coffey geotechnics
SPECIALISTS MANAGING THE EARTH

# GEOTECHNICAL AND ENVIRONMENTAL REPORT, PROPOSED MSB BUILDING

University of New South Wales

GEOTLCOV24080AC-AB
11 October 2010

**Coffey Geotechnics Pty Ltd** ABN 93 056 929 483
8/12 Mars Road Lane Cove West NSW 2066 Australia

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

11 October 2010

University of New South Wales
C/- Taylor Thomson Whitting
Level 3, 48 Chandos Street,
St Leonards, NSW 2065

**Attention: Richard Green**

Dear Sir

**RE: UNSW MSB Development Project, Geotechnical and Environmental Investigation.**

Coffey Geotechnics Pty Ltd is pleased to present the results of geotechnical and environmental investigations for the proposed University of New South Wales MSB development project being implemented at the Kensington Campus.

Should you have any queries or comments regarding this report please contact Dan Gorman or the undersigned on (02) 9911 1000.

For and on behalf of Coffey Geotechnics Pty Ltd

Peter Waddell

**Peter Waddell**

Principal Engineer

| | |
|---|---|
| Distribution: | Original held by Coffey Geotechnics Pty Ltd |
| | 1 copy held by Coffey Geotechnics Pty Ltd |
| | 4 hard copies and electronic copy to UNSW C/- Taylor Thomson Whitting |

**Coffey Geotechnics Pty Ltd** ABN 93 056 929 483
8/12 Mars Road Lane Cove West NSW 2066 Australia
PO Box 125 North Ryde NSW 1670 Australia
T (+61) (2) 9911 1000 F (+61) (2) 9911 1001 www.coffey.com/geotechnics

# CONTENTS

# CONTENTS

# CONTENTS

**Figures**

**Appendices**

# 1 INTRODUCTION

This report presents the results of geotechnical and environmental investigations carried out by Coffey Geotechnics Pty Ltd (Coffey) on behalf of University of New South Wales (UNSW) for the proposed MSB development project at the UNSW, Kensington Campus.

The investigation was undertaken in general accordance with the scope of works presented in our initial proposal; reference GEOTLCOV24080AC-AA, dated 6 September 2010.

It is understood that the project is currently at an early planning stage and that the results of this investigation will be used to further refine the proposed development and to assist with civil/structural design.

Based on an email received from Richard Green of TTW dated 2 September 2010 it is understood that the proposed development in the area of investigation comprises excavation up to 4.5m for one basement level, a ground floor and six upper floors. Column loads are anticipated to be about 6000kN. A basic outline of the proposed building extent is presented in Figure 1. No specific drawings (other than the general site locality) were provided at the time of this commission

The objectives of the geotechnical investigation are to provide comments and recommendations on:

- Soil and rock stratigraphy;
- Groundwater levels and influence;
- Site excavations and earthworks;
- Excavation retention systems and parameters for retaining wall design;
- Suitable footing types and design parameters;
- Material characteristics for disposal and/or suitability for material re-use.

# 2 SITE INFORMATION

## 2.1 Site description

The site is located at the University of New South Wales on an area of the Kensington Campus currently occupied by a car park to the east of International House as shown on Figure 1.

The areas of investigation were accessible from the High Street site boundary to the north through Gate 2. Figure 1 shows the layout of the site. The ground surface was observed on site to be relatively level and typically varies from about 28.4mAHD to 29.6mAHD on the UNSW survey drawings.

## 2.2 Published Geology

The Sydney Geological Map (Sheet 9130 1:100,000) indicates that the site is underlain by medium to fine grained sand overlying Hawkesbury Sandstone. Discontinuous bands of iron-indurated sand, known as “Waterloo Rock” occur within the Dune Sands throughout the Botany Basin area. These bands may vary from a few millimetres up to 3m thick.

## 2.3 Hydrogeology

A search of groundwater bore licences was undertaken using the NSW Natural Resources Atlas (NSW-NRA, http://nratlas.nsw.gov.au) on 30 September 2010. Several registered groundwater bores are located within a 500m radius of the site, with the majority being located to the west. A review of the groundwater bore data indicated that these bores are authorised for use for industrial, recreation, irrigation and domestic purposes with groundwater generally present at depths between 5m and 10m below ground surface.

Groundwater flow on the site is considered likely to be in a northerly direction towards surface water features in Centennial Park, or in a westerly direction towards Alexandra Canal and/or Eastlakes.

