum 10-tonne roller (where accessible) in non-vibration mode. The proof roll should be witnessed by an experienced geotechnical engineer to detect any 'soft' spots;
- Any loose/soft areas identified during proof rolling should be removed/rectified as directed by the geotechnical engineer;
- Replacement filling should be free of oversize particles (>100 mm) and deleterious material, and should be placed in loose layer thicknesses not greater than 200 mm (dependent upon the size of compaction machinery) and compacted to a dry density ratio of at least 98% relative to Standard compaction, with moisture contents maintained within 2% of Standard optimum moisture content, increasing to 100% for the upper layer of the subgrade. If the replacement filling used is sand, compact to a minimum density index of 75%;
- Some moisture conditioning (i.e. drying or wetting) may be required for compaction of filling; and
- Density testing in accordance with AS 3798 - 2007 Guidelines on earthworks for commercial and residential developments should be undertaken to verify that the required compaction/moisture criteria are achieved.

If the proposed floor slabs are to bear on-grade then 'Level 1' (i.e. full time) inspections and testing of engineered filling is recommended to confirm the required compaction is achieved and to further reduce the risk for future differential settlement problems associated with variably compacted filling.

8.6 Ground Vibration

During construction, it will be necessary to use appropriate methods and equipment to keep ground vibrations at adjacent buildings and structures within acceptable limits. Based on DP's experience and with reference to Australian Standard AS 2670.2-1990 "Evaluation of human exposure to whole-body vibrations – continuous and shock induced vibrations in buildings (1-80 Hz)", it is suggested a vibration limit be initially limited to 8 mm/sec vector sum peak particle velocity (VSPPV) at the foundation level of adjacent buildings for human comfort consideration, although this vibration limit may need to be reduced if there are vibration-sensitive buildings (or equipment) in the area.

As the magnitude of vibration transmission is site specific, it is recommended that a vibration trial be undertaken at the commencement of excavation, and any compaction rolling during earthworks and possibly during piling/shoring construction. The trial may indicate that smaller or different types of earthworks equipment should be used.

8.7 Excavation Support

8.7.1 General

The suitability of various types of excavation support for this development will ultimately depend on the space available as well as the footprint and depth of the excavation. Due to the presence of filling, natural sand and rock at variable depths across the site, with the possibility of a locally elevated groundwater table, various options for excavation support are described below.

8.7.2 Batter Slopes

Steep or vertical excavations in uncontrolled filling and natural sand are not expected to be stable for any period of time. Therefore, both temporary and permanent batters may be required for excavations and earthworks.

Where there is sufficient space, maximum temporary and permanent batters of 1.5H:1V and 2H:1V, respectively, are suggested for excavations less than 3 m high in filling and/or natural sand, above the water table, and where not subjected to surcharge loads. Where adjacent to existing buildings supported at a high level (on footings), an additional 'set-back' distance of at least 2 - 3 m should be incorporated in the absence of specific geotechnical advice.

Batters may also be suitable for temporary support of excavations for service pits and lift over-runs, which are located a sufficient distance away from site boundaries and neighbouring structures, as described below.

Care should be taken where any loads are planned at the crest of batter slopes (e.g. scaffolding sole boards). A slope stability analysis should be undertaken for batters subjected to surcharge loads on a case-by-case basis following dynamic penetrometer testing to assess the in-situ density and strength of the soils.

If vegetation and maintenance of permanent batters is proposed, a flatter permanent batter of 3H:1V is suggested. Erosion control should also be provided for permanent batters, and this may simply include a layer of geofabric covered by grass or vegetation.

If the proposed excavations are setback sufficient distance from the site boundaries so that no surcharge loads exist above a 3:1 (H:V) zone of influence line extending up from the bulk excavation level (BEL) or finished floor level (FFL), then temporary batter slopes with retaining walls constructed in front/below the batters is likely to be feasible.

8.7.3 Retaining Wall Types

The proposed underground water tank and lift pit over-runs are shown on current drawings to be located close the central area of the site and proposed building. If localised service pits and lift over-runs, however, are relocated close to the site boundaries and existing structures, such that insufficient space exists for construction of temporary batters, then retaining walls are likely to be required to provide temporary and permanent support.

For excavations above the groundwater table, contiguous pile walls, together with perimeter drainage for collection and subsequent discharge of any seepage may be a feasible retaining system. Contiguous pile walls comprise closely spaced (i.e. less than 50 mm gaps) CFA (concrete or grout-injected) piles. Any gaps between piles can be plugged with dry-pack mortar as the excavation proceeds, with installation of weep holes/spitter pipes at regular vertical and horizontal spacing across the walls for drainage, if and as necessary.

There is a risk of soil loss occurring between contiguous piles in sand, particularly if there are localised areas of elevated groundwater (i.e. springs). If present this would generally require the use of a secant pile wall comprising interlocking piles. Design would then necessarily have to consider the hydrostatic pressures associated with the water acting on such water tight walls.

Alternatively, interlocking steel sheet piles may be used for localised excavations if vibration-sensitive structures are absent near the proposed excavation and the relatively loud noise of driving the sheet piles is acceptable to the University. Trench and shoring boxes may be suitable to form temporary linear excavation support for pipe/conduit construction.

Another alternative to contiguous piles is small diaphragm wall systems such as the Castec® wall system. This involves the construction of in-situ mixed concrete wall panels that overlap forming a continuous concrete wall that should be suitable as a final finish for any lift pit or in-ground structures.

For retaining walls extending between the split levels of the ground floor, these could be formed by cast-in-situ 'L' shaped or counterfort wall systems that are built progressively as earthworks proceed. Due consideration of surcharges associated with compaction plant operating behind the retaining walls will be required in this instance.

The retaining walls may also require the use of temporary 'tie-back' ground anchors or internal bracing/strutting to provide additional lateral support during construction. Further advice on ground anchors is provided in Section 8.8.

8.7.4 Retaining Wall Design

Excavations close to facilities where batters cannot be used will generally require both temporary and permanent support.

Cantilevered retaining walls or walls supported with a single row of ground anchors or bracing/props could be designed on the basis of a triangular earth pressure distribution based on the bulk unit weights and lateral earth pressure coefficients provided in Table 4. Active earth pressure coefficients (K_a) may be used where some wall movement is acceptable. At rest earth pressure coefficients (K_o) should be used where wall movement is to be limited, such as close to structures or where the wall is propped or braced prior to excavation (e.g. 'top-down' construction).

All surcharge loads should be allowed for in the design of retaining walls, including building footings, traffic and construction related activities.

Table 4: Recommended Earth Pressure Coefficients and Bulk Unit Weights

Material	Active Earth Pressure Coefficient (K_a)	At Rest Earth Pressure Coefficient (K_o)	Bulk Unit Weight (kN/m^3)	Ultimate Passive Earth Pressure (K_p) (1)
Sandy Filling or Natural Sand	0.4	0.6	20	2.5

Notes: (1) For piled or embedded wall systems only, from 0.5 m below FFL or BEL, as appropriate.

Passive lateral resistance for retaining walls embedded into sand below FFL or BEL, as appropriate, may be based on an ultimate passive earth pressure (or the coefficient K_p) provided in Table 4. A factor of safety of at least 2 must be applied to the ultimate value to limit wall movement that would normally be required to mobilise the full passive resistance. Passive resistance should be considered beneath 0.5 m below FFL/BEL due to unconfined sand, disturbance and possible perimeter nearby excavations such as toe drains.

8.8 Ground Anchors

If localised excavations are proposed near the site boundaries and existing structures, then temporary ground anchors may be required to restrict wall movements during the construction prior to permanent support of retaining walls by the structure.

Ground anchors are typically inclined at about 10° to 20° below the horizontal, have a free length equal to or greater than the height of the anchor above the base of the excavation and have a minimum free length of 3 m. A minimum bond length of 3 m should also be used. The anchors should be bonded behind a line drawn up at 45° from the base of the excavation.

Design of temporary anchors within loose and medium dense / dense sand may be based on a friction angle (ϕ) of 30 and 33 degrees, respectively. Trial anchors may be used to determine if higher friction angles values are achievable and lift-off tests should be carried out to confirm the anchor capacities during construction.

Movement of anchors in sand is common and care should be taken if anchors are installed under existing buildings to minimise disturbance to the foundation materials. The anchors will need to be carefully positioned and possibly inclined at steeper angles to avoid footings for adjacent buildings or existing in-ground services. Sand anchors should be installed and tested only by experienced and reputable specialist anchoring contractors.

After installation, anchors should be proof stressed to 125% of their nominal working load and locked-off no higher than 70% of the Working Load. Periodic checks should also be carried out throughout the construction phase to ensure that the lock-off load is maintained and not lost due to creep effects or other causes.

If vertical ('tie-down') ground anchors are required for crane tower pads, the building core, lift shafts etc. then ground anchors into bedrock may be required. For ground anchors within the bedrock, the bond length can be designed on the basis of the maximum allowable bond stresses provided in Table 5. The parameters provided in Table 5 assume that anchor holes are clean and adequately flushed, with grouting and other installation procedures carried out carefully and in accordance with normal good anchoring practice. The design of vertical anchors should also consider cone pull-out failure mechanisms within the surrounding rock.

Table 5: Maximum Allowable Bond Stresses for Ground Anchors in Rock

Material	Working Bond Stress
Variable Extremely Low to Low Strength Rock	80 kPa
Medium Strength (or Stronger) Sandstone	500 kPa

If ground anchors extend into adjacent properties then permission from the property owners for their installation will generally be required.

8.9 Foundations

8.9.1 Site Classification

Based on the subsurface conditions intersected by the boreholes, the site is assessed as having a 'Class P' site classification in accordance with the Australian Standard AS 2870 Residential Slabs and Footings – 2011. For Class P sites, footing design should be based on "engineering principles".

8.9.2 Shallow Footings

For lightly loaded structures such as garden bed retaining walls up to 1 m high, light or security camera poles and security bollards, shallow strip or pad footings bearing in (natural) loose or loose to medium dense sand, below the uncontrolled filling, may be feasible.

By way of example, a 0.5 m by 0.5 m pad footing or a 0.5 m wide strip footing, embedded 0.5 m deep in loose to medium dense sand, with a water table at least twice the minimum footing width below the base of the footing, may be designed for a maximum allowable bearing pressure of 150 kPa and 100 kPa, respectively. Reduced bearing pressures will apply in cases where footings are founded close to the water table.

The amount of settlement for shallow footings founded in sand depends upon the load conditions, footing size and foundation material, but should be less than 1% of the footing width if proportioned on the basis of the above parameters.

All footings should bear at a level that is below an imaginary influence line rising at a slope of 30 degrees from the base of and adjacent excavations, pits or basements.

8.9.3 Piles

It is 'good engineering practice' to uniformly support a multi-storey building such as that proposed on bedrock of uniform strength to reduce the potential for differential settlement, especially considering the variable depth and density of the natural sand at the site.

Given the presence of collapsible, sandy soils and groundwater, CFA piles or cased bored piles are considered to be appropriate piling methods. Driven piles are considered to be unsuitable for this site given the presence of sandy filling/natural sand and nearby vibration-sensitive structures. Open bored piles are also considered to be unsuitable for this site due to collapsible material and groundwater issues. Given the variability in the soil profile and bedrock depth/strength, steel screw piles are also unlikely to provide a suitable foundation system for this site.

Recommended maximum pressures and elastic modulus values for the design of piers/piles in various soil and rock strata are presented in Table 6. For piles, shaft adhesion values for uplift (tension) may be taken as being equal to 70% of the values for compression.

Table 6: Recommended Design Parameters for Foundation Design

Foundation Stratum	Maximum Allowable Pressure		Maximum Ultimate Pressure		Elastic Modulus (MPa)
	End Bearing[1] (kPa)	Shaft Adhesion[2] (Compression) (kPa)	End Bearing[1] (kPa)	Shaft Adhesion[2] (Compression) (kPa)	
Medium Dense / Dense Sand	800	Ref Note 3	2500	Ref Note 3	40
Very Dense Sand	2000	Ref Note 3	6000	Ref Note 3	75
Extremely Low to Low Strength Sandstone	1000	50	3000	100	50
Medium or Stronger Sandstone	3500	300	20,000	600	800

Note: 1. End bearing pressure for sand applies to pile foundations that are founded 4 diameters below the ground surface.

2. Shaft adhesion applies to pile foundations for which the socket sidewalls are adequately cleaned and roughened to "R2" standard (or better) as defined in Pells et. al. (1998)

3. Dependent on the length and depth of the pile, depth of the water table, and the piling methodology used. Shaft adhesion for these units should be calculated using industry standard methods with a friction angle (ϕ) of 33 degrees for the medium dense / dense natural sand and 36 degrees for the very dense natural sand.

Foundations proportioned on the basis of the allowable bearing pressures in Table 6 would be expected to experience total settlements of less than 1% of the pile diameter or minimum footing dimension under the applied working load, with differential settlements between adjacent columns expected to be less than half of this value.

To reduce the potential risk of total and differential settlement of pile, all piles should be founded below or not within five pile diameters above the lower strength or stiffness materials.

For limit state design, selection of the geotechnical strength reduction factor (ϕ_g) in accordance with Australian piling code AS 2159 – 2009 is based on a series of individual risk ratings (IRR), which are weighted on numerous factors and lead to an average risk rating (ARR). Therefore, it is recommended that an appropriate geotechnical strength reduction factor be calculated by the pile designer. Footing settlements may be calculated for assessment of the serviceability limiting state using the elastic modulus values given in Table 6.

Soil decompression can occur during CFA piling when a strong stratum such as bedrock is encountered. This occurs when the augers continue to rotate but the rate of auger progression decreases, displacing soil from around the auger upwards towards the surface. Decompression can cause weakening and settlement of the soils adjacent to the pile which can lead to damage for buildings and structures supported on high-level footings. The risk of decompression can be reduced by monitoring auger speed and progression closely.

Piling should be inspected by a geotechnical engineer to confirm that foundation conditions are suitable for the design parameters. It is noted that CFA piles involves a ‘blind’ drilling technique and therefore the piling contractor should certify the construction of CFA piles. For CFA piles, DP can witness the drilling resistance and pile depths to correlate this information with adjacent borehole data, however additional boreholes will generally be required if this pile type is used. A heavy duty, high torque piling rig will be required to form sockets within the medium strength (or stronger) sandstone.

8.9.4 Floor Slabs

Consideration may be given to the use of a raft slab foundation. However, this will be subject to detailed review and analysis of bearing pressures and settlements once more specific details of the column layout and slab loadings have been confirmed. The presence of the loose natural sands and uncontrolled filling should be considered in the design particularly for the concentrated column loadings.

Given the highly variable thickness of sand over bedrock across the site, differential settlement across the raft slab footprint may be a significant risk for the performance of any raft slab foundations at this site. A piled raft foundation could also be considered to reduce differential settlements, if required.

Further geotechnical analysis and advice would generally be required in relation to the design and construction of both raft slabs and piled raft slabs, if these are to be considered.

In general, all slab foundations should be supported on strata of uniform strength/stiffness to reduce differential settlements, however this will also depend on the loads and the settlement tolerances.

Slab design may be based on modulus of subgrade reaction, which is highly dependent on the size of the slab area subject to loading and the foundation material. Design parameters can be provided once the column details, loads and slab areas are known.

8.10 Soil Aggressivity

Comparison of the results of the aggressivity testing with Tables 6.4.2(C) and 6.5.2(C) in Australian Standard AS 2159 Piling Design and Installation - 2009, indicates that the tested samples are likely to be mildly-aggressive to buried concrete elements and non-aggressive to buried steel elements, assuming Soil “Conditions A” exist (i.e. high permeability soils below groundwater).

8.11 Working Platform Assessment

Given that a piling rig is likely to be required to construct shoring and foundation piles, a working platform assessment will be required to assess whether the subgrade is sufficient or if an engineered platform is required to support the piling rig (and / or mobile crane) loads. The platform thickness will need to be assessed once details of piling rig or other plant loads are confirmed. If the piling rig is proposed to be set up close to batter slopes then a slope stability assessment may also be required.

8.12 Pavements

Based on the variable results of CBR tests and DP’s past experience in the area, a design CBR of 10% is recommended for the preliminary design of pavements assuming subgrade preparation is carried out in accordance with Section 8.5 of this report and assuming a granular subgrade (e.g. sand or gravel).

8.13 Seismic Design

Given that site is expected to be underlain by less than 1 m deep of poorly compacted sandy filling (i.e. of similar consistency to very loose sand) in the near-surface material, the site is considered to be consistent with a Site Sub-soil “Class C_e” (Shallow Soil Site) in accordance with Australian Standard AS 1170.4 Structural design actions Part 4: Earthquake actions in Australia - 2007.

For Sydney, AS 1170.4 nominates a Hazard Factor (z) of 0.08.

8.14 Dilapidation Surveys

Dilapidation surveys should be carried out on adjacent buildings and pavements that may be affected by earthworks and piling. The dilapidation surveys should be undertaken before construction commences in order to document any existing defects, so that any claims for damage due to construction related activities can be accurately assessed.

8.15 Further Investigation

Additional rock-cored boreholes, groundwater wells and groundwater monitoring is recommended to fill in data-gaps across the site for design and construction.

9. Limitations

Douglas Partners (DP) has prepared this report for this project at the UNSW D14 Building in accordance with DPs proposal SYD180599, Revision 1, dated 18 June 2018. The work was carried out under a Consultant Agreement between DP and UNSW, dated 26 April 2018, which was agreed on a previous project. This report is provided for the exclusive use of UNSW 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/report did not include the assessment of surface or sub-surface materials or groundwater for contaminants, within or adjacent to the site. 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 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

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.

Copyright

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.

About this Report

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

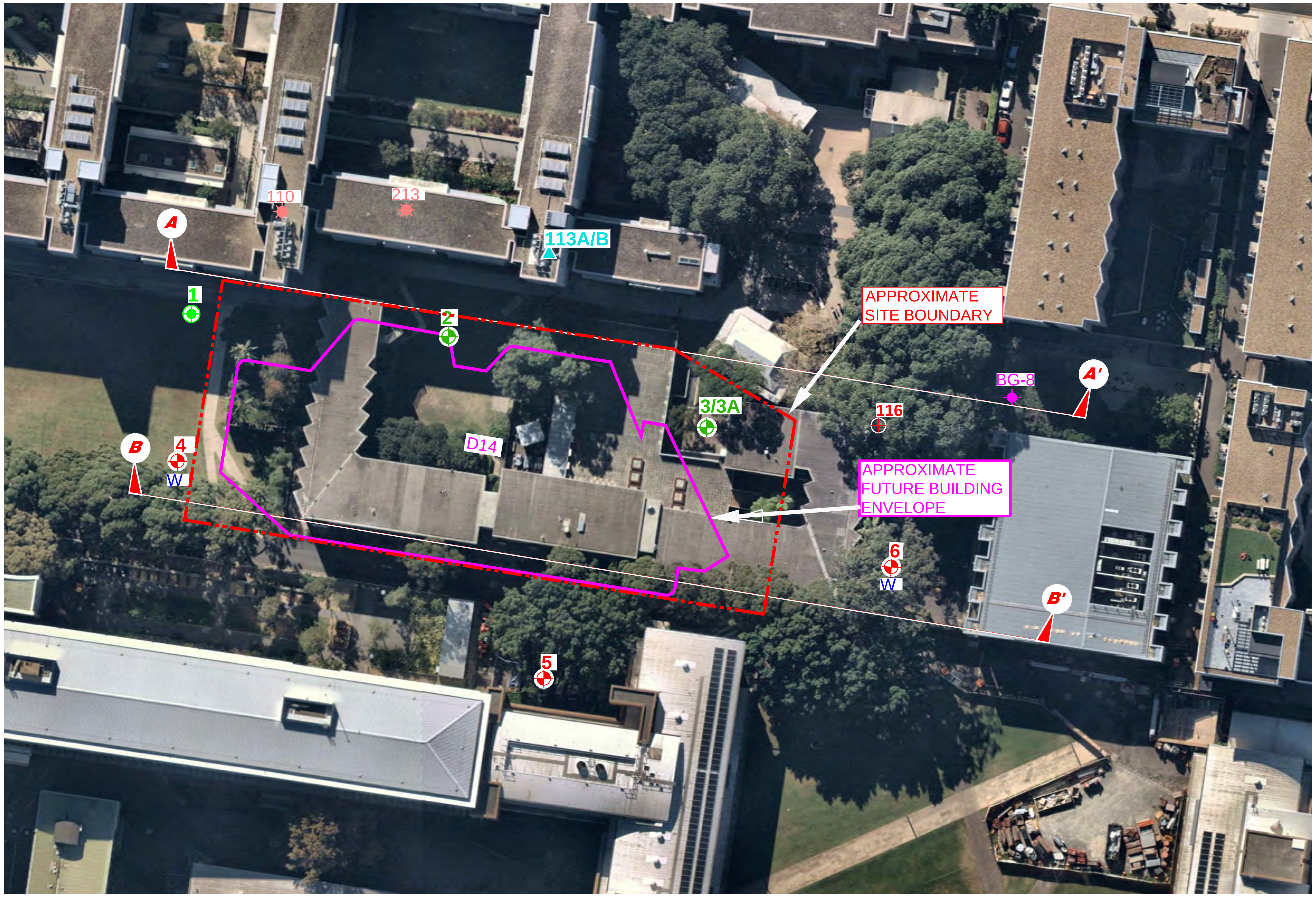
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate 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.

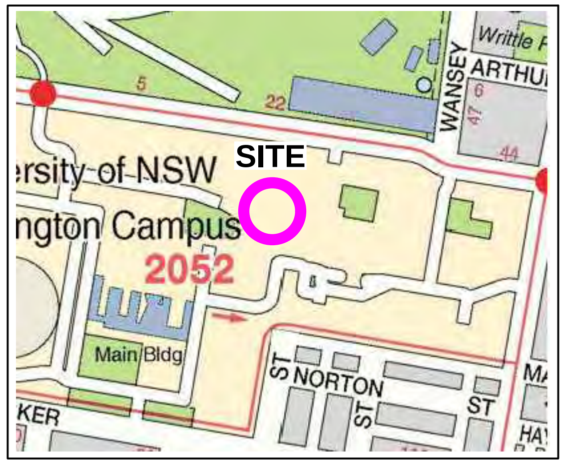
Site Inspection

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.

Appendix B

Drawings





Locality Plan

LEGEND

PREVIOUS INVESTIGATION

- Borehole (Coffey)
- Borehole (DP Proj. 44301)
- CPT (DP Proj. 44301)
- Borehole and CPT (DP Proj. 44301)

CURRENT INVESTIGATION

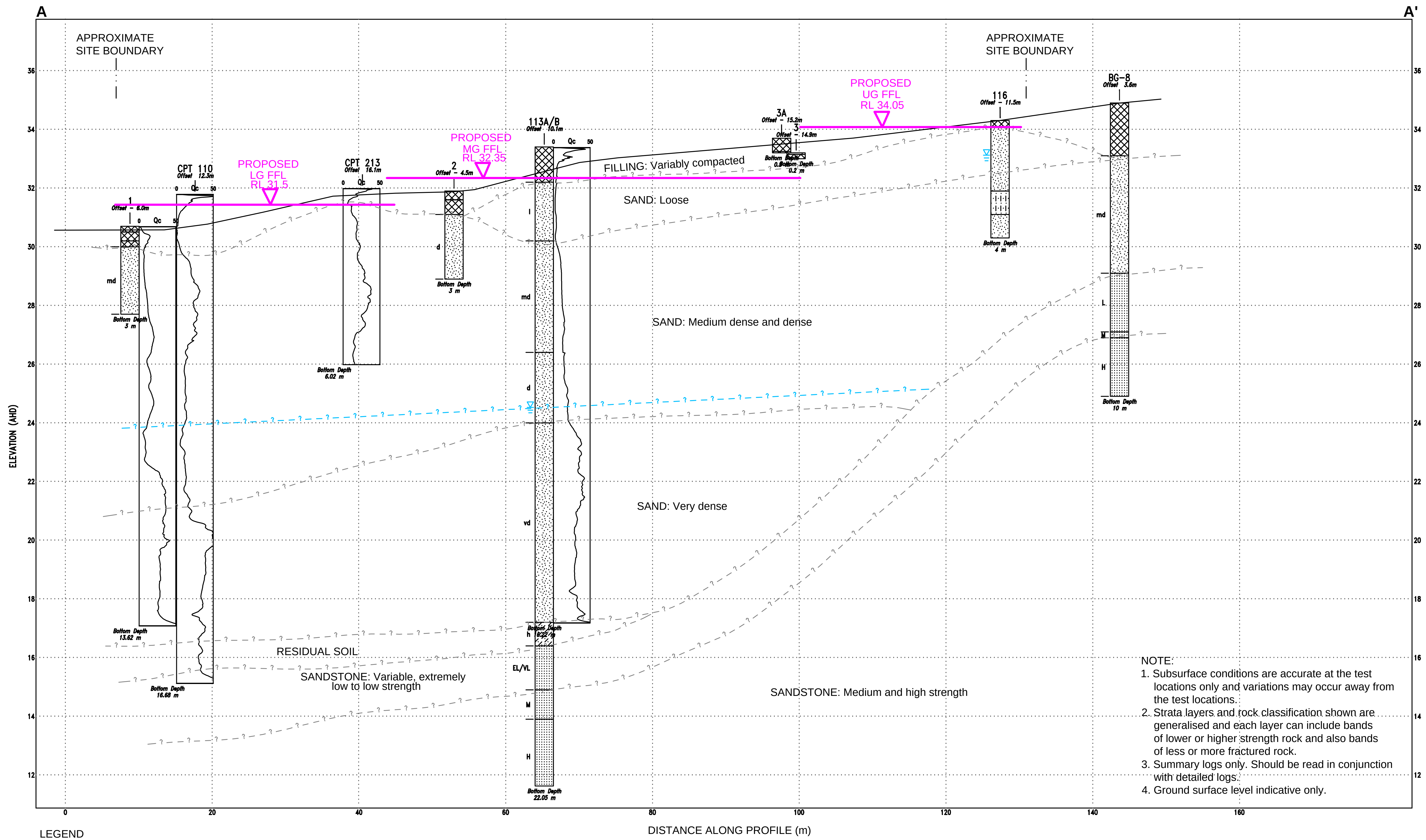
- CPTu & contamination borehole
- Contamination borehole
- W CPTu, cored borehole and well
- CPTu and cored borehole
- A — A' Geotechnical Cross Section A-A'

NOTE:
1: Base image from Nearmap.com
(Dated 5.5.2018)
2: Test locations are approximate only and
are shown with reference to existing features.

0 5 10 15 20 30 40 60 80m
1:800 @ A3

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: University of New South Wales		TITLE: **Test Location Plan**	PROJECT No: 86457.00
OFFICE: Sydney	DRAWN BY: PSCH	**Proposed UNSW D14 Building**	DRAWING No: 1
SCALE: 1:800 @ A3	DATE: 2.11.2018	**High Street, KENSINGTON**	REVISION: 1



NOTE:
1. Subsurface conditions are accurate at the test locations only and variations may occur away from the test locations.
2. Strata layers and rock classification shown are generalised and each layer can include bands of lower or higher strength rock and also bands of less or more fractured rock.
3. Summary logs only. Should be read in conjunction with detailed logs.
4. Ground surface level indicative only.

LEGEND

- Filling
- Sand
- Asphaltic Concrete
- Pavers
- Silty Sand
- Clayey Sand
- Sandstone

l	Loose
md	Medium dense
d	Dense
vd	Very dense
h	Hard

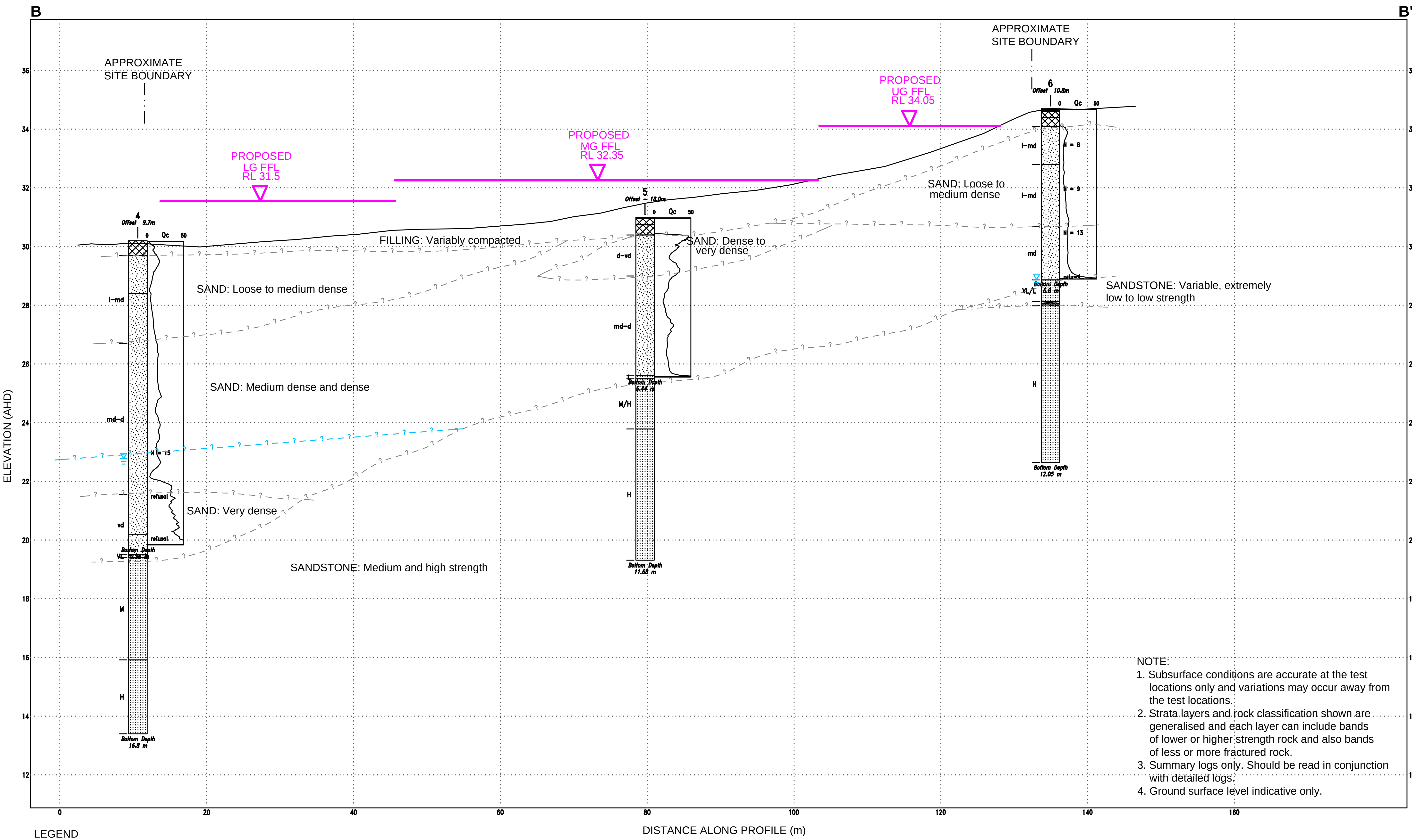
EL	Extremely low strength
VL	Very low strength
L	Low strength
M	Medium strength
H	High strength

TESTS / OTHER
- N - Standard penetration test value
- Water level
- PP- Pocket penetrometer test value
- — ? — Interpreted Geotechnical boundary
- — ? — Interpreted Groundwater table

0 10
Horizontal Scale (metres)
Vertical Exaggeration = 4.0

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: University of New South Wales		TITLE: **Interpreted Geotechnical Cross-section A-A'**	PROJECT No: 86457.00
OFFICE: Sydney	DRAWN BY: PSCH	**Proposed UNSW D14 Building**	DRAWING No: 2
SCALE: 1:500 (H) 1:125 (V) @ A3	DATE: 2.11.2018	**High Street, KENSINGTON**	REVISION: 1



NOTE:
1. Subsurface conditions are accurate at the test locations only and variations may occur away from the test locations.
2. Strata layers and rock classification shown are generalised and each layer can include bands of lower or higher strength rock and also bands of less or more fractured rock.
3. Summary logs only. Should be read in conjunction with detailed logs.
4. Ground surface level indicative only.