# 3 POTENTIAL CONTAMINATING ACTIVITIES & AREAS OF CONCERN

## 3.1 Site Walkover

The following features with respect to contamination in the open accessible areas were noted during the site walkover by Coffey in August 2010:

- The site comprises an asphalt paved car park bound by several buildings;
- Mature trees are present in the vicinity of the site, which are healthy in appearance;
- No evidence of underground storage tanks was observed; and
- No obvious contaminating activities were observed.

## 3.2 Site History Review

Information on the site history was obtained from:

- Review of selected aerial photographs;
- A search of NSW DECC register for listings of the site and nearby sites; and
- Review of records relevant to site conditions made available by UNSW.

The site history information is summarised in the following sections.

### 3.2.1 Aerial Photography

A review of available current and historical aerial photographs of the site was carried out. Table 1 provides a summary of the results of the photograph review.

***Table 1: Summary of Aerial Photography Review***

| Year | Site Features | Surrounding Area |
|---|---|---|
| 1942 | The site formed part of a race track complex. | Randwick Racecourse is present to the north, while the remainder of the immediately surrounding area comprises the smaller race track complex. |

| | | |
|---|---|---|
| 1951 | The race track complex has been demolished. The site area appears to be vacant land that is potentially grass covered. | Randwick Racecourse remains to the north, while buildings have been constructed to the immediate east of the site. The remainder of the immediately surrounding area is vacant land. |
| 1961 | The site has been redeveloped with buildings associated with the university. | As above, however the density of university buildings to the immediate north and east of the site has increased. |
| 1970 | As above. | As above, however the density of university buildings surrounding the site has increased. |
| 1978 | As above. | As above. |
| 1991 | As above. | As above. |

### 3.2.2 NSW Department of Environment, Climate Change and Water

Coffey undertook a search of the NSW Department of Environment and Climate Change (DECCW) online contaminated land register on 30 August 2010.

The search did not identify notices that have been issued on the Site under the Contaminated Land Management Act (1997).

### 3.2.3 UNSW Records

At the time of reporting, no records pertaining to the site had been made available by UNSW for review.

## 3.3 Gaps in Site History

The following gaps in the site history were identified for the site:

- Site activities prior to the commencement of the racecourse are not known.
- It is unclear if underground chemical/fuel storage structures are present or had been present.
- Historical chemical usage/storage (such as pesticide application) is not known.
- The volume and origin of fill is not known.
- Site features in inaccessible areas (such as inside the buildings) are not known.

## 3.4 Potential Areas of Environmental Concern and Chemicals of Concern

Based on the site history information and visual observations, the following potential Areas of Environmental Concern (AECs) and Chemicals of Concern (COCs) were identified:

***Table 2: Potential Contaminating Activities and Contaminants of Concern***

| Potential Contaminating Activity / Area | Potential Contaminants of Concern | Comments |
|---|---|---|
| Potential fill material underlying the site | TPH<br>BTEX<br>PAH<br>Metals<br>OC/OP pesticides<br>asbestos | Cut and fill features were observed (i.e. the retaining wall along the western boundary of the site) suggesting that fill may be present within the subsurface. |
| Car park – oil/grease leaks from parked vehicles etc | TPH | Likely to be localised and minor |
| Use of pesticides for pest/weed control on the Site | OC/OP pesticides | Likely to be localised and minor |
| Hazardous Building Materials (HBMs) | Asbestos<br>Lead<br>PCBs | No obvious HBMs were observed on external features of the buildings, however sampling and analysis of materials was not carried out as part of the scope of works |

TPH = total petroleum hydrocarbons

BTEX = benzene, toluene, ethylbenzene, xylenes

PAH = polycyclic aromatic hydrocarbons

OC/OP pesticides = organochlorine / organophosphate pesticides

Metals = arsenic, cadmium, chromium, copper, nickel, zinc, lead, mercury

# 4 METHOD OF INVESTIGATION

## 4.1 Geotechnical Fieldwork

The fieldwork for the investigation was conducted on the 18 September 2010, and comprised drilling 4 boreholes (BH MSB-1 to BH MSB-4) and 5 Cone Penetrometer Tests (CPT) (CPT MSB-1 to CPT MSB-3a). Figure 1 shows the approximate borehole and CPT locations. Boreholes and CPT’s were carried out within the proposed development extents. The borehole and CPT positions were measured from site features, and levels were extrapolated from the UNSW survey drawings.

A Coffey Engineering Geologist was present throughout the drilling/CPT operations to conduct:

- Geotechnical sampling and testing, record test results and log materials encountered;
- Environmental sampling/testing;
- Liaison with UNSW representatives;
- Implementation of the Site Specific Health, Safety and Environmental Management Plan.

### 4.1.1 Borehole Drilling

The boreholes were drilled using an Edson 3000 truck mounted drilling rig. Each borehole was advanced using solid flight augers with a tungsten carbide (TC) drill bit until termination in the sand deposits at depths between 1.1m and 11.4m.

Standard Penetration Testing (SPT) was carried out in BH MSB-4 at selected depth intervals to assess soil strength and obtain soils for logging purposes. Environmental samples were also collected at selected depth intervals in each borehole.

Groundwater inflows and soil moisture observed during drilling in soil were recorded.

On completion, a piezometer was installed in BH MSB-4 to 8.5m depth for monitoring groundwater levels and groundwater sampling. The piezometer was constructed with approximately 6m of slotted 50mm diameter PVC screen and filter sock from the base of the borehole and extended to the surface with blank 50mm PVC casing. The borehole was backfilled with graded sand to above the top of the screen and sealed with bentonite pellets. A gatic cover was installed and cemented at surface to protect the piezometer installation.

All remaining boreholes were backfilled with cuttings to 0.1m below ground level, and the pavement patched at the ground surface with bitumen.

### 4.1.2 Cone Penetrometer Testing (CPT)

Cone Penetrometer Testing was undertaken until refusal using a purpose built 22 tonne rig on a 6m x 4m Hino 700 truck base with a push capability of 200kN.

A 100MPa Electric Friction Cone Penetrometer was hydraulically pushed into the underlying natural soils at each locality to collect continuous readings of point load and friction to refusal depths of between 8.2m and 15.5m.

On completion CPT test holes were backfilled with cuttings obtained from the borehole investigation to 0.1m below ground level and the pavement patched at the ground surface with bitumen.

## 4.2 Environmental Sampling

Environmental sampling was conducted by a Coffey Engineering Geologist under the direction of an experienced Coffey Environments Scientist. Sampling was carried out in general accordance with Coffey Environments Standard Operating Procedures.

Fieldwork included the collection of representative soil samples from boreholes BH MSB-2 to BH MSB-4 at regular intervals within the subsurface. A total of 7 primary samples, plus one duplicate sample, were submitted for laboratory analysis. In addition, one trip blank and one trip spike were collected and submitted for quality assurance / quality control (QA/QC) purposes.

The soil samples were collected in appropriate containers prepared and supplied by the laboratory and stored in an insulated container on ice.

The samples were dispatched to SGS Environmental, a NATA registered laboratory under standard Chain of Custody documentation for analysis.

## 4.3 Geotechnical Laboratory Testing

A Particle Size Distribution (PSD) test was carried out on a sample from BH MSB-4. The laboratory test report is presented in Appendix C.

## 4.4 Environmental Laboratory Testing

Environmental soil samples obtained during the investigation were dispatched to SGS, a NATA registered laboratory.

Between two and three samples from boreholes BH MSB-2 to BH MSB-4 were submitted for analysis for a suite of contaminants of potential concern including total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and total xylene (BTEX), polycyclic aromatic hydrocarbons (PAHs), organochlorine and organophosphorous pesticides (OC/OPs), polychlorinated biphenyls (PCB), heavy metals and asbestos.

## 4.5 Environmental Assessment Criteria

NSW DEC (2006) *Contaminated Sites: Guidelines for the Site Auditor Scheme* (2nd edition) provides assessment criteria for soils based on various land use scenarios. Based on the current residential/student accommodation land use for the Site, it is considered that the applicable assessment criteria for the site soils are:

- Column 2: residential with minimal access to soil including high-rise apartments and flats soil investigational levels (SILs); and
- Column 5: provisional phytotoxicity based investigation levels (PILs).

For TPH and BTEX, the threshold concentrations for sensitive land use (soils) in Table 3 of NSW EPA (1994) *Contaminated Sites: Guidelines for Assessing Service Station Sites* have been adopted as assessment criteria for the Site.

There are currently no guidelines endorsed by Department of Environment, Climate Change and Water (DECCW) for the assessment of asbestos. For the purposes of this assessment, the criteria adopted for asbestos will be:

- No asbestos detected by laboratory analysis of soils; and
- No visible fragments of asbestos within the soils.