LEGEND

- Core Loss
- Asphaltic Concrete
- Filling
- Sand
- Sandstone

l	Loose
md	Medium dense
d	Dense
vd	Very dense

EL	Extremely low strength
VL	Very low strength
L	Low strength
M	Medium strength
H	High strength

TESTS / OTHER
N - Standard penetration test value
- Water level
PP- Pocket penetrometer test value
— ? — — Interpreted Geotechnical boundary
— ? — — Interpreted Groundwater table

0 10
Horizontal Scale (metres)
Vertical Exaggeration = 4.0

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: University of New South Wales	TITLE: **Interpreted Geotechnical Cross-section B-B'**	PROJECT No: 86457.00
	OFFICE: Sydney / DRAWN BY: PSCH	**Proposed UNSW D14 Building**	DRAWING No: 3
	SCALE: 1:500 (H) 1:125 (V) @ A3 / DATE: 2.11.2018	**High Street, KENSINGTON**	REVISION: 1

Appendix C

Field Work Results

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

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Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726-1993, 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.

Rock Descriptions

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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 - 2007. The terms used to describe rock strength are as follows:

Term	Abbreviation	Point Load Index $Is_{(50)}$ MPa	Approximate 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 $Is_{(50)}$. It should be noted that the UCS to $Is_{(50)}$ ratio varies significantly for different rock types and specific ratios should be determined for each site.

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 longer 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

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

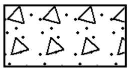
Symbols & Abbreviations

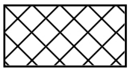
Graphic Symbols for Soil and Rock

General

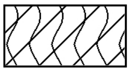
 Asphalt

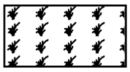
 Road base

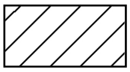
 Concrete

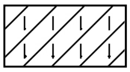
 Filling

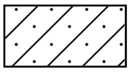
Soils

 Topsoil

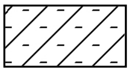
 Peat

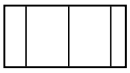
 Clay

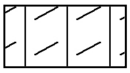
 Silty clay

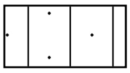
 Sandy clay

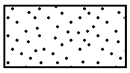
 Gravelly clay

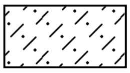
 Shaly clay

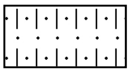
 Silt

 Clayey silt

 Sandy silt

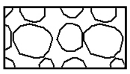
 Sand

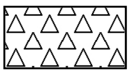
 Clayey sand

 Silty sand

 Gravel

 Sandy gravel

 Cobbles, boulders

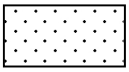
 Talus

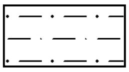
Sedimentary Rocks

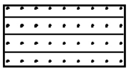
 Boulder conglomerate

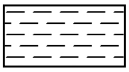
 Conglomerate

 Conglomeratic sandstone

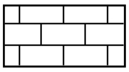
 Sandstone

 Siltstone

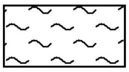
 Laminite

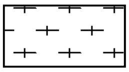
 Mudstone, claystone, shale

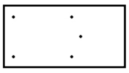
 Coal

 Limestone

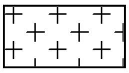
Metamorphic Rocks

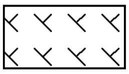
 Slate, phyllite, schist

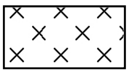
 Gneiss

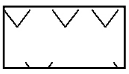
 Quartzite

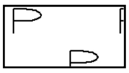
Igneous Rocks

 Granite

 Dolerite, basalt, andesite

 Dacite, epidote

 Tuff, breccia

 Porphyry

Cone Penetration Tests

Introduction

The Cone Penetration Test (CPT) is a sophisticated soil profiling test carried out in-situ. A special cone shaped probe is used which is connected to a digital data acquisition system. The cone and adjoining sleeve section contain a series of strain gauges and other transducers which continuously monitor and record various soil parameters as the cone penetrates the soils.

The soil parameters measured depend on the type of cone being used, however they always include the following basic measurements

- Cone tip resistance q_c
- Sleeve friction f_s
- Inclination (from vertical) i
- Depth below ground z

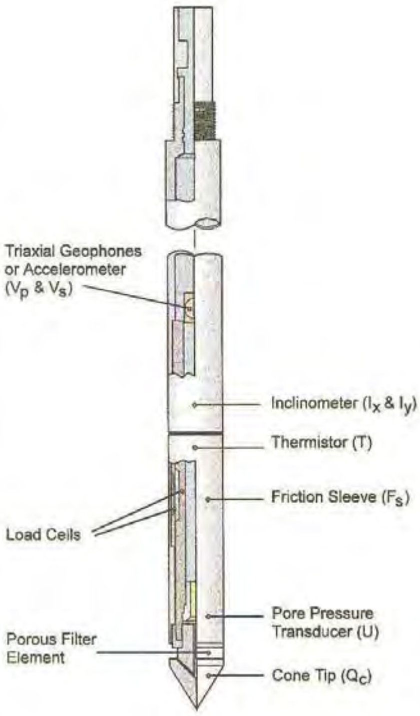


Figure 1: Cone Diagram

The inclinometer in the cone enables the verticality of the test to be confirmed and, if required, the vertical depth can be corrected.

The cone is thrust into the ground at a steady rate of about 20 mm/sec, usually using the hydraulic rams of a purpose built CPT rig, or a drilling rig. The testing is carried out in accordance with the Australian Standard AS1289 Test 6.5.1.

Figure 2: Purpose built CPT rig

The CPT can penetrate most soil types and is particularly suited to alluvial soils, being able to detect fine layering and strength variations. With sufficient thrust the cone can often penetrate a short distance into weathered rock. The cone will usually reach refusal in coarse filling, medium to coarse gravel and on very low strength or better rock. Tests have been successfully completed to more than 60 m.

Types of CPTs

Douglas Partners (and its subsidiary GroundTest) owns and operates the following types of CPT cones:

Type	Measures
Standard	Basic parameters (q_c, f_s, i & z)
Piezocone	Dynamic pore pressure (u) plus basic parameters. Dissipation tests estimate consolidation parameters
Conductivity	Bulk soil electrical conductivity (σ) plus basic parameters
Seismic	Shear wave velocity (V_s), compression wave velocity (V_p), plus basic parameters

Strata Interpretation

The CPT parameters can be used to infer the Soil Behaviour Type (SBT), based on normalised values of cone resistance (Qt) and friction ratio (Fr). These are used in conjunction with soil classification charts, such as the one below (after Robertson 1990)

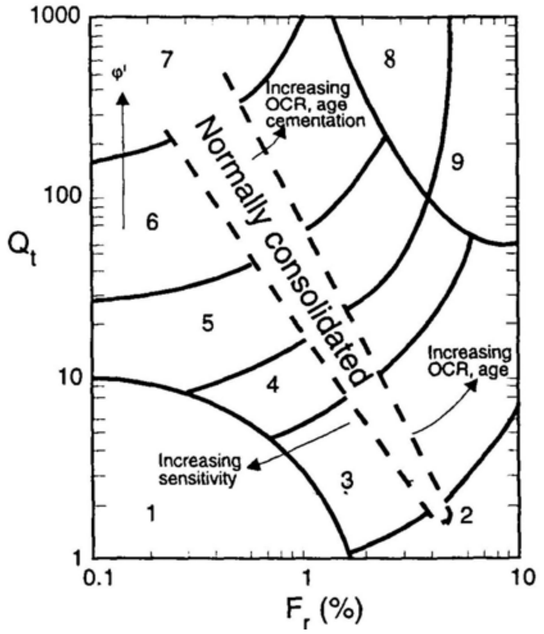


Figure 3: Soil Classification Chart

DP's in-house CPT software provides computer aided interpretation of soil strata, generating soil descriptions and strengths for each layer. The software can also produce plots of estimated soil parameters, including modulus, friction angle, relative density, shear strength and over consolidation ratio.

DP's CPT software helps our engineers quickly evaluate the critical soil layers and then focus on developing practical solutions for the client's project.

Engineering Applications

There are many uses for CPT data. The main applications are briefly introduced below:

Settlement

CPT provides a continuous profile of soil type and strength, providing an excellent basis for settlement analysis. Soil compressibility can be estimated from cone derived moduli, or known consolidation parameters for the critical layers (eg. from laboratory testing). Further, if pore pressure dissipation tests are undertaken using a piezocone, in-situ consolidation coefficients can be estimated to aid analysis.

Pile Capacity

The cone is, in effect, a small scale pile and, therefore, ideal for direct estimation of pile capacity. DP's in-house program ConePile can analyse most pile types and produces pile capacity versus depth plots. The analysis methods are based on proven static theory and empirical studies, taking account of scale effects, pile materials and method of installation. The results are expressed in limit state format, consistent with the Piling Code AS2159.

Dynamic or Earthquake Analysis

CPT and, in particular, Seismic CPT are suitable for dynamic foundation studies and earthquake response analyses, by profiling the low strain shear modulus G_0. Techniques have also been developed relating CPT results to the risk of soil liquefaction.

Other Applications

Other applications of CPT include ground improvement monitoring (testing before and after works), salinity and contaminant plume mapping (conductivity cone), preloading studies and verification of strength gain.

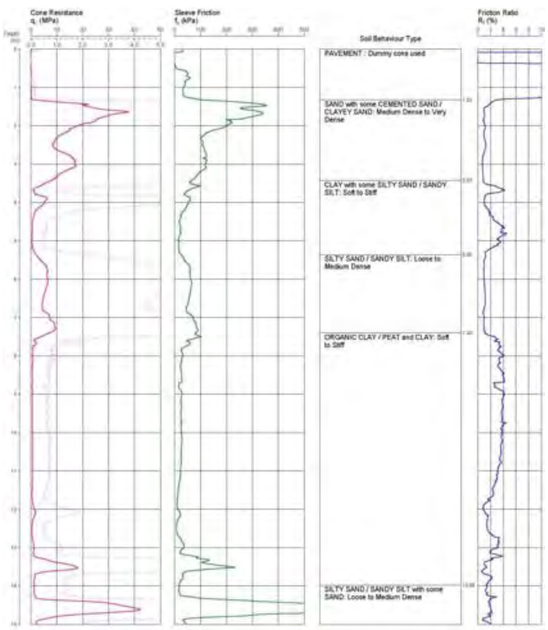


Figure 4: Sample Cone Plot

BOREHOLE LOG

CLIENT: University of New South Wales
PROJECT: Proposed Upgrade UNSW HALL SITE
LOCATION: High Street, Kensington

SURFACE LEVEL: 30.7 AHD
EASTING: 336344
NORTHING: 6245725
DIP/AZIMUTH: 90°/--

BORE No: 1
PROJECT No: 86457.00
DATE: 25/7/2018
SHEET 1 OF 1

Depth (m)	Description of Strata
0.2	FILLING: brown, fine to medium sand filling with a trace of fine sandstone gravel and some rootlets, moist
0.5	FILLING: dark grey, fine to medium sand filling with a trace of fine to medium gravel
0.7	FILLING: dark grey, sandy gravel filling, gravel is medium sandstone, sand is fine to medium, moist, terracotta and tile fragments (10-30mm)
3.0	SAND: medium dense, yellow mottled light grey fine to medium sand, moist 1.5m: becoming yellow-brown
	Bore discontinued at 3.0m Target depth reached

Sampling & In Situ Testing

Type	Depth
E*	0.0–0.1
A	0.1–0.2
A	0.4–0.5
E	0.4–0.5
B	0.5–0.7
E	0.9–1.0
A	0.9–1.0
A	1.5–1.6
E	1.6–1.7
A/E	2.9–3.0

RIG: 3t Excavator **DRILLER:** Brian **LOGGED:** SLB **CASING:** Uncased
TYPE OF BORING: Solid flight auger to 3.0m
WATER OBSERVATIONS: No free ground water observed whilst augering
REMARKS: *BD1/20182507taken from 0.0-0.1m

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: University of New South Wales
PROJECT: Proposed Upgrade UNSW HALL SITE
LOCATION: High Street, Kensington

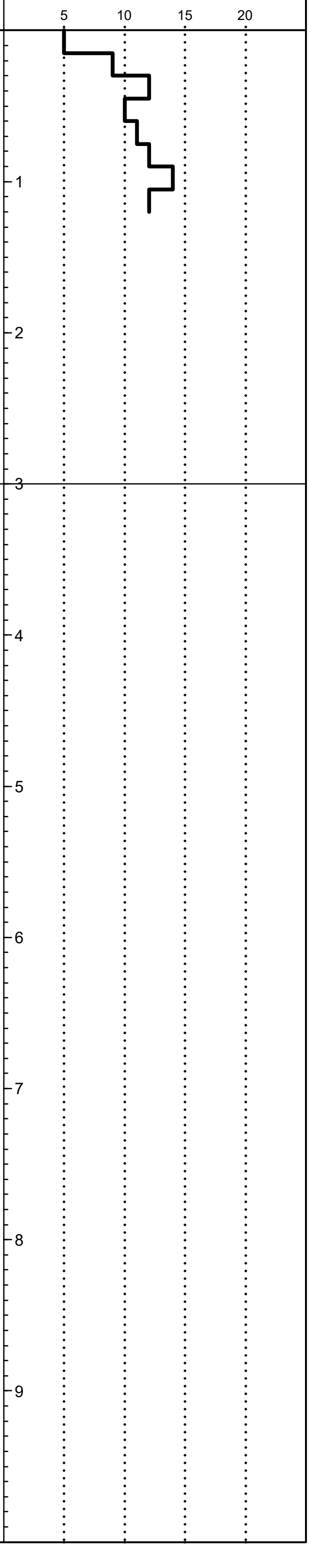
SURFACE LEVEL: 31.9 AHD
EASTING: 336388
NORTHING: 6245721
DIP/AZIMUTH: 90°/--

BORE No: 2
PROJECT No: 86457.00
DATE: 25/7/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		FILLING: dark brown fine to medium sand filling with a trace of asphaltic gravel, moist		E*	0.0–0.1			
	0.3			A	0.1–0.2			
	0.305	ASPHALTIC CONCRETE		A/E	0.4–0.5			
		FILLING: dark brown, fine to medium sand filling with some fine to medium gravel, gravel is sandstone and asphaltic concrete, moist 0.6m: piece of steel wire						
	0.8	SAND: dense, yellow-brown fine to medium sand, moist 1.2m: becoming yellow		A	0.9–1.0			
				E	1.0			
				B	1.2			
				A	1.7–1.8			
				E	1.8			
				A	2.9–3.0			
	3.0	Bore discontinued at 3.0m Target depth reached		E	3.0			

RL scale: 31 (at 1 m), 30 (2 m), 29 (3 m), 28 (4 m), 27 (5 m), 26 (6 m), 25 (7 m), 24 (8 m), 23 (9 m), 22.

Dynamic Penetrometer Test (blows per 150mm)



RIG: 3t Excavator **DRILLER:** Brian **LOGGED:** SLB **CASING:** Uncased
TYPE OF BORING: Solid flight auger to 3.0m
WATER OBSERVATIONS: No free ground water observed whilst augering
REMARKS: *BD3/20182507 taken from 0.0-0.1m

☒ 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: University of New South Wales
PROJECT: Proposed Upgrade UNSW HALL SITE
LOCATION: High Street, Kensington

SURFACE LEVEL: 33.2 AHD
EASTING: 336433
NORTHING: 6245705
DIP/AZIMUTH: 90°/--

BORE No: 3
PROJECT No: 86457.00
DATE: 26/7/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
33	0.05	BRICK PAVEMENT		A/E*	0.05				
	0.2	FILLING: dark brown, sandy gravel filling, gravel is fine to medium igneous and sandstone, sand is fine to coarse			0.1				
		Bore discontinued at 0.2m Auger refusal on sandstone boulder							

RIG: Hand Auger **DRILLER:** SLB **LOGGED:** SLB **CASING:** Uncased
TYPE OF BORING: Hand auger to 0.2m
WATER OBSERVATIONS: No free ground water observed whilst augering
REMARKS: *BD5/20182607 taken from 0.0-0.1m

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: University of New South Wales
PROJECT: Proposed Upgrade UNSW HALL SITE
LOCATION: High Street, Kensington

SURFACE LEVEL: 33.7 AHD
EASTING: 336431
NORTHING: 6245705
DIP/AZIMUTH: 90°/--

BORE No: 3A
PROJECT No: 86457.00
DATE: 26/7/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		FILLING: dark brown, fine to medium sand filling with a trace of fine to medium sandstone gravel, damp, trace of rootlets and bark (topsoil)		A/E	0.1 0.2				
	0.45	FILLING: dark brown sandy gravel filling, gravel is fine to medium igneous and sandstone, sand if fine to medium, damp, trace of carbonaceous material		A/E	0.4 0.5				
33	0.5	Bore discontinued at 0.5m Auger refusal on sandstone boulder							

RL scale: 33, 32, 31, 30, 29, 28, 27, 26, 25, 24. Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9. Penetrometer scale: 5, 10, 15, 20.

RIG: Hand Auger **DRILLER:** SLB **LOGGED:** SLB **CASING:** Uncased

TYPE OF BORING: Hand auger to 0.5m

WATER OBSERVATIONS: No free ground water observed whilst augering

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: University of New South Wales
PROJECT: Proposed Upgrade UNSW HALL SITE
LOCATION: High Street, Kensington

SURFACE LEVEL: 30.2 AHD
EASTING: 336341
NORTHING: 6245700
DIP/AZIMUTH: 90°/--

BORE No: 4
PROJECT No: 86457.00
DATE: 26/7/2018
SHEET 1 OF 2

Depth (m)	Description of Strata	Graphic Log	Water	Sample Type	Test Results & Comments
0.0–0.5	FILLING: dark brown, fine to medium sand filling with trace fine to medium gravel, moist 0.3m: piece of slag	Fill		A/E* (0.0); A (0.4); E (0.5)	
0.5–1.8	SAND: loose to medium dense, light grey fine to medium sand, damp	Sand		A (0.9); E (1.5)	
1.8–10.0	SAND: loose to medium dense, yellow mottled brown fine to medium sand, trace of fine sandstone gravel, damp 3.5m: becoming medium dense to dense, yellow 8.0m: thin band of silty fine sandy clay 8.65m: becoming very dense 9.8m: with some sandstone and ironstone gravel and some mottled grey silty sand	Sand	▼ 05-08-18 (~7.4m)	A (2.5); A (4.0); A (5.5); S (7.0–7.45); S (8.5–8.9)	7,7,8 N = 15 (S at 7.0m) 8,17,25/110 refusal (S at 8.5m)

RIG: Scout 4 **DRILLER:** RK **LOGGED:** SLB **CASING:** HW to 6.0m, HQ to 10.8m

TYPE OF BORING: Solid flight auger to 6.0m, rotary wash boring to 10.8m, NMLC-coring to 16.8m

WATER OBSERVATIONS: No free goundwater observed whilst augering

REMARKS: *BD4/20182507 taken from 0.0-0.1m, Well Installed (screen 16.8-7.8m, blank 7.8-GL, gravel 16.8-6.5m, bentonite 6.5-5.5m, backfill to GL, gatic cover)

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: University of New South Wales
PROJECT: Proposed Upgrade UNSW HALL SITE
LOCATION: High Street, Kensington

SURFACE LEVEL: 30.2 AHD
EASTING: 336341
NORTHING: 6245700
DIP/AZIMUTH: 90°/--

BORE No: 4
PROJECT No: 86457.00
DATE: 26/7/2018
SHEET 2 OF 2

Depth (m)	Description of Strata	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
	SAND: very dense, yellow sand, with some sandstone and ironstone gravel and some mottled grey silty sand	Unless otherwise stated rock is fractured along rough planar bedding dipping 0°-5°	S			30,30/140 refusal
10.7	SANDSTONE: very low strength, highly weathered, yellow-brown medium to coarse sandstone					
10.8	SANDSTONE: medium strength, slightly weathered, slightly fractured to unbroken, yellow-brown medium to coarse grained sandstone	11.46m: B 0°, pl, ro, cly co 11.53m: B 5°, pl, ro, cly 3mm 11.65m: B 10°, he, cbs 12.28m: J 30°, pl, ro, cly 5mm 13.27m: B 10°, pl, ro, cly 1mm	C	100	99	PL(A) = 0.4 PL(A) = 1 PL(A) = 0.7
14.28	SANDSTONE: high strength, fresh, slightly fractured then unbroken, light grey medium to coarse grained sandstone with carbonaceous laminations and some low strength bands	14.75m: B 3°, pl, ro, cly 10mm 15.25-15.27m: B 0°, pl, ro, cly 20mm J 45°, pl, ro, cly co J 45°, pl, ro, cly co	C	100	99	PL(A) = 0.5 PL(A) = 1.4 PL(A) = 1.2
16.8	Bore discontinued at 16.8m Target depth reached					

RIG: Scout 4 **DRILLER:** RK **LOGGED:** SLB **CASING:** HW to 6.0m, HQ to 10.8m

TYPE OF BORING: Solid flight auger to 6.0m, rotary wash boring to 10.8m, NMLC-coring to 16.8m

WATER OBSERVATIONS: No free goundwater observed whilst augering

REMARKS: *BD4/20182507 taken from 0.0-0.1m, Well Installed (screen 16.8-7.8m, blank 7.8-GL, gravel 16.8-6.5m, bentonite 6.5-5.5m, backfill to GL, gatic cover)

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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BORE:4 PROJECT: 86457.00 JULY 2018

10.8 – 15.0 m

BORE:4 PROJECT: 86457.00 JULY 2018

15.0 – 16.80 m

BOREHOLE LOG

CLIENT: University of New South Wales
PROJECT: Proposed Upgrade UNSW HALL SITE
LOCATION: High Street, Kensington

SURFACE LEVEL: 31.0 AHD
EASTING: 336405
NORTHING: 6245662
DIP/AZIMUTH: 90°/--

BORE No: 5
PROJECT No: 86457.00
DATE: 27/7/2018
SHEET 1 OF 2

Column headings: RL | Depth (m) | Description of Strata | Degree of Weathering (EW, HW, MW, SW, FS, FR) | Graphic Log | Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High) | Water | Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00) | Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault) | Sampling & In Situ Testing: Type, Core Rec. %, RQD %, Test Results & Comments

RL	Depth (m)	Description of Strata	Discontinuities	Type	Core Rec. %	RQD %	Test Results & Comments
31	0.05	ASPHALTIC CONCRETE		A/E*			
	0.25	FILLING: grey fine to medium gravel filling with some fine sand, humid (roadbase)		A/E			
	0.6	FILLING: light brown, fine to medium sand filling with some fine sandstone gravel and trace of medium igneous gravel, humid		A			
30	1	SAND: dense to very dense, yellow-brown fine to medium sand, humid		A/E			
		1.7m: becoming moist					
29	2	2.0m: becoming medium dense to dense					
28	3			A/E			
27	4			A			
		4.7m: becoming yellow					
26	5		Unless otherwise stated rock is fractured along rough planar bedding dipping at 0°-5°	A			
	5.4	SANDSTONE: low strength, highly to moderately weathered, red-brown medium to coarse grained sandstone		A			
	5.5		5.85m: B 0°, pl, ro, cln				PL(A) = 0.7
25	6	SANDSTONE: medium then high strength, moderately then slightly weathered, slightly fractured, red-brown and grey medium to coarse grained sandstone	5.91m: B 0°, pl, ro, cly 5mm 5.95m: B 0°, pl, ro, cly 5mm 6.61m: J 30°, pl, ro, cln, ti				PL(A) = 1.1
24	7			C	100	100	
	7.21	SANDSTONE: high strength, fresh, slightly fractured and unbroken, pale grey medium to coarse grained sandstone with some low strength bands, trace of carbonaceous flecks	7.47m: B 0°, pl, ro, cly, fg 10mm				PL(A) = 1.4
23	8		8.02 & 8.10m: B (x2) 0°, pl, ro, cly co 8.2m: B 5°, pl, ro, cly 5mm 8.29m: B 5°, pl, ro, fe 8.35m: J 20°, pl, ro, cln				PL(A) = 1.4
22	9		9.08m: J 20°, pl, ro, cln	C	100	100	
			9.54m: B 0°, pl, ro, cly 8mm 9.61m: B 5°, pl, ro, cly				PL(A) = 1.3

RIG: Scout 4 **DRILLER:** RK **LOGGED:** SLB **CASING:** HW to 5.5m
TYPE OF BORING: Solid flight auger to 5.5m, NMLC-coring to 11.68m
WATER OBSERVATIONS: No free ground water observed whilst augering
REMARKS: *BD2/20182507 taken from 0.1-0.2m

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: University of New South Wales
PROJECT: Proposed Upgrade UNSW HALL SITE
LOCATION: High Street, Kensington

SURFACE LEVEL: 31.0 AHD
EASTING: 336405
NORTHING: 6245662
DIP/AZIMUTH: 90°/--

BORE No: 5
PROJECT No: 86457.00
DATE: 27/7/2018
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
21–20	11	SANDSTONE: high strength, fresh, slightly fractured and unbroken, pale grey medium to coarse grained sandstone with some low strength bands, trace of carbonaceous flecks *(continued)*	co 10.07m: B 0°, pl, ro, cly co 10.6m: B 0°, pl, ro, cly co 10.74m: J 30°, pl, ro, cly 5mm	C	100	100	PL(A) = 0.9 PL(A) = 1.4
19–12	11.68 (12–19)	Bore discontinued at 11.68m Target depth reached					

RIG: Scout 4 **DRILLER:** RK **LOGGED:** SLB **CASING:** HW to 5.5m
TYPE OF BORING: Solid flight auger to 5.5m, NMLC-coring to 11.68m
WATER OBSERVATIONS: No free ground water observed whilst augering
REMARKS: *BD2/20182507 taken from 0.1-0.2m

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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BORE:5 PROJECT: 86457.00 JULY 2018

5.5 – 10.0 m

BORE:5 PROJECT: 86457.00 JULY 2018

10.0 – 11.68 m

BOREHOLE LOG

CLIENT: University of New South Wales
PROJECT: Proposed Upgrade UNSW HALL SITE
LOCATION: High Street, Kensington

SURFACE LEVEL: 34.7 AHD
EASTING: 336464
NORTHING: 6245682
DIP/AZIMUTH: 90°/--

BORE No: 6
PROJECT No: 86457.00
DATE: 25/7/2018
SHEET 1 OF 2

Depth (m)	Description of Strata	Water	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Sampling Type	Core Rec. %	RQD %	Test Results & Comments
0.1	ASPHALTIC CONCRETE			A			
0.3	FILLING: yellow-grey, gravelly medium sand filling, gravel is fine sandstone, humid (possible roadbase gravel)			A			
0.6	FILLING: dark grey, slightly gravelly filling with some silt, humid			A			
	SAND: loose to medium dense, light yellow-white fine to medium sand, humid			S			4,4,4 N = 8
				A			
1.9	SAND: loose to medium dense, yellow fine to coarse sand, damp			S			3,4,5 N = 9
	4.0m: medium dense			S			3,5,8 N = 13
			Unless otherwise stated rock is fractured along rough planar bedding dipping 0°-5°	S			3,8,20/130 refusal Bouncing
5.83	SANDSTONE: very low becoming low strength, highly weathered, fractured, orange and yellow-brown medium to coarse grained sandstone with some low strength bands	05-08-18	6.27m: B 10°, un, fe, pl, ro				PL(A) = 0.1
6.65			6.57m: CORE LOSS: 80mm				
6.71	SANDSTONE: high strength, slightly weathered then fresh, slightly fractured and unbroken red-brown and pale grey medium to coarse grained sandstone		6.65-6.71m: Cs 7.1m: B 10°, pl, sm, cly co	C	97	90	PL(A) = 0.8
							PL(A) = 1.4
			8.81m: B 5°pl, sm, cly inf 10mm	C	100	98	PL(A) = 1.1

RIG: Scout 4 **DRILLER:** RK **LOGGED:** SB/SLB **CASING:** HQ to 6.0m, HW to 5.5m
TYPE OF BORING: Solid flight auger to 5.5m, rotary wash boring to 6.0m, NMLC-coring to 12.05m
WATER OBSERVATIONS: Free ground water observed at 5.8m
REMARKS: Well Installed (screen 12.05-4.0m, blank 4.0-GL, gravel 12.05-3.5m, bentonite 3.5m-2.5m, backfill to GL, gatic cover)

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: University of New South Wales
PROJECT: Proposed Upgrade UNSW HALL SITE
LOCATION: High Street, Kensington

SURFACE LEVEL: 34.7 AHD
EASTING: 336464
NORTHING: 6245682
DIP/AZIMUTH: 90°/--

BORE No: 6
PROJECT No: 86457.00
DATE: 25/7/2018
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01 0.05 0.10 0.50 1.00)	Discontinuities (B - Bedding J - Joint S - Shear F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
24, 23	11, 12	SANDSTONE: high strength, slightly weathered then fresh, slightly fractured and unbroken red-brown and pale grey medium to coarse grained sandstone *(continued)*						10.09m: B 5°, pl, sm, cly co 10.19m: B 10°, pl, sm, st, cly 10.85m: B 10°, cln 11.19m: B 5°, pl, sm, inf, cly 10mm	C	100	98	PL(A) = 1.2 PL(A) = 1.5
22, 21, 20, 19, 18, 17, 16, 15	12.05, 13, 14, 15, 16, 17, 18, 19	Bore discontinued at 12.05m Target depth reached										

RIG: Scout 4 **DRILLER:** RK **LOGGED:** SB/SLB **CASING:** HQ to 6.0m, HW to 5.5m
TYPE OF BORING: Solid flight auger to 5.5m, rotary wash boring to 6.0m, NMLC-coring to 12.05m
WATER OBSERVATIONS: Free ground water observed at 5.8m
REMARKS: Well Installed (screen 12.05-4.0m, blank 4.0-GL, gravel 12.05-3.5m, bentonite 3.5m-2.5m, backfill to GL, gatic cover)

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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BORE:6 PROJECT: 86457.00 JULY 2018