The NSW DECCW (2009) *Waste Classification Guidelines: Part 1 Classifying Waste* has been referred to for the waste classification assessment criteria, for waste classification purposes of soil at the Site.

# 5 RESULTS OF INVESTIGATION

## 5.1 Subsurface Conditions

Engineering borehole logs from the current investigation are presented within Appendix A, together with Explanation Sheets defining the terms and symbols adopted in the borehole log preparation. CPT logs are presented in Appendix B.

The boreholes typically intersected a thin fill layer overlying sand deposits to depths unproven during the investigation. Groundwater inflow was observed during drilling from about 6.1m depth in BH MSB-3 and about 6.2m depth in BH MSB-4. The groundwater level in BH MSB-4 was monitored on 29 September 2010 and was observed to be at 6.1m depth.

Based on the information obtained from the boreholes and Cone Penetrometer Testing, cross sections have been drawn through the site and are presented in Figure 2 and Figure 3. A geotechnical model has been developed for the site, and is presented in Table 3.

***Table 3: Interpreted Subsurface Conditions***

| Unit | Material / Origin | Depth to Top of Unit (m) | Thickness of Unit (m) | Top of Unit (mAHD) | Description |
|---|---|---|---|---|---|
| 1 | Fill | 0.0 | 0.4 to >1.5 | 28.6 to 29.4 | Bitumen/Concrete/Gravelly Sand. |
| 2a | Sand/ Dune Deposits (medium dense) | 0.4 to 1.5 | 4.8 to 6.8 | 28.0 to 28.8 | Sand: fine to medium grained, pale grey/brown orange with some iron-indurated bands (medium dense). |
| 2b | Sand/ Dune Deposits (dense to very dense) | 5.8 to 7.8 | Unproven | 21.4 to 22.7 | Sand: fine to medium grained, pale grey/brown orange with some iron-indurated bands (dense to very dense with some loose sand/firm clay layers) |

The depths and layer thicknesses in Table 3 are based on the subsurface conditions at the borehole locations and may not represent conditions at all areas of the site.

## 5.2 Laboratory Test Results

### 5.2.1 Geotechnical Testing

A Particle Size Distribution test was carried out on a sample from BHMSB4 at 4.5m to 4.95m depth. The results indicate a fine to medium grained, uniformly graded sand.

### 5.2.2 Environmental Testing

Soil samples collected from each borehole were screened for the presence of volatile organics using a Photoionisation Detector (PID). The PID was calibrated daily to a known concentration of isobutylene calibration gas. The results of the headspace screening reported concentrations between 0.0ppm and 12.6ppm which suggests that low concentrations of volatile organic compounds may be present in the soil samples collected from the site.

Laboratory analytical results are summarised in the Analytical Results Table presented in Appendix D. A QA/QC validation report is presented in Appendix E.

The results of the laboratory analysis indicated the following:

- Samples tested reported concentrations of TPH, BTEX, OCP, OPP and PCB less than the laboratory limit of reporting (LOR).
- Samples tested reported concentrations of PAHs less than the adopted assessment criteria and/or the laboratory LOR.
- Samples tested reported detectable concentrations of heavy metals, however these were less than both the health-based and ecological assessment criteria.
- Samples tested reported no detectable asbestos fibres.

For preliminary waste classification purposes:

- The results of the laboratory analysis reported chemical contaminant concentrations below the CT1 threshold for General Solid Waste with the exception of the benzo(a)pyrene in sample BH MSB4 (1.0m to 1.1m) and its duplicate sample D1, which exceeded the CT1 threshold. Given the variable results, there is uncertaintiy as to whether the material would classify as either General Solid Waste or Restricted Solid Waste. Further testing would be required to provide a waste classification prior to disposal of the material.

It is noted that the above preliminary waste classification should be considered indicative only and additional waste classification would be required. Sampling requirements for waste classification should be based on the volume of soil to be excavated.

# 6 DISCUSSION AND RECOMMENDATIONS

## 6.1 Earthworks

### 6.1.1 Presence of Fill

The investigation indicates that Unit 1 Fill is up to 1.5m thick. Existing Unit 1 fill should be classified as Uncontrolled Fill and is not considered suitable as a foundation for structures or subgrade for new pavements, unless excavated and recompacted, if suitable, or replaced.

### 6.1.2 Trafficability of Soils

Unit 2 soils are expected to behave poorly if exposed to heavy construction traffic, particularly when wet. A minimum 300mm thick working platform of roadbase may be needed where construction plant is to traffic Unit 2. Where heavy plant such as piling rigs or mobile cranes are to traffic the site specific analysis of working platform requirements may be required to assess working platform thickness.