6.0 – 10.0 m

BORE:6 PROJECT: 86457.00 JULY 2018

10.0 – 12.05 m

PIEZOCONE PENETRATION TEST

CLIENT: UNIVERSITY OF NEW SOUTH WALES

PROJECT: KENSINGTON UNSW, D14 UNSW HALL

LOCATION: HIGH ST, KENSINGTON

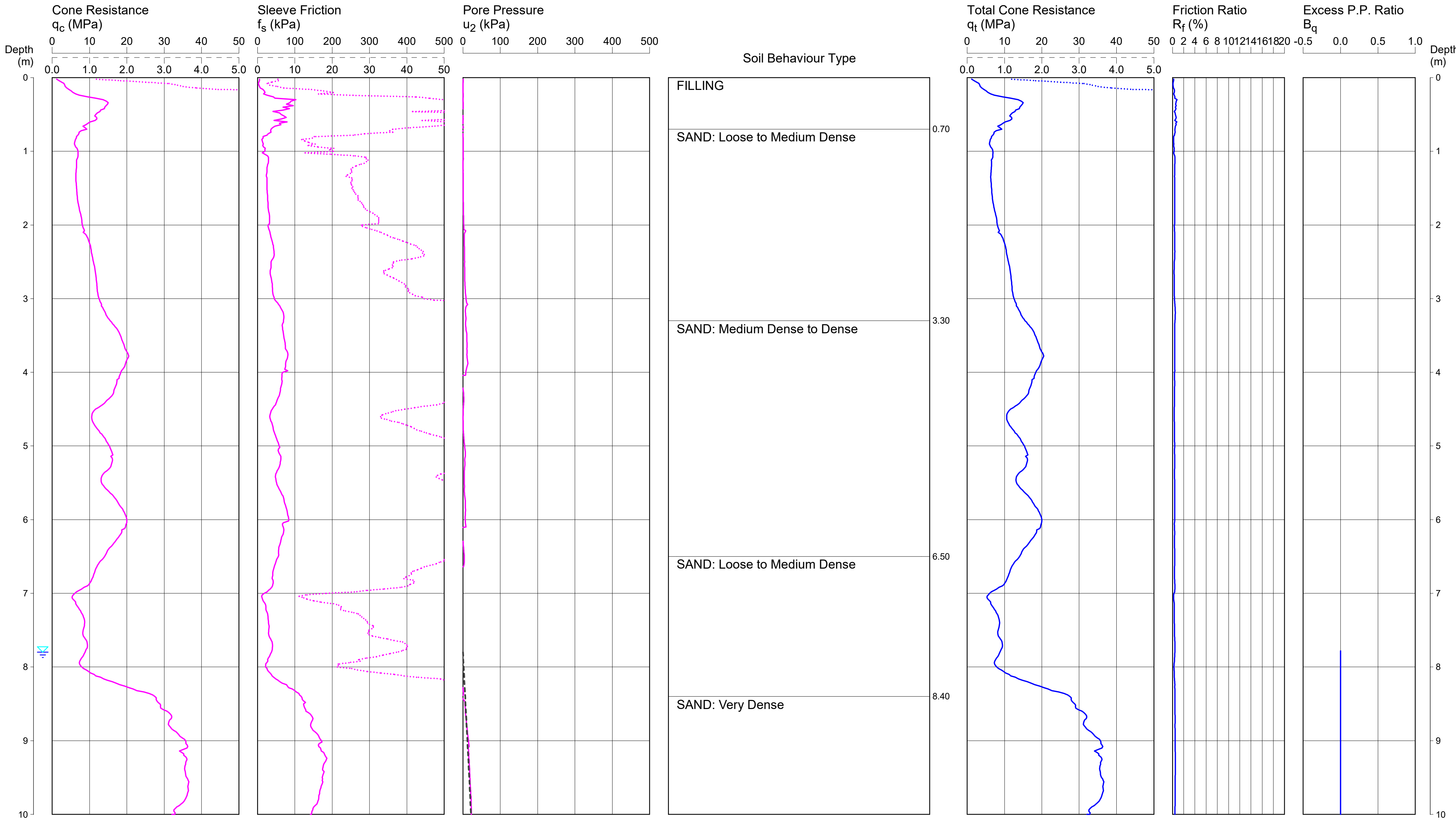
REDUCED LEVEL: 30.7 AHD

COORDINATES: 336344E 6245725N

CPT1

DATE 25/07/2018

PROJECT No: 86457



REMARKS: TEST DISCONTINUED DUE CONE TIP REFUSAL. GROUNDWATER OBSERVED AT 7.8 m AFTER WITHDRAWAL OF RODS.

Water depth after test: 7.80m depth (assumed)

File: P:\86457.00 - KENSINGTON UNSW, D14 UNSW HALL\4.0 Field Work\4.2 Testing\CPT\CPT1 Interpreted.CP5

Cone ID: 171006 **Type:** I-CFXYP20-10

ConePlot Version 5.9.2

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PIEZOCONE PENETRATION TEST

CLIENT: UNIVERSITY OF NEW SOUTH WALES

PROJECT: KENSINGTON UNSW, D14 UNSW HALL

LOCATION: HIGH ST, KENSINGTON

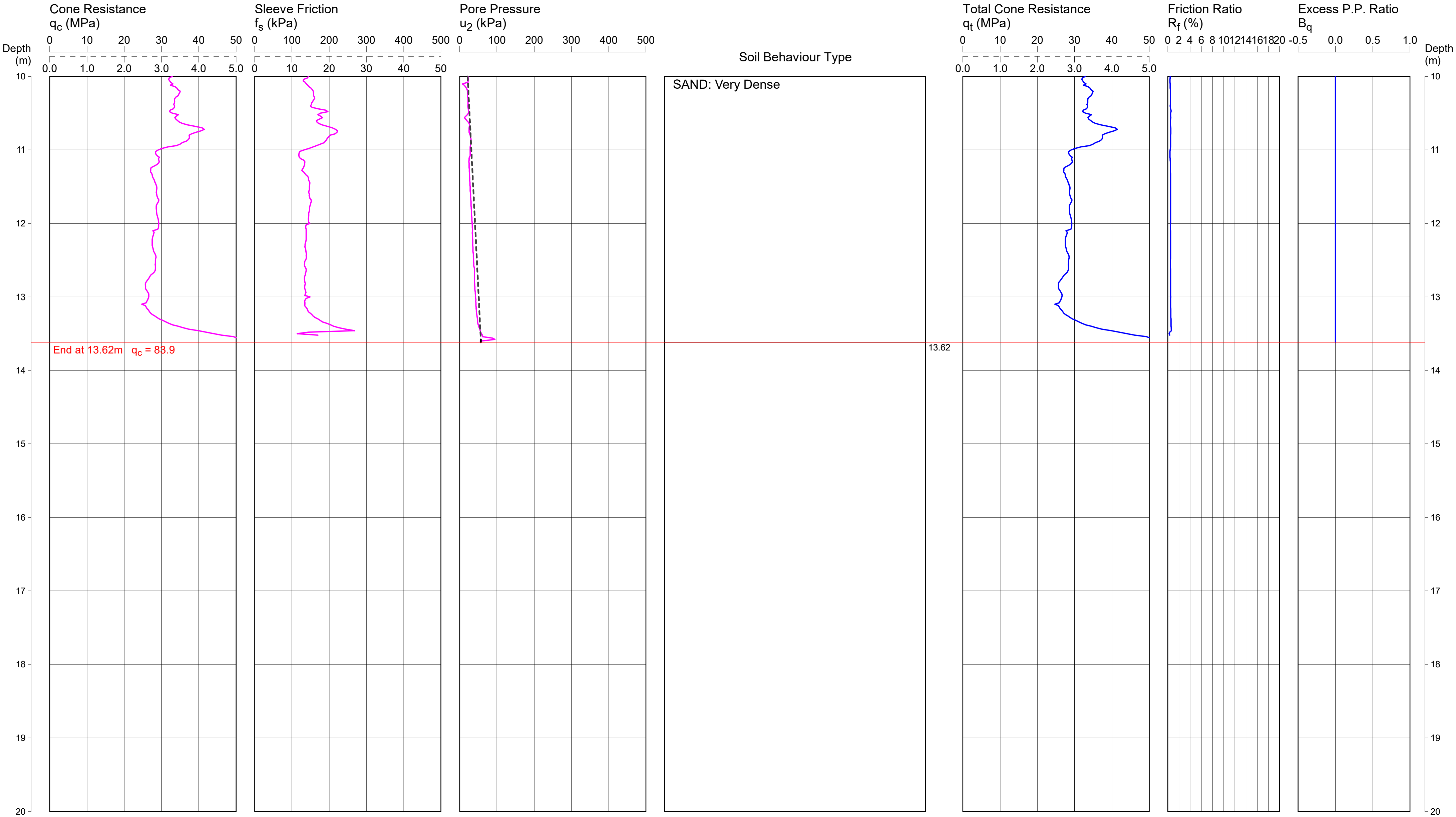
REDUCED LEVEL: 30.7 AHD

COORDINATES: 336344E 6245725N

CPT1

DATE 25/07/2018

PROJECT No: 86457



REMARKS: TEST DISCONTINUED DUE CONE TIP REFUSAL. GROUNDWATER OBSERVED AT 7.8 m AFTER WITHDRAWAL OF RODS.

Water depth after test: 7.80m depth (assumed)

File: P:\86457.00 - KENSINGTON UNSW, D14 UNSW HALL\4.0 Field Work\4.2 Testing\CPT\CPT1 Interpreted.CP5
Cone ID: 171006 **Type:** I-CFXYP20-10

ConePlot Version 5.9.2

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PIEZOCONE PENETRATION TEST

CLIENT: UNIVERSITY OF NEW SOUTH WALES

PROJECT: KENSINGTON UNSW, D14 UNSW HALL

LOCATION: HIGH ST, KENSINGTON

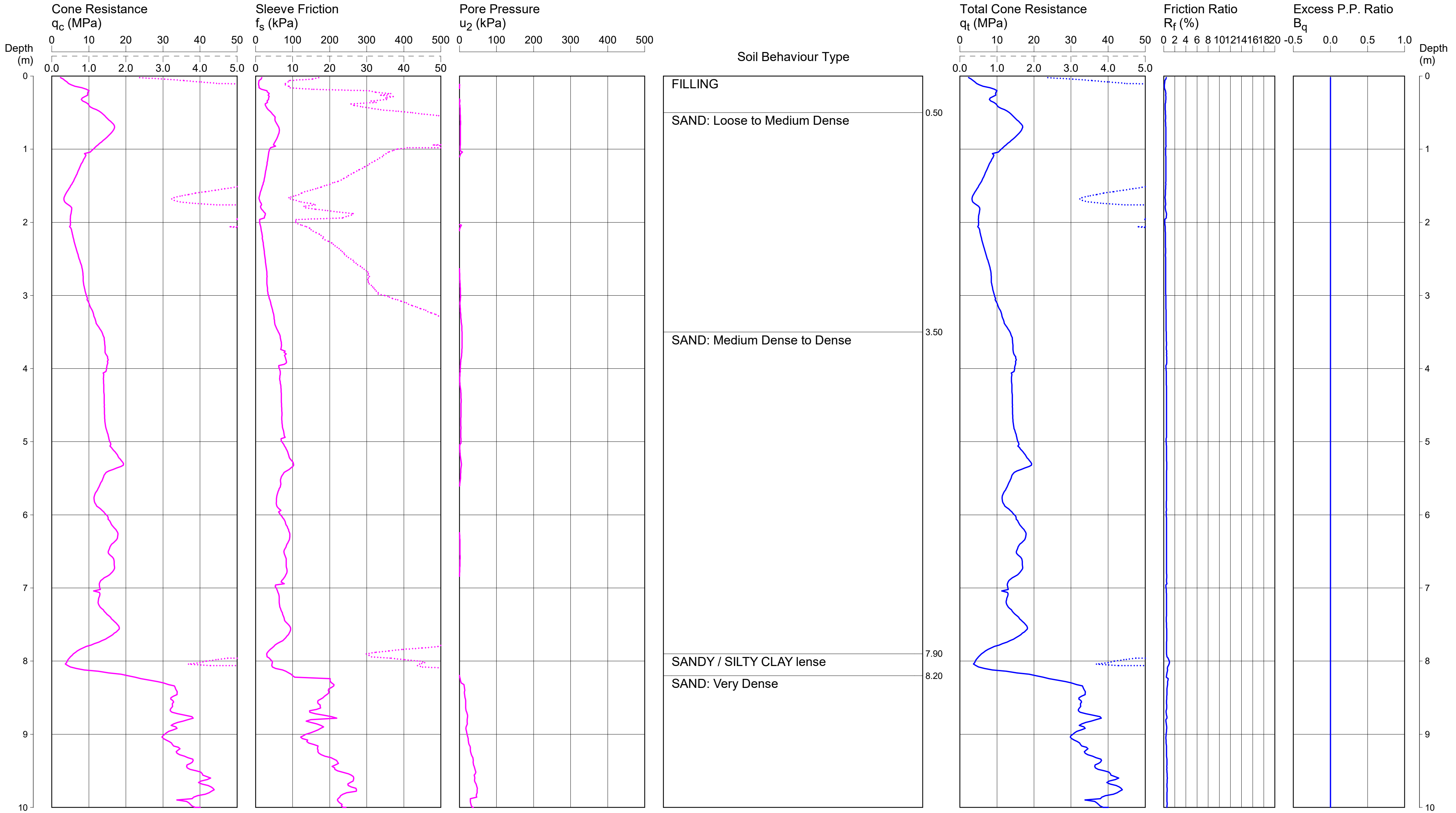
REDUCED LEVEL: 30.2 AHD

COORDINATES: 336341E 6245700N

CPT4

DATE 25/07/2018

PROJECT No: 86457



REMARKS: TEST DISCONTINUED DUE CONE TIP REFUSAL. HOLE COLLAPSE AT 7.2 m AFTER WITHDRAWAL OF RODS.

File: P:\86457.00 - KENSINGTON UNSW, D14 UNSW HALL\4.0 Field Work\4.2 Testing\CPT\CPT4 Interpreted.CP5
Cone ID: 140913 **Type:** I-CFXYP20-10

ConePlot Version 5.9.2

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PIEZOCONE PENETRATION TEST

CLIENT: UNIVERSITY OF NEW SOUTH WALES

PROJECT: KENSINGTON UNSW, D14 UNSW HALL

LOCATION: HIGH ST, KENSINGTON

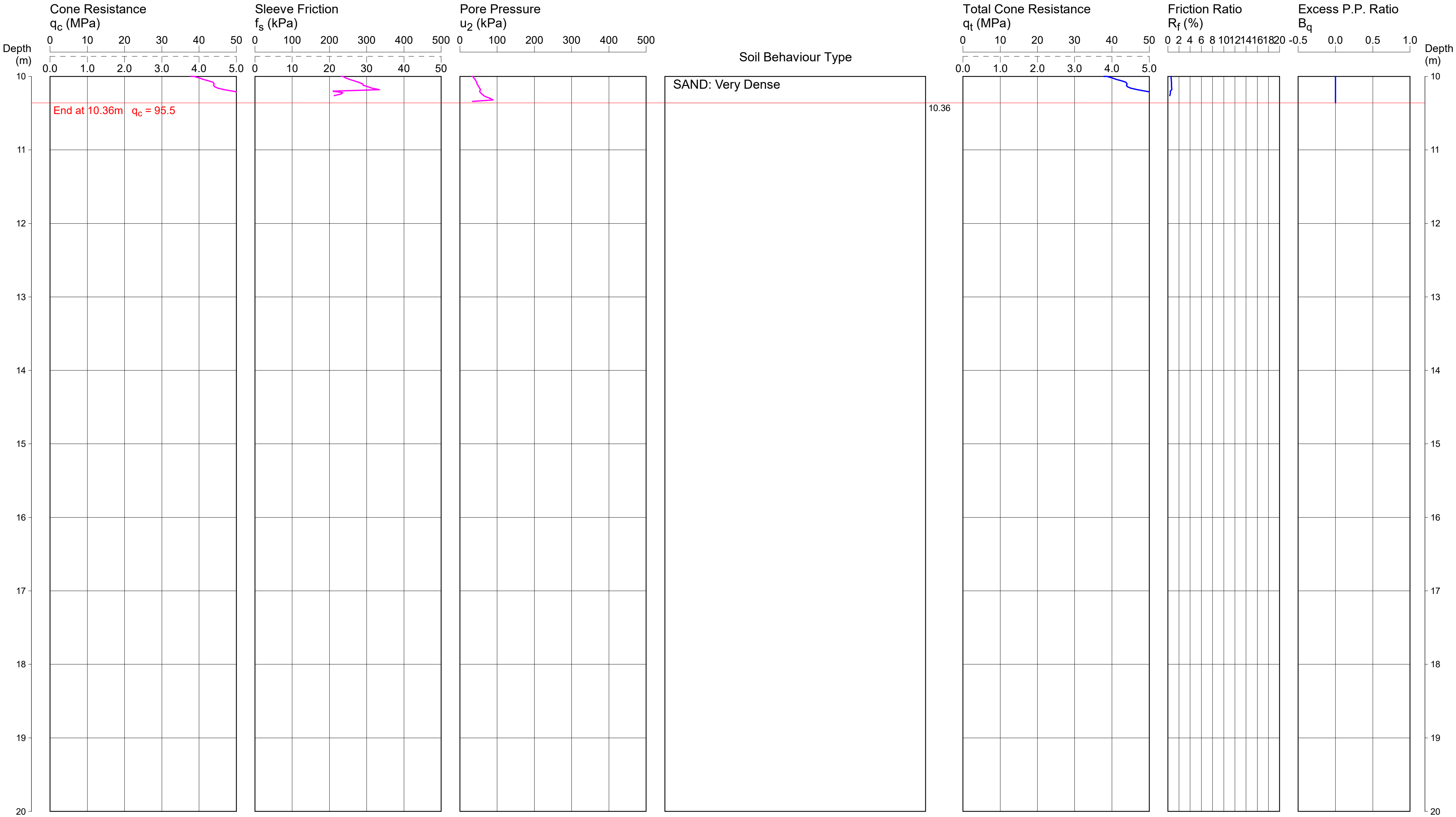
REDUCED LEVEL: 30.2 AHD

COORDINATES: 336341E 6245700N

CPT4

DATE 25/07/2018

PROJECT No: 86457



REMARKS: TEST DISCONTINUED DUE CONE TIP REFUSAL. HOLE COLLAPSE AT 7.2 m AFTER WITHDRAWAL OF RODS.