### 6.1.3 Suitability of On-Site materials for use as Engineered Fill

From a geotechnical viewpoint, Unit 1 Fill and Unit 2 Dune Sand encountered should generally be suitable for re-use as Engineered Fill, provided unsuitable materials such as organics, waste or oversized particles (>75mm) are removed.

### 6.1.4 Site Preparation

Areas where new structures and pavements are proposed should be stripped of existing Unit 1 Fill (and topsoil, if encountered). The exposed Unit 2 soils should be prepared as outlined below prior to placement of Engineered Fill:

- Where the exposed subgrade is more than 0.5m depth below the proposed structure or pavement formation, it should be proof rolled with at least 8 passes of a 10 tonne non-vibratory roller. Any soft or heaving areas detected by proof rolling should be excavated and replaced with Engineered Fill.
- Where the exposed subgrade is less than 0.5m depth below the proposed structure or pavement formation, the subgrade should be compacted to achieve the criteria below for Engineered Fill.

### 6.1.5 Compaction Criteria

Where Engineered Fill is required to form the foundation for pavements or footings, it should be compacted as indicated below:

- Sand with <5% fines should be compacted to a minimum Density Index of 70%.
- Soil with >5% fines should be compacted to a minimum Dry Density Ratio of 98% Standard Maximum Dry Density (SMDD), and moisture conditioned to be within ±2% of Standard Optimum Moisture Content (SOMC).
- The layer thickness should be appropriate to achieve uniform compaction throughout the layer for the plant adopted.

## 6.2 Excavation

### 6.2.1 Excavatability

Coffey understands that the proposed basement excavation is expected to be 4.5m deep. Based on this information excavation would penetrate Unit 1 Fill and Unit 2a Dune Sands.

Unit 1 contains reinforced concrete pavement and slabs that would require a hydraulic breaker to penetrate. Excavation in Unit 2a would be possible using conventional earthmoving equipment such as tracked loaders and hydraulic excavators. Unit 2b may have iron-indurated layers that impede excavation.

### 6.2.2 Bulk Excavation Support Requirements

We recommend unsupported batter slopes for excavations above the groundwater table in sand of 2H:1V provided surcharge loads are kept well clear of the crest of batters. If there is insufficient room to form temporary batters or where excavation encounters groundwater, a retention system will be required.

Further advice on retention systems is provided in Section 6.3.

### 6.2.3 Groundwater

Groundwater was encountered at around 6m below ground level. Excavations that penetrate below the water table should be shored or retained. Dewatering in the sands may be required for basement and footing excavation and would require the installation of well points connected to a pumping system. The results of the particle distribution tests indicate that the sands have a permeability, k, of the order of $1x10^{-4}$ to $1x10^{-5}$m/s.

## 6.3 Retention Systems

### 6.3.1 Possible Systems and Limitations

We understand that the proposed development will require excavation up to 4.5m below ground level for basements and as such temporary and permanent retention systems are likely to be required. Retention systems that could be considered include:

- Sheet Piled Walls;
- Secant or Contiguous Piled Walls;
- Diaphragm Walls.

Sheet piles should be able to be driven through the Unit 2a medium dense sands to provide temporary support for the basement excavations. A suitable method of retarding groundwater should be adopted such as the use of sealants or welding of joints. A cast insitu concrete wall would be required to provide a permanent retention system.

Driving in the Unit 2b dense to very dense sands may be difficult and is not recommended for certain methods of installation. Impact driving may be a practicable technique for driving sheet piles in this stratum subject to noise and vibration considerations. Specialist advice should be sought from a piling contractor with experience in these ground conditions.

Secant piles comprising alternate soft and hard piles may be used to provide temporary support. Close control of pile verticality is critical to achieving interlock of the piles for secant pile walls.

Contiguous piles could be adopted, however with such a system gaps between the piles may allow sand to run into the excavation destabilising the ground behind the piles and risking undermining of adjacent structures. The risk of running sands is greatest if saturated sands are encountered. Careful construction procedures would be a required with allowance for progressive grouting of gaps between piles for this system to provide effective temporary and permanent support.

A well constructed diaphragm wall may be an appropriate solution, but is generally more costly than the above retaining wall types.

Groundwater was encountered at around 6m depth during the investigation. Short term build up of hydrostatic pressures could occur during prolonged wet periods or due to broken services, hence the possibility of hydrostatic pressures that could extend to the ground surface should be considered.

Surcharges due to equipment, stockpiles or other loadings behind the wall should also be considered in the design.

### 6.3.2 Design Parameters for Shoring and Earth Retaining Structures

For the design of retaining walls a triangular earth pressure distribution can be adopted to calculate earth pressures for relatively flexible shoring systems such as cantilevered walls or walls supported by a single row of props or anchors. The horizontal earth pressure profile may be calculated using the following formula:

$$p = K(\gamma' z + p_s)$$

where $p$ = lateral earth pressure (kPa)

$K$ = earth pressure coefficient, to be selected depending on consideration of the amount of movement that can be tolerated

$\gamma'$ = effective unit weight (kN/m$^3$)

$z$ = depth below top of excavation (m)

$H$ = height of excavation at base of excavation (m)

$p_s$ = design uniform surcharge pressure at ground level

Flexible shoring systems such as cantilevered walls should be avoided where there is a risk of movements damaging structures or services adjacent to an excavation.

Design of braced shoring or permanent retaining structures walls, which are constrained at several levels can be based on a trapezoidal earth pressure distribution. Where retention of a multi-layered material profile is required, modification of the distribution (including the definition of H) will be necessary.

***Table 4: Trapezoidal Pressure Distribution***

| Depth (m) | Horizontal Pressure (kPa) |
|---|---|
| 0 | $K.p_s$ |
| 0.25 H | $K\ (0.8.\gamma'.H + p_s)$ |
| 0.75 H | $K\ (0.8.\gamma'.H + p_s)$ |
| H | $K.p_s$ |

In addition to lateral earth pressures and surcharge loads, consideration should be given to the hydrostatic pressure from the permanent groundwater table and the possibility of build-up of water behind the wall from broken services, unless permanent subsurface drainage can be provided.

Table 5 provides retaining wall design parameters:

***Table 5: Recommended Design Parameters for Retaining Wall Design***

| Geotechnical Unit | Active Earth Pressure Coefficient ($K_a$) | At Rest Earth Pressure Coefficient ($K_0$) | Passive Earth Pressure Coefficient $K_p$ | Bulk Density (kN/m$^3$) | Drained Cohesion c' (kPa) | Effective Friction $\phi_p$' ($^o$) | Elastic Modulus (MPa) |
|---|---|---|---|---|---|---|---|
| Unit 1 | 0.33 | 0.5 | 3.00 | 20 | 0 | 30 | 10 |
| Unit 2a | 0.30 | 0.5 | 3.39 | 19 | 0 | 33 | 20 |
| Unit 2b | 0.24 | 0.5 | 4.20 | 20 | 0 | 38 | 50 |

The earth pressure coefficients in Table 5 assume horizontal ground surface at the crest and toe of the retaining wall. If this is not the case then the coefficient should be modified or surcharges added, as necessary. Care will be required when compacting fill adjacent to retaining walls to avoid lateral pressures in excess of the tabulated values.

From the location of the proposed building footprints and depth of associated excavation levels, several adjacent structures would appear to be located within the zone of influence of the excavation. The excavation system will need to be designed to support the footing surcharge loads.

The amount of movement that will be experienced by a retaining wall will depend on various factors including the earth pressures that exist, groundwater conditions and the excavation and construction sequence, including the tensioning sequence of anchors. Detailed soil structure interaction analysis should be carried out if movement sensitive structures are located within close proximity to the retaining wall. In particular, if movement sensitive services are located close to the excavation the design should consider the need to limit movements. In such situations the earth pressures may need to be modified from those tabulated to assess the impact on predicted movements.

## 6.4 Foundation Options

Foundation options that could be considered include:

- Pad footings – bearing on Unit 2 Dune Sands

- Piles founded within Unit 2 Dune Sands;
- A raft or piled raft foundation. Where substantial column loads occur and the ground profile is variable settlements may prevent adoption of a raft. However, in such cases a piled raft can be used with the raft providing the bulk of the bearing capacity and piles being used to satisfy serviceability criteria.

### 6.4.1 Pad Footings

For footings bearing on medium dense sand in the Unit 2a Dune Sands:

Ultimate Bearing Pressure = 440D + 80B (kPa)

*Where: B is the footing width in metres*

*D is the embedment depth below basement level in metres*

For footings bearing on dense to very dense sands in the Unit 2b Dune Sands:

Ultimate Bearing Pressure = 900D + 190B (kPa)

The above can be adopted for footings with a minimum embedment of 1m below basement level with width B in the range 1m to 4m. We recommend a geotechnical strength reduction factor, $\Phi_g$, of 0.5.