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Cone ID: 140913 **Type:** I-CFXYP20-10

ConePlot Version 5.9.2

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PIEZOCONE PENETRATION TEST

CLIENT: UNIVERSITY OF NEW SOUTH WALES

PROJECT: KENSINGTON UNSW, D14 UNSW HALL

LOCATION: HIGH ST, KENSINGTON

REDUCED LEVEL: 31.0 AHD

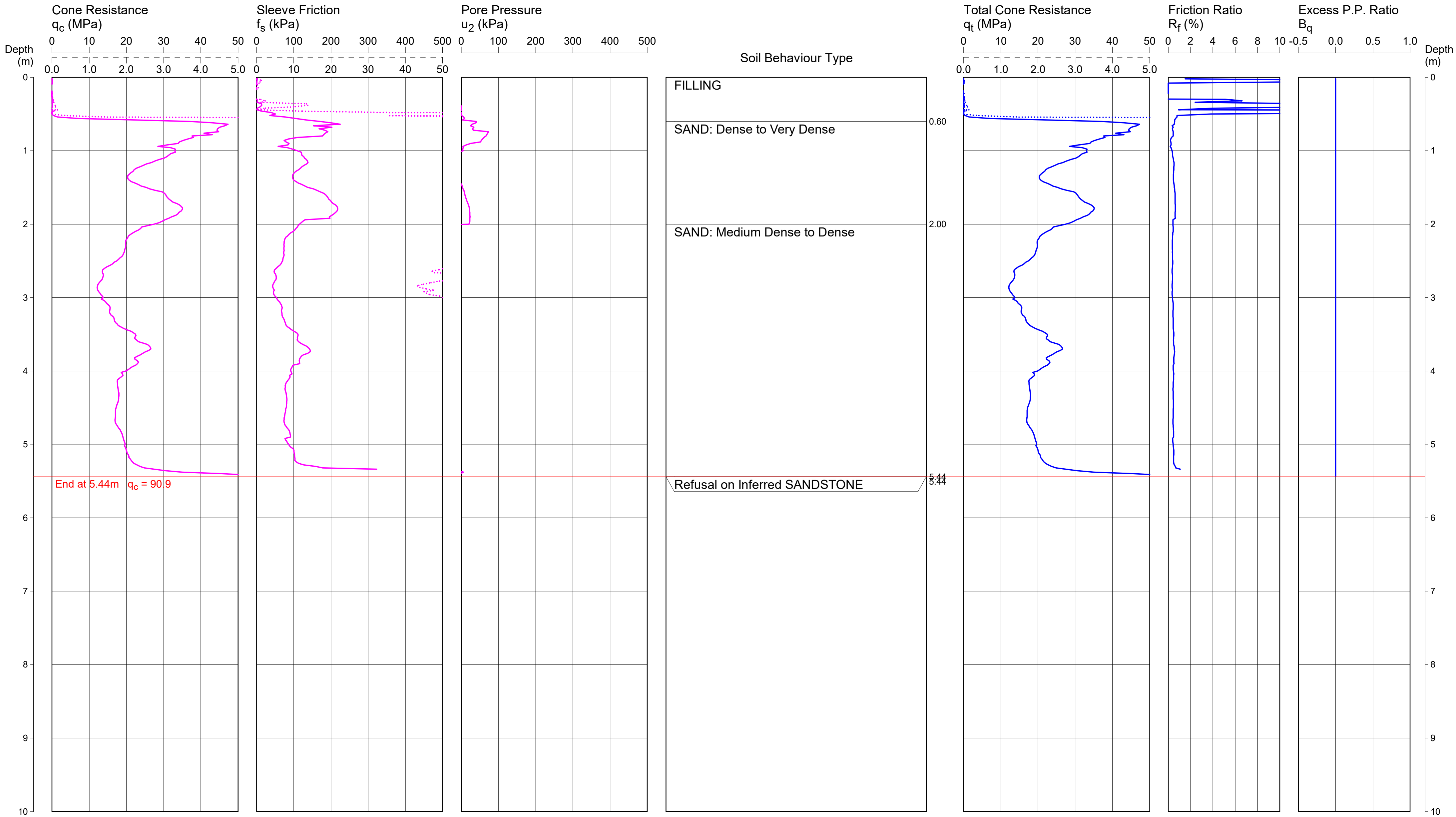
COORDINATES: 336405E 6245662N

CPT5

Page 1 of 1

DATE 25/07/2018

PROJECT No: 86457



REMARKS: DUMMY CONE FROM 0.0 m TO 0.6 m TO PENETRATE PAVEMENT AND FILLING. TEST DISCONTINUED DUE CONE TIP REFUSAL. HOLE COLLAPSED AT 2.6m AFTER WITHDRAWAL OF RODS

File: P:\86457.00 - KENSINGTON UNSW, D14 UNSW HALL\4.0 Field Work\4.2 Testing\CPT\CPT5 Interpreted.CP5

Cone ID: 1609 **Type:** I-CFXY-20-10

ConePlot Version 5.9.2

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PIEZOCONE PENETRATION TEST

CLIENT: UNIVERSITY OF NEW SOUTH WALES

PROJECT: KENSINGTON UNSW, D14 UNSW HALL

LOCATION: HIGH ST, KENSINGTON

REDUCED LEVEL: 34.7 AHD

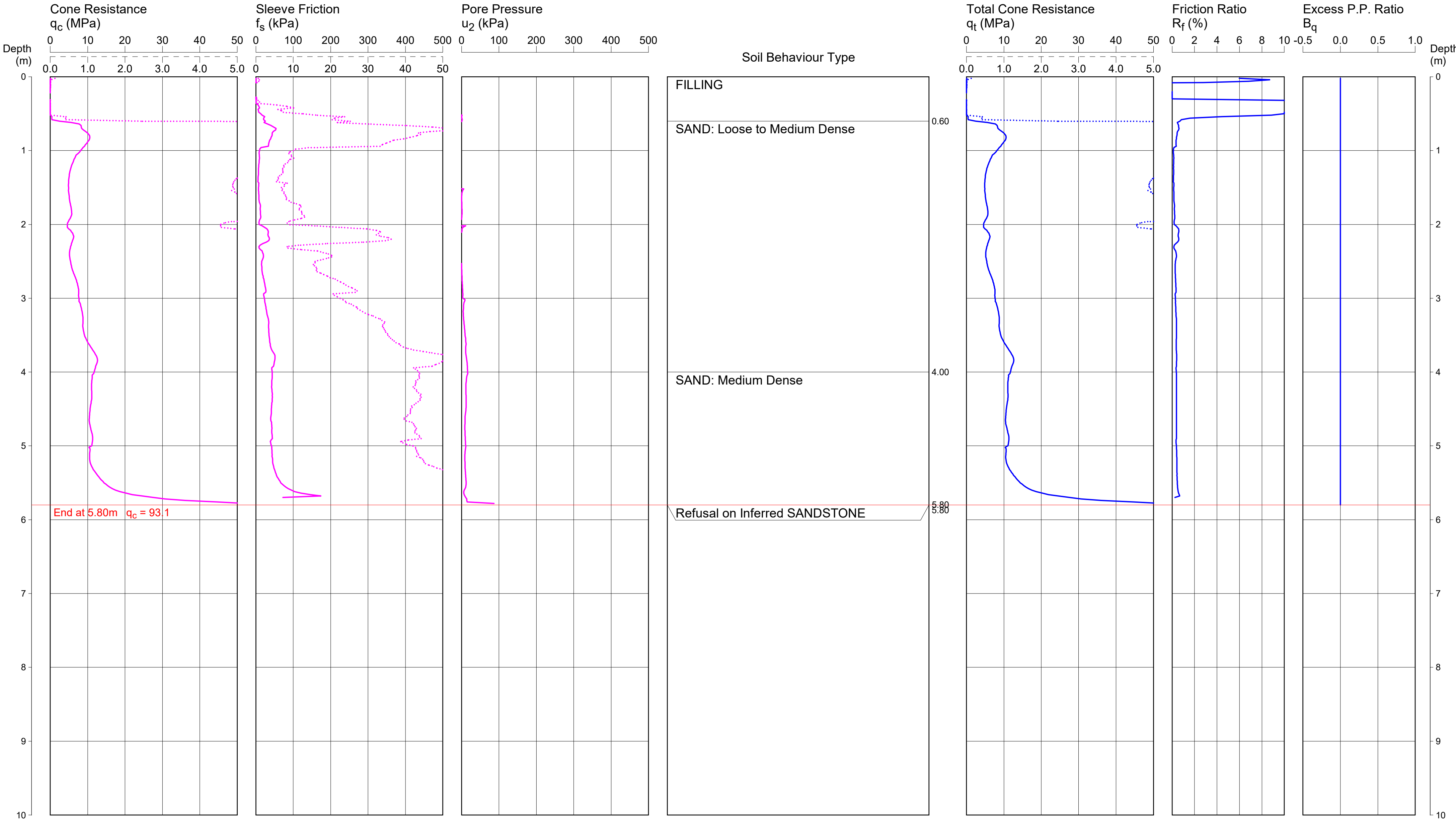
COORDINATES: 336464E 6245682N

CPT6

Page 1 of 1

DATE 25/07/2018

PROJECT No: 86457



REMARKS: TEST DISCONTINUED DUE CONE TIP REFUSAL. HOLE COLLAPSE AT 5.3 m AFTER WITHDRAWAL OF RODS.

File: P:\86457.00 - KENSINGTON UNSW, D14 UNSW HALL\4.0 Field Work\4.2 Testing\CPT\CPT6.CP5
Cone ID: 140913 **Type:** I-CFXYP20-10

ConePlot Version 5.9.2

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Appendix D

Laboratory Test Results

Material Test Report

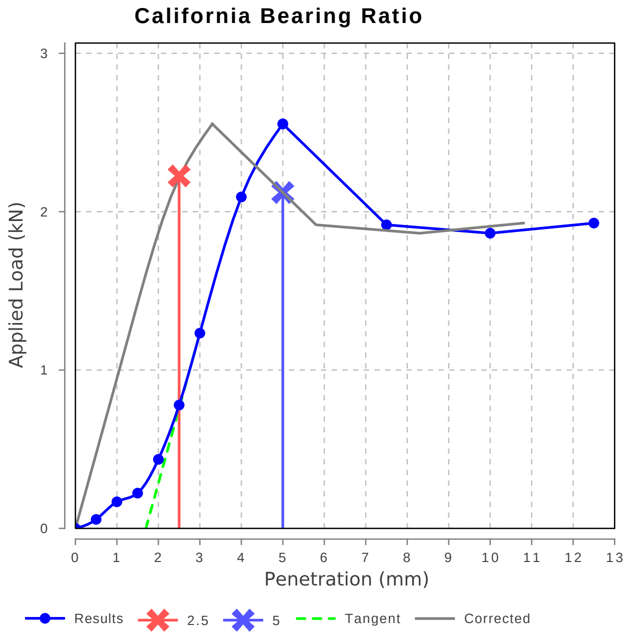
Report Number: **86457.00-1**
Issue Number: 1
Date Issued: 06/08/2018
Client: University of New South Wales
PO Box 1, Kensington NSW 2033
Contact: Tania Costa
Project Number: 86457.00
Project Name: Proposed Upgrade UNSW HALL SITE
Project Location: High Street, Kensington
Work Request: 3593
Sample Number: 18-3593A
Date Sampled: 25/07/2018
Sampling Method: Sampled by Engineering Department
Sample Location: **BH1 (0.7 - 1.0m)**
Material: Sand

Douglas Partners
Geotechnics / Environment / Groundwater
Douglas Partners Pty Ltd
Sydney Laboratory
96 Hermitage Road West Ryde NSW 2114
Phone: (02) 9809 0666
Fax: (02) 9809 0666
Email: mick.gref@douglaspartners.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Michael Gref
NATA Accredited Laboratory Number: 828

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**17**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.66		
Optimum Moisture Content (%)	16.5		
Laboratory Density Ratio (%)	100.5		
Laboratory Moisture Ratio (%)	100.0		
Dry Density after Soaking (t/m^3)	1.66		
Field Moisture Content (%)	6.0		
Moisture Content at Placement (%)	16.5		
Moisture Content Top 30mm (%)	17.3		
Moisture Content Rest of Sample (%)	16.0		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	102		
Swell (%)	0.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



Material Test Report

Douglas Partners
Geotechnics / Environment / Groundwater
Douglas Partners Pty Ltd
Sydney Laboratory
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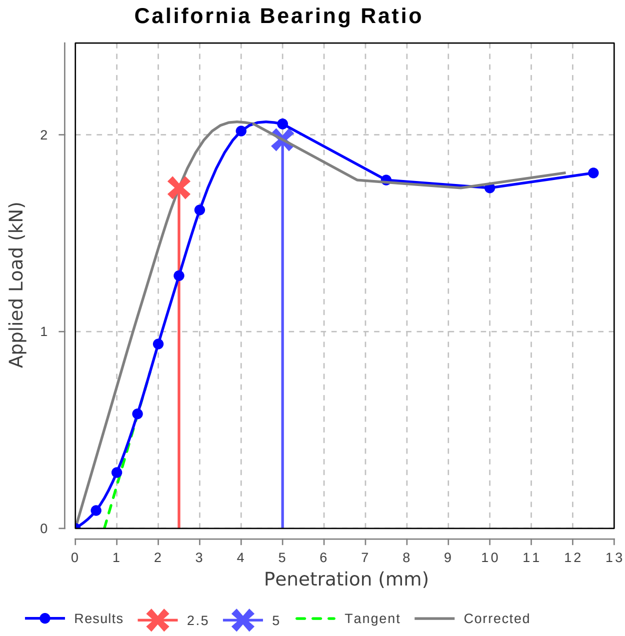
Email: mick.gref@douglaspartners.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Michael Gref
NATA Accredited Laboratory Number: 828

Report Number: **86457.00-1**
Issue Number: 1
Date Issued: 06/08/2018
Client: University of New South Wales
PO Box 1, Kensington NSW 2033
Contact: Tania Costa
Project Number: 86457.00
Project Name: Proposed Upgrade UNSW HALL SITE
Project Location: High Street, Kensington
Work Request: 3593
Sample Number: 18-3593B
Date Sampled: 25/07/2018
Sampling Method: Sampled by Engineering Department
Sample Location: **BH2 (0.8 - 1.1m)**
Material: Sand

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**13**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.65		
Optimum Moisture Content (%)	16.5		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	100.0		
Dry Density after Soaking (t/m^3)	1.65		
Field Moisture Content (%)	3.6		
Moisture Content at Placement (%)	16.4		
Moisture Content Top 30mm (%)	18.4		
Moisture Content Rest of Sample (%)	18.1		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	103		
Swell (%)	0.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



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

CERTIFICATE OF ANALYSIS 197337

Client Details

Client	Douglas Partners Pty Ltd
Attention	Sam Balian
Address	96 Hermitage Rd, West Ryde, NSW, 2114

Sample Details

Your Reference	**86457.00, UNSW, D14 Hall**
Number of Samples	4 Soil
Date samples received	31/07/2018
Date completed instructions received	31/07/2018

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.

Report Details

Date results requested by	07/08/2018
Date of Issue	06/08/2018

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Priya Samarawickrama, Senior Chemist

Authorised By

Jacinta Hurst, Laboratory Manager

Soil Aggressivity					
Our Reference	UNITS	197337-1	197337-2	197337-3	197337-4
Your Reference		BH2	BH4	BH5	BH6
Depth		0.4-0.5	8.5	4	1
Date Sampled		25/07/2018	26/07/2018	27/07/2018	25/07/2018
Type of sample		Soil	Soil	Soil	Soil
pH 1:5 soil:water	pH Units	7.1	7.2	7.0	5.8
Electrical Conductivity 1:5 soil:water	µS/cm	18	25	9	26
Resistivity by calculation	ohm m	560	400	1,100	390
Chloride, Cl 1:5 soil:water	mg/kg	<10	20	<10	10
Sulphate, SO4 1:5 soil:water	mg/kg	<10	<10	<10	22

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA 22nd ED 2510 and Rayment & Lyons. Resistivity is calculated from Conductivity.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Alternatively determined by colourimetry/turbidity using Discrete Analyer.

QUALITY CONTROL: Soil Aggressivity					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	1	7.1	6.9	3	101	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	1	18	18	0	102	[NT]
Resistivity by calculation	ohm m	0.1	Inorg-002	<0.1	1	560	540	4	[NT]	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	1	<10	<10	0	107	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	1	<10	<10	0	107	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

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.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

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.

Measurement Uncertainty estimates are available for most tests upon request.

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Geotechnics • Environment • Groundwater

CHAIN OF CUSTODY

Project Name: UNSW, D14 Hall
Project No: 86457.00 Sampler: SLB..
Project Mgr: SB ...Mob. Phone: 0414 716 493
Email: sam.balian@douglaspartners.com.au
Date Required: ......Standard...... Lab Quote No. ......

To: Envirolab Services
12 Ashley Street, Chatswood NSW 2068
Attn: Aileen Hie
Phone: 02 9910 6200 Fax: 02 9910 6201
Email: ahie@envirolabservices.com.au

Sample ID	Sample Depth (m)	Lab ID	Sampling Date	Sample Type S - soil W – water	Container type	Analytes: Aggresivity						Notes
BH2	0.4-0.5	1	25/7	S	Bag	X						
BH4	8.5	2	26/7	S	Bag	X						
BH5	4	3	27/7	S	Bag	X						
BH6	1	4	25/7	S	Bag	X						

Lab Report No. ...... Phone: (02) 9809 0666 Fax: (02) 9809 4095
Send Results to: Douglas Partners Address: 96 Hermitage Road, West Ryde 2114
Relinquished by: Sam Balian Signed: S.B. Date & Time: 9:10AM 31/7/18 Received By: KG ELS. Date & Time: 31/7/18 10:30
Relinquished by: Signed: Date & Time: Received By: Date & Time:

Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 197337
Date Received: 31/7/18
Time Received: 10:30
Received By: KG ELS.
Temp: Cool/Ambient
Cooling: Ice/Icepack 18.2
Security: Intact/Broken/None

Appendix E

Results of Previous Tests

CONE PENETRATION TEST

CLIENT: THE UNIVERSITY OF NEW SOUTH WALES

PROJECT: HIGH STREET HOUSING PROJECT

LOCATION: THE UNIVERSITY OF NEW SOUTH WALES, KENSINGTON

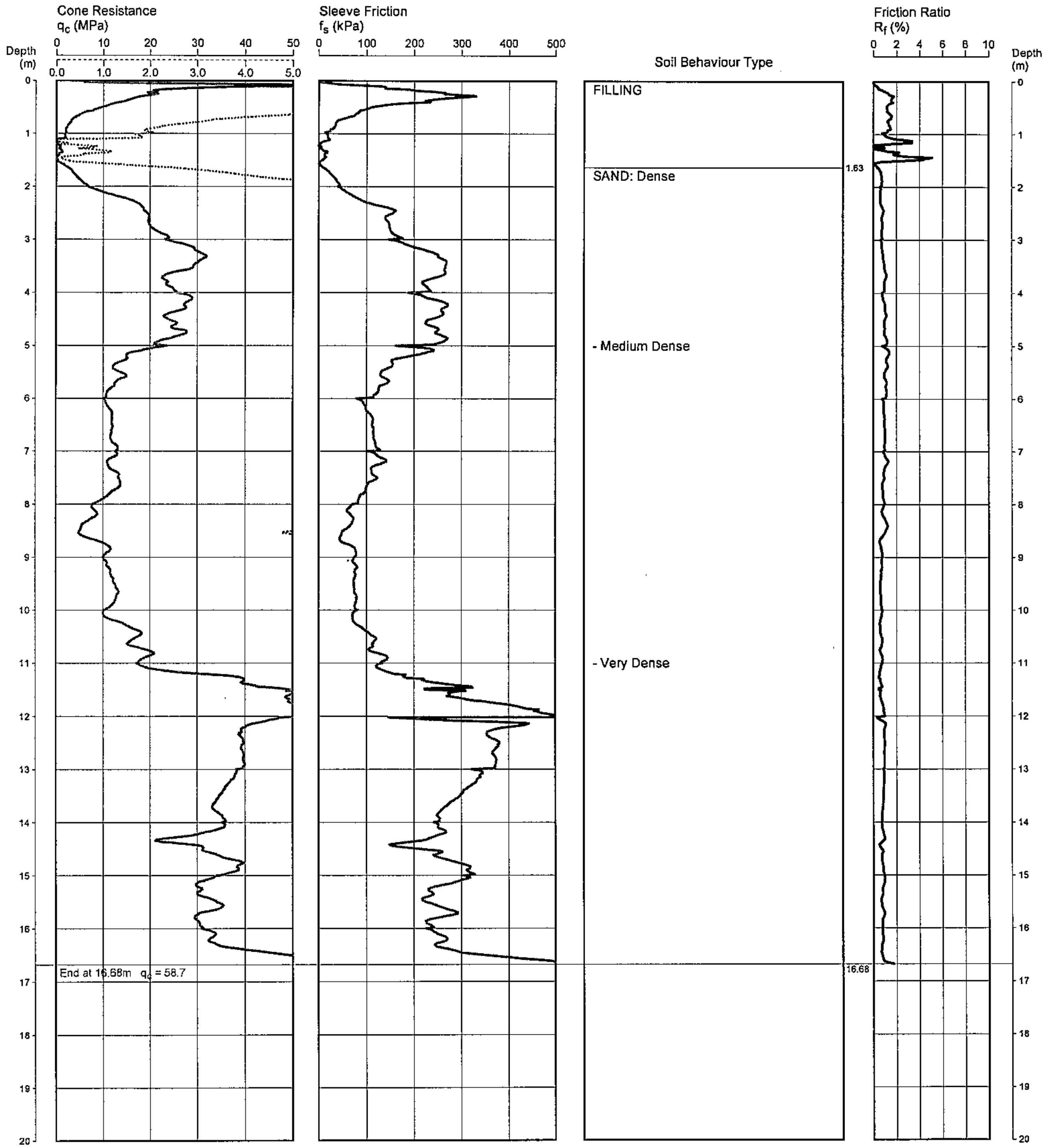
PROJECT No: 44301A

CPT 110

Page 1 of 1

DATE 25/09/2006

SURFACE RL: 31.8



REMARKS: HOLE COLLAPSED AT COMPLETION OF TEST: 1.6 m

Date Plotted	16/10/06
Checked	G

File: P:\44301A KENSINGTON , University of New South Wales GNJ\Field\44301A110.CP5
Cone ID: 417 **Type:** 2 Standard

ConePlot Version 5.8.1

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CONE PENETRATION TEST

CLIENT: THE UNIVERSITY OF NEW SOUTH WALES

PROJECT: HIGH STREET HOUSING PROJECT

LOCATION: THE UNIVERSITY OF NEW SOUTH WALES, KENSINGTON

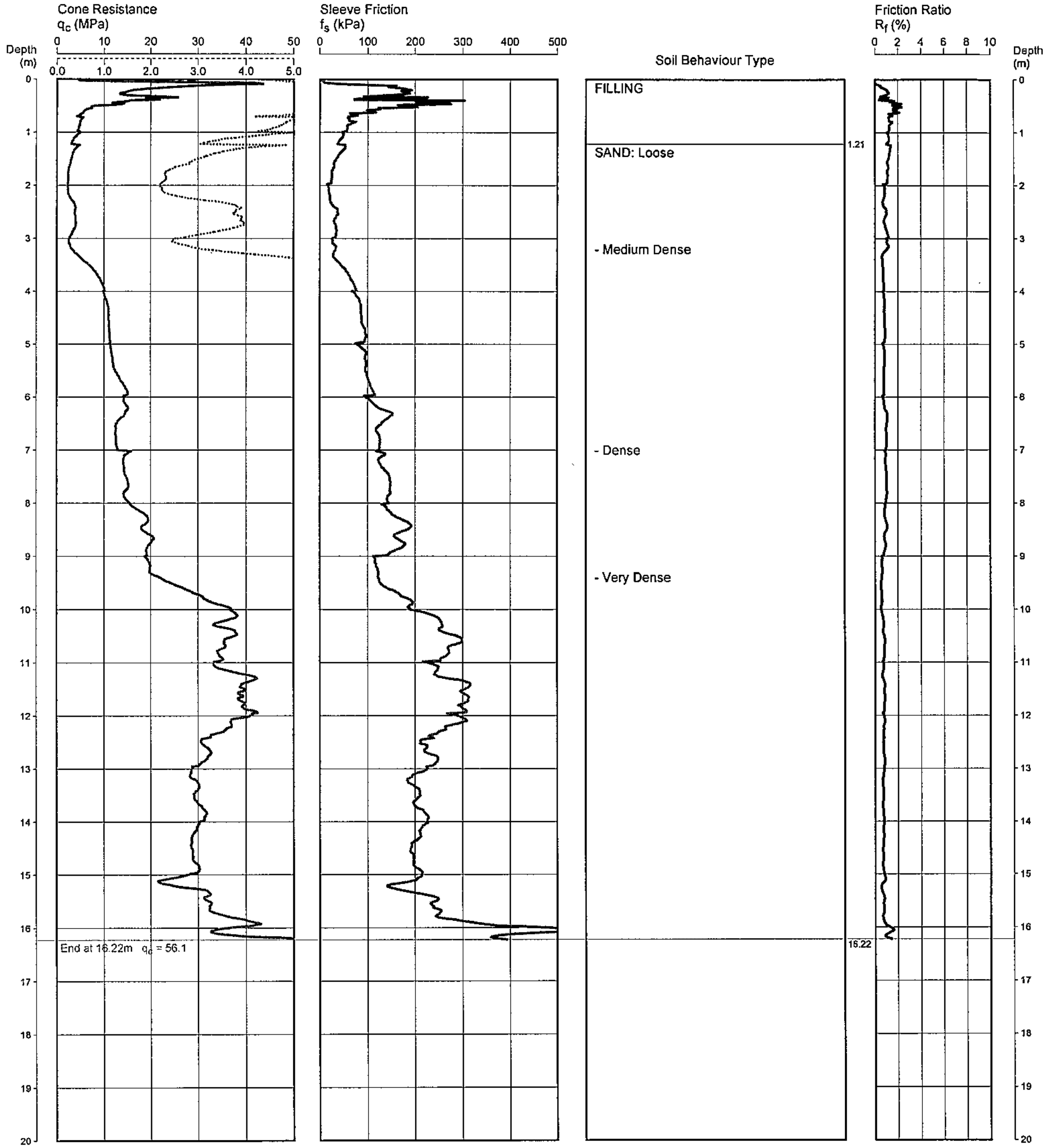
PROJECT No: 44301A

CPT 113

Page 1 of 1

DATE 25/09/2006

SURFACE RL: 33.4



REMARKS: HOLE COLLAPSED AT COMPLETION OF TEST: 0.7 m

Date Plotted 16/10/06
Checked CS

File: P:\44301A KENSINGTON , University of New South Wales GNJ\Field\44301A113.CP5
Cone ID: 417 Type: 2 Standard

ConePlot Version 5.8.1

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BOREHOLE LOG

CLIENT: The University of NSW	**SURFACE LEVEL:** 33.4	**BORE No:** 113A
PROJECT: High Street Housing Project	**EASTING:**	**PROJECT No:** 44301A
LOCATION: Gate 3 & 4, High Street, Kensington	**NORTHING:**	**DATE:** 06 Oct 06
	DIP/AZIMUTH: 90°/--	**SHEET** 1 OF 3

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01 0.05 0.10 0.50 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, D - Drill Break)	Type	Core Rec. %	RQD %	Test Results & Comments
	0.03	ASPHALTIC										
33		ROADBASE GRAVEL - gravelly roadbase with slag										
	0.6	FILLING - Light brown sandy filling with a trace of gravel and slag										
	1								A			
	1.2	SAND - orange brown medium grained sand with a trace of silt										
32												
	2											
31												
	3								A			
30												
	4											
29												
	5											
28												
	6											
27												
	6.5	SAND - light grey and orange brown coarse grained sand										
	7											
26												
	8											
25		- Gravelly band, possibly cemented										
	9	- With a trace of clay										
24												

RIG: Scout 2 **DRILLER:** Gogarty **LOGGED:** SI **CASING:** HW to 4.0m HQ to 19.0

TYPE OF BORING: Solid flight auger to 4.0m; Case Advance to 19.0m; NMLC-Coring to 22.05m

WATER OBSERVATIONS: No free groundwater observed whilst augering. See Borehole 113B for standing water level

REMARKS: Cone Penetration Test 113 carried out and Piezometer 113B installed

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: CG
Date: 17/10/06

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DOUGLAS PARTNERS PTY LTD
HIGH STREET HOUSING PROJECT - KENSINGTON
BORE 113A PROJECT 44301A OCT 2006
Kensinton 44310A B.H. 113A 6.10.06 Start 19M
19
20
21
22
END B/H 22.05M
19.00 - 22.05M

BOREHOLE LOG

CLIENT: The University of NSW
PROJECT: High Street Housing Project
LOCATION: Gate 3 & 4, High Street, Kensington

SURFACE LEVEL: 33.4
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 113A
PROJECT No: 44301A
DATE: 06 Oct 06
SHEET 2 OF 3

Depth (m)	Description of Strata	Discontinuities	Type	Core Rec. %	RQD %	Test Results & Comments
	SAND - light grey and orange brown coarse grained sand *(continued)*					
11.5	SAND - orange sand with occasional ironstone bands					
16.2	CLAYEY SAND - orange clayey sand with ironstone bands					
17.0	SANDSTONE -extremely low and very low strength sandstone	Note: Unless otherwise stated, rock is fractured along rough planar bedding planes or joints dipping at 0°- 10°				
18.5	SANDSTONE - medium strength medium to coarse grained sandstone					
19.0	SANDSTONE - medium then high strength, fresh, slightly fractured, light grey medium to coarse grained sandstone, with very low strength bands 19.45-19.70m: shale inclusions	19.15m: B5° 5mm clay 19.27m: B5° 2mm clay 19.44-19.54m: highly weathered shale inclusion 19.49m: J30° with clay	C	100	95	PL(A) = 0.5MPa

Discontinuities legend: B - Bedding, J - Joint, S - Shear, D - Drill Break

RIG: Scout 2 **DRILLER:** Gogarty **LOGGED:** SI **CASING:** HW to 4.0m, HQ to 19.0
TYPE OF BORING: Solid flight auger to 4.0m; Case Advance to 19.0m; NMLC-Coring to 22.05m
WATER OBSERVATIONS: No free groundwater observed whilst augering. See Borehole 113B for standing water level
REMARKS: Cone Penetration Test 113 carried out and Piezometer 113B installed

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: GG
Date: 17/10/06

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BOREHOLE LOG

CLIENT: The University of NSW
PROJECT: High Street Housing Project
LOCATION: Gate 3 & 4, High Street, Kensington

SURFACE LEVEL: 33.4
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 113A
PROJECT No: 44301A
DATE: 06 Oct 06
SHEET 3 OF 3

RL	Depth (m)	Description of Strata	Discontinuities	Type	Core Rec. %	RQD %	Test Results & Comments
13–11	21–22.05	SANDSTONE - medium then high strength, fresh, slightly fractured, light grey medium to coarse grained sandstone, with very low strength bands *(continued)* 21.26-22.05m: fine to medium grained	19.59m: B0° 2mm clay 20.59m: B0° 3mm clay 21.26m: B0° 10mm clay	C	100	95	PL(A) = 1.8MPa PL(A) = 2.1MPa
	22.05	Bore discontinued at 22.05m					

Discontinuities key: B - Bedding, J - Joint, S - Shear, D - Drill Break

RIG: Scout 2 **DRILLER:** Gogarty **LOGGED:** SI **CASING:** HW to 4.0m, HQ to 19.0

TYPE OF BORING: Solid flight auger to 4.0m; Case Advance to 19.0m; NMLC-Coring to 22.05m

WATER OBSERVATIONS: No free groundwater observed whilst augering. See Borehole 113B for standing water level

REMARKS: Cone Penetration Test 113 carried out and Piezometer 113B installed

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: G
Date: 17/10/06

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BOREHOLE LOG

CLIENT: University of NSW
PROJECT: Preliminary Contamination Assessment
LOCATION: High Street Housing Project, UNSW

SURFACE LEVEL: 33.36 *
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 113B
PROJECT No: 44301
DATE: 04 Oct 06
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.035	ASPHALT							Gatic cover
		FILLING - gravel and slag filling (basecourse)							
	0.6	FILLING - light brown sand filling with gravel and slag							
	1.2	SAND - light brown sand							Bentonite
	6.5	SAND - light grey and orange brown sand - with a trace of clay from 9.1m						▼ 05-10-06	Gravel Machine slotted PVC screen
	11.5	SAND - orange sand with occasional ironstone bands							End Cap
	16.15	Bore discontinued at 16.15m - auger refusal (on ironstone?)							