Serviceability should be assessed by calculating settlements using a Youngs Modulus of 25MPa in medium dense sand and 50MPa in Unit 2b Dune Sands.

A geotechnical engineer should observe pad footing excavations and undertake dynamic cone penetration tests in each footing to confirm the adequacy of the bearing stratum.

### 6.4.2 Piled Foundations

Open bored piles are unlikely to be feasible due to the risk of collapse of the sand below the groundwater table, unless provided with temporary casing. Continuous flight auger (CFA) piles should be practicable and do not require temporary casing.

For the design of piled footings founded within the Unit 2 Dune Sands the geotechnical parameters provided in Table 6 can be adopted.

***Table 6: Recommended Design Parameters for Piles in Unit 2 Dune Sand***

| Geotechnical Unit | Ultimate End Bearing Coefficient, $f_b$ (MPa) (1) | Ultimate Skin Friction Coefficient, $f_s$ (kPa) (2) | Elastic Modulus, $E'_v$ (MPa) (3) |
|---|---|---|---|
| Unit 2a | 1.5 | 25 | 20 |
| Unit 2b | 5 | 75 | 50 |

(1) Assumes a minimum penetration of at least three pile diameters into the relevant bearing stratum.
(2) Skin friction should be ignored to a depth of at least two pile diameters below pile cap.
(3) Serviceability should be assessed using modulus value to check that settlements are within tolerable limits.

For preliminary design a geotechnical strength reduction factor, $\Phi_g$, of 0.6 is recommended with the parameters in Table 6. Higher values may be able to be adopted if load testing is carried out.

If pile loads are such that there is insufficient capacity for piles in the sands, additional investigation would be required to assess rock levels and quality.

Continuous flight auger piles should be carefully controlled to avoid spoil falling off the auger and fouling the base of the pile. Pile dynamic integrity testing should be carried out particularly, if CFA piles are adopted. At least 5% of all piles should be subjected to integrity testing in addition to any load testing that may be specified.

### 6.4.3 Raft and Piled Raft

Piled raft foundations utilise piles for control of settlements with the piles providing most of the stiffness at serviceability loads, and the raft providing additional capacity at ultimate loading. A geotechnical assessment for design of such a foundation system therefore needs to consider not only the capacity of the pile elements and the raft elements but their combined capacity and interaction under serviceability loading.

Coffey has specialist skills in the assessment raft and piled raft foundation systems. Typically, we work with the structural engineer to assess the feasibility with preliminary assessments of building loads. If the preliminary assessment indicates savings over conventional piled foundations, we can assist with detailed design, undertaking soil structure interaction analysis to provide bearing moments and shear forces in a raft and pile loads for structural detailing.

## 7 EARTHQUAKE DESIGN

We recommend that the site be classified as Class $D_e$ in accordance with the site sub-soil classes defined in AS1170.4-2007 Part 4, Earthquake Actions in Australia. A hazard factor of 0.08 is recommended.

## 8 CONTAMINATED SOIL PLANNING & MANAGEMENT

The conclusions and recommendations presented below are based on the limited scope of works adopted for the preliminary environmental assessment of the site.

The results of the laboratory analysis indicate that concentrations of contaminants within the subsurface are less than the adopted health-based and ecological assessment criteria.

Given the limited nature of this assessment Coffey recommends additional assessment of the subsurface to further characterise the fill with respect to land suitability for the proposed development and waste classification.

## 9 LIMITATIONS

The geotechnical model and recommendations in this report are based on a limited number of boreholes and cone penetration tests. The engineering logs describe subsurface conditions only at the specific borehole locations. Ground conditions can vary over relatively close distances and a geotechnical engineer should be engaged at the construction stage to assess whether site conditions are consistent with design assumptions.

The attached document entitled “Important Information about your Coffey Report” presents additional information about the uses and limitations of this report.

The conclusions and recommendations presented below are based on the limited scope of works adopted for the preliminary environmental assessment of the site.

The results of the laboratory analysis indicate that concentrations of contaminants within the subsurface are less than the adopted health-based and ecological assessment criteria.

Given the limited nature of this assessment Coffey recommends additional assessment of the subsurface to further characterise the fill with respect to land suitability for the proposed development and waste classification.