RIG: Bobcat **DRILLER:** I Drever **LOGGED:** NLE **CASING:** Uncased
TYPE OF BORING: 100mm diameter solid flight auger
WATER OBSERVATIONS: Free groundwater observed at 9.0m during drilling. Groundwater measured at 8.9m on 5/10/06
REMARKS: * Levelled from spot level taken from UNSW Facilities Management Drawing (24/08/06)

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: NE
Date: 17/10

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BOREHOLE LOG

CLIENT: University of NSW
PROJECT: Preliminary Contamination Assessment
LOCATION: High Street Housing Project, UNSW

SURFACE LEVEL: 34.3
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 116
PROJECT No: 44301
DATE: 21 Sep 06
SHEET 1 OF 1

Depth (m)	Description of Strata	Graphic Log	Sampling Type	Sampling Depth	Sample	Results & Comments	Water	Well Construction Details
0.03	ASPHALT							
0.2	FILLING - grey sand filling, with trace gravel		A	0.1–0.2		PID=9ppm		
0.6	SAND - light brown and grey sand, with trace roots, moist		A	0.5		PID=4ppm		
1.3	SAND - dark grey sand, moist to wet		A	1.0–1.5		PID=9ppm	▼ (1.2)	
2.4	SAND - light grey sand, wet							
3.2	SILTY SAND - brown silty sand, wet		A	2.5–3.0		PID=8ppm		
4.0	SAND - yellow brown sand with trace roots, wet		A	3.5–4.0		PID=5ppm		
	Bore discontinued at 4.0m - target depth reached							

RIG: Bobcat DRILLER: B Ellis LOGGED: NLE CASING: Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: Free groundwater observed at 1.2m

REMARKS: Soil registered <0.2 µSv/hr of radioactivity; levels interpolated from UNSW Facilities Management Drawing (24/08/06)

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED
Initials: NL
Date: 17/10

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CONE PENETRATION TEST

CLIENT: WATPAC NSW PTY LTD

PROJECT: ADDITIONAL GEOTECHNICAL INVESTIGATIONS

LOCATION: GATES 2-4 HIGH STREET, UNSW, KENSINGTON

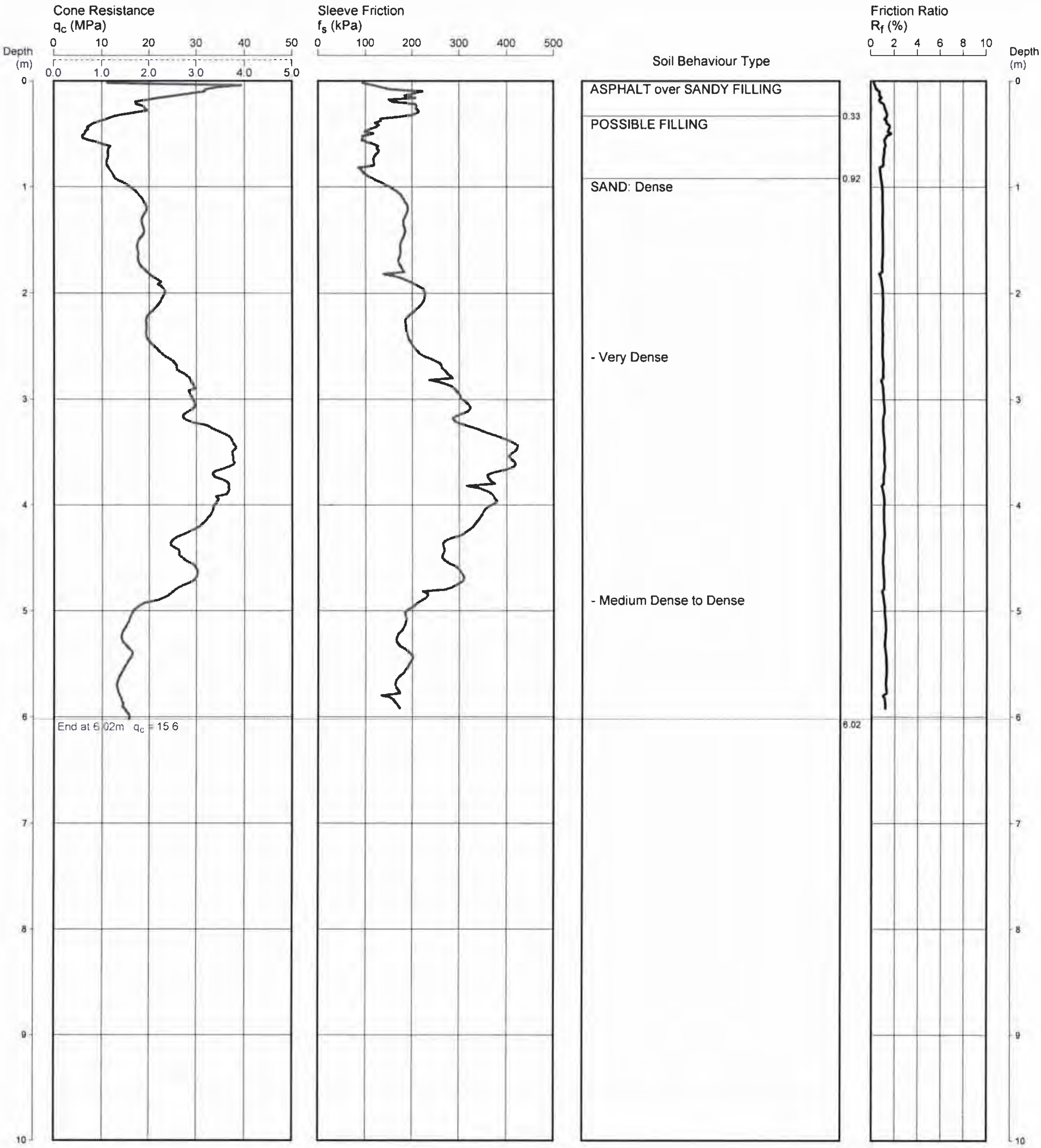
PROJECT No: 44301C

CPT 213

Page 1 of 1

DATE 24/10/2007

SURFACE RL: 32 0



REMARKS: HOLE COLLPASED AT 5 7 m

Date	16/11/07
Plotted	
Checked	

File: P:\44301C KENSINGTON, Additional Geotechnical Investigation GNJ\Field\cone\4430[illegible]
Cone ID: CONE-HS5 **Type:** 2 Standard

ConePlot Version 5.8.1

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Engineering Log - Borehole

coffey geotechnics

Borehole No.	**BH BG-8**
Sheet	1 of 3
Project No:	**GEOTLCOV24080AA**
Client:	**University of New South Wales C/- Taylor Thomson Whitting**
Date started:	**3.8.2010**
Principal:	
Date completed:	**3.8.2010**
Project:	**Basser and Goldstein Colleges - Geotechnical Investigation**
Logged by:	**DB**
Borehole Location:	**Kensington Campus, Gate 4**
Checked by:	**PJW**

drill model and mounting:	Hydrapower Truck	Easting:	336479.15	slope:	-90°	R.L. Surface:	34.9
hole diameter:	100 mm	Northing	6245717.69	bearing:	N/A	datum:	AHD

drilling information / material substance

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADT			None observed			0.0			**FILL:** BRICK PAVING				FILL: PAVEMENT
									FILL: CONCRETE				
				E					**FILL: SAND:** Fine to medium grained, dark brown, dark-pale grey, with some sub-angualr gravels, with some red brick.	D			SUB GRADE
				E									
					34	1							
				E						M			
				SPT 2,3,3 N*=6	33	2		SP	**SAND:** Medium grained, with some fine grained, pale grey-pale brown, yellow orange.		MD		DUNE SAND DEPOSITS
				SPT 2,6,6 N*=12	32	3							
					31	4		SP	**SAND:** Medium grained, yellow-pale brown.				
				SPT 1,7,8 N*=15	30	5							
					29	6			**SANDSTONE:** Fine to medium grained, pale grey-white, with orange and pale brown, highly weathered, estimated low strength.				WEATHERED BEDROCK
									Borehole BH BG-8 continued as cored hole				
					28	7							
					27	8							

method
AS auger screwing*
AD auger drilling*
RR roller/tricone
W washbore
CT cable tool
HA hand auger
DT diatube
B blank bit
V V bit
T TC bit
*bit shown by suffix
e.g. ADT

support
M mud N nil
C casing

penetration
1 2 3 4
no resistance ranging to refusal

water
10/1/98 water level on date shown
water inflow
water outflow

notes, samples, tests
U_{50} undisturbed sample 50mm diameter
U_{63} undisturbed sample 63mm diameter
D disturbed sample
N standard penetration test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
V vane shear (kPa)
P pressuremeter
Bs bulk sample
E environmental sample
R refusal

classification symbols and soil description
based on unified classification system

moisture
D dry
M moist
W wet
Wp plastic limit
W_L liquid limit

consistency/density index
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

BOREHOLE GEOTLCOV24080AA.GPJ COFFEY.GDT 9.24.10

Form GEO 5.3 Issue 3 Rev.2

Engineering Log - Cored Borehole

Borehole No.	**BH BG-8**
Sheet	2 of 3
Project No:	**GEOTLCOV24080AA**
Client:	**University of New South Wales C/- Taylor Thomson Whitting**
Date started:	**3.8.2010**
Principal:	
Date completed:	**3.8.2010**
Project:	**Basser and Goldstein Colleges - Geotechnical Investigation**
Logged by:	**DB**
Borehole Location:	**Kensington Campus, Gate 4**
Checked by:	**PJW**

drill model & mounting: Hydrapower Truck | Easting: 336479.15 | slope: -90° | R.L. Surface: 34.9

hole diameter: 100 mm | Drilling fluid: | Northing: 6245717.69 | bearing: N/A | datum: AHD

method	core-lift	water	RL	depth metres	graphic log / core recovery	material: rock type; grain characteristics, colour, structure, minor components	weathering alteration	estimated strength (VL L M H VH EH)	Is(50) MPa D-diametral A-axial	RQD %	defect spacing mm (30 100 300 1000 3000)	defect description: type, inclination, planarity, roughness, coating, thickness (particular / general)
		None observed	34	1								
			33	2								
			32	3								
			31	4								
			30	5								
			29	6		Continued from non-cored borehole						
NMLC						**SANDSTONE:** Fine to medium grained, pale brown-orange-pale grey, indistinctly bedded at 10°, black carbonaceous flecks.	DW		D 0.04, A 0.05			SM, 0°, PL, 15mm, Clayey sand
												SM, 0°, PL, 10mm, Clayey sand
			28	7								SM, 0°, PL, 25mm, Clayey sand
									D 0.29, A 0.2	91		
												PT, 0°, IR, VR, CN
												JT, 35°, IR, VR, SN-Iron
			27	8			SW					PT, 10°, PL, RO, CN

method
DT diatube
AS auger screwing
AD auger drilling
RR roller/tricone
CB claw or blade bit
NMLC NMLC core
NQ, HQ, PQ wireline core

core-lift
casing used
barrel withdrawn

graphic log/core recovery
core recovered - graphic symbols indicate material
no core recovered

water
10/1/98 water level on date shown
water inflow
partial drill fluid loss
complete drill fluid loss
25 water pressure test result (lugeons) for depth interval shown

weathering
FR fresh
SW slightly weathered
MW moderately weathered
HW highly weathered
XW extremely weathered
DW distinctly weathered (covers MW and HW)

strength
VL very low
L low
M medium
H high
VH very high
EH extremely high

defect type
JT joint
PT parting
SM seam
SZ sheared zone
SS sheared surface
CS crushed seam

planarity
PL planar
CU curved
UN undulating
ST stepped
IR irregular

roughness
VR very rough
RO rough
SO smooth
SL slickensided

coating
CN clean
SN stained
VN veneer
CO coating

coffey geotechnics

Engineering Log - Cored Borehole

Borehole No.	**BH BG-8**
Sheet	3 of 3
Project No:	**GEOTLCOV24080AA**
Client:	**University of New South Wales C/- Taylor Thomson Whitting**
Date started:	**3.8.2010**
Principal:	
Date completed:	**3.8.2010**
Project:	**Basser and Goldstein Colleges - Geotechnical Investigation**
Logged by:	**DB**
Borehole Location:	**Kensington Campus, Gate 4**
Checked by:	**PJW**

drill model & mounting:	Hydrapower Truck	Easting:	336479.15	slope:	-90°	R.L. Surface:	34.9
hole diameter:	100 mm Drilling fluid:	Northing:	6245717.69	bearing:	N/A	datum:	AHD

drilling information | material substance | rock mass defects

method	core-lift	water	RL	depth metres	graphic log / core recovery	material: rock type; grain characteristics, colour, structure, minor components	weathering alteration	estimated strength (VL L M H VH EH)	$Is_{(50)}$ MPa (D- diametral, A- axial)	RQD %	defect spacing mm (30 100 300 1000 3000)	defect description: type, inclination, planarity, roughness, coating, thickness (particular / general)
NMLC		None observed				**SANDSTONE:** Fine to medium grained, pale grey-dark grey-off white, distinctly bedded at 12°-15°, some dark grey laminations, with some black carbonaceous flecks and some medium to coarse grained bands < 30mm.	FR		D 1.76 A 1.36			SM, 0°, IR, 20mm, Clay
			26	9		**SANDSTONE:** Fine to medium grained, pale grey-off white, distinctly bedded at 15°, with some black carbonaceous flecks, and dark grey laminations.			D 1.38 A 1.68			SM, 5°, PL, 5mm, Clay
			25	10					D 1.83 A 1.42			
						BH BG-8 terminated at 10m						
			24	11								
			23	12								
			22	13								
			21	14								
			20	15								
			19	16								

method
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AS auger screwing
AD auger drilling
RR roller/tricone
CB claw or blade bit
NMLC NMLC core
NQ, HQ, PQ wireline core

core-lift
casing used
barrel withdrawn

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core recovered - graphic symbols indicate material
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PT parting
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CS crushed seam

planarity
PL planar
CU curved
UN undulating
ST stepped
IR irregular

roughness
VR very rough
RO rough
SO smooth
SL slickensided

coating
CN clean
SN stained
VN veneer
CO coating


PROJECT UNSW
JOB NO GEOTLCOV24080AA
BH NO BH BG-8 DATE 31 AUG 2010
DEPTH 6.10M TO 10.00M
coffey geotechnics
SPECIALISTS MANAGING THE EARTH
GEOTLCOV24080AA BH BG-8 START OF CORE AT 6.10M 31-8-2010
6
7
8
9