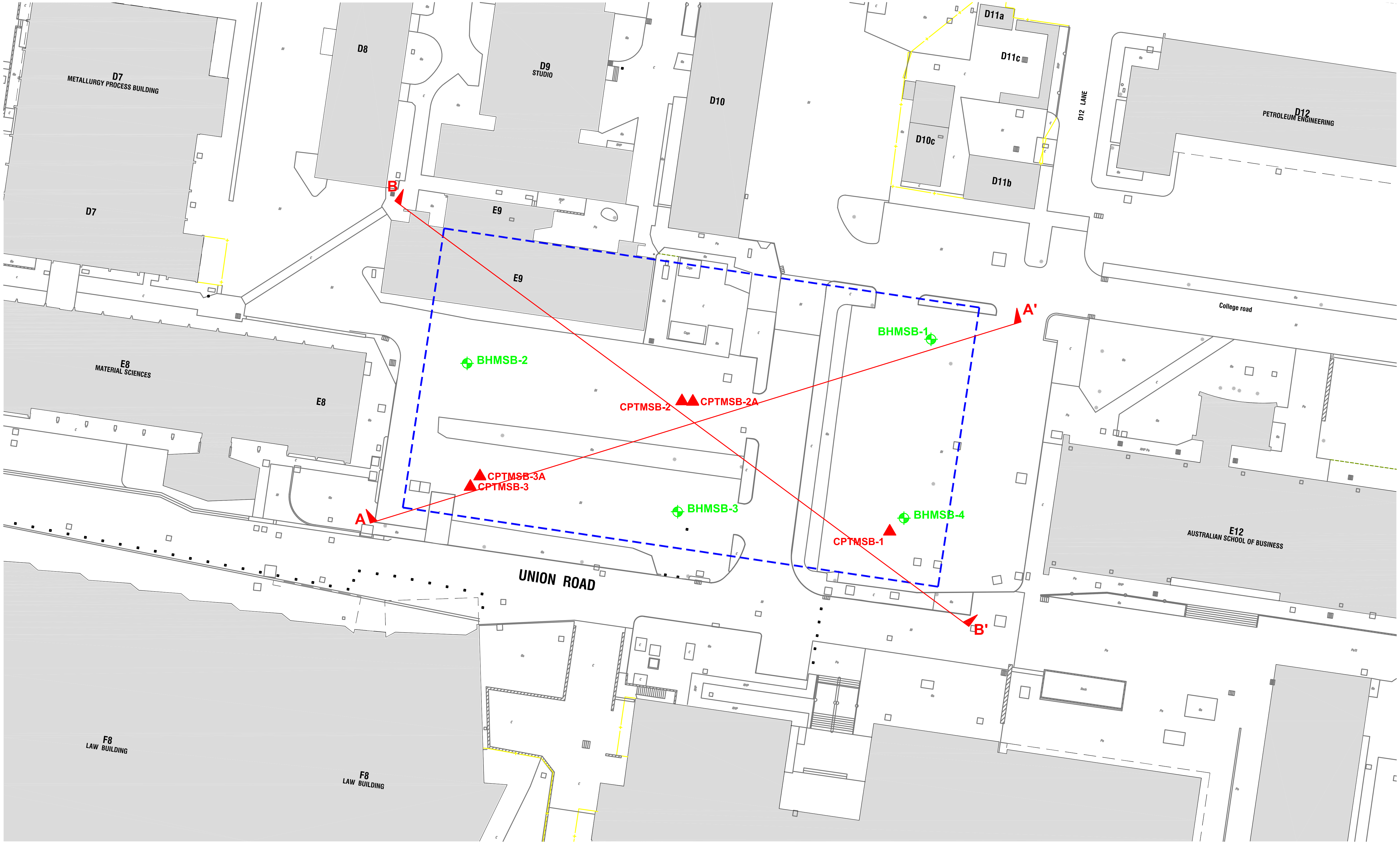
For and on behalf of Coffey Geotechnics Pty Ltd

Peter Waddell

**Peter Waddell**

Principal Engineer

# Figures



**LEGEND**

- 🟢 BOREHOLE LOCATION
- ▲ CPT LOCATION
- A▲—▲A' GEOTECHNICAL CROSS SECTION
- – – PROPOSED BUILDING FOOTPRINT

0 5 10 20 30

Scale (metres)

| | |
|---|---|
| drawn | DG/AW |
| approved | DG |
| date | 12/10/10 |
| scale | 1:500 |
| original size | A3 |

coffey geotechnics

SPECIALISTS MANAGING THE EARTH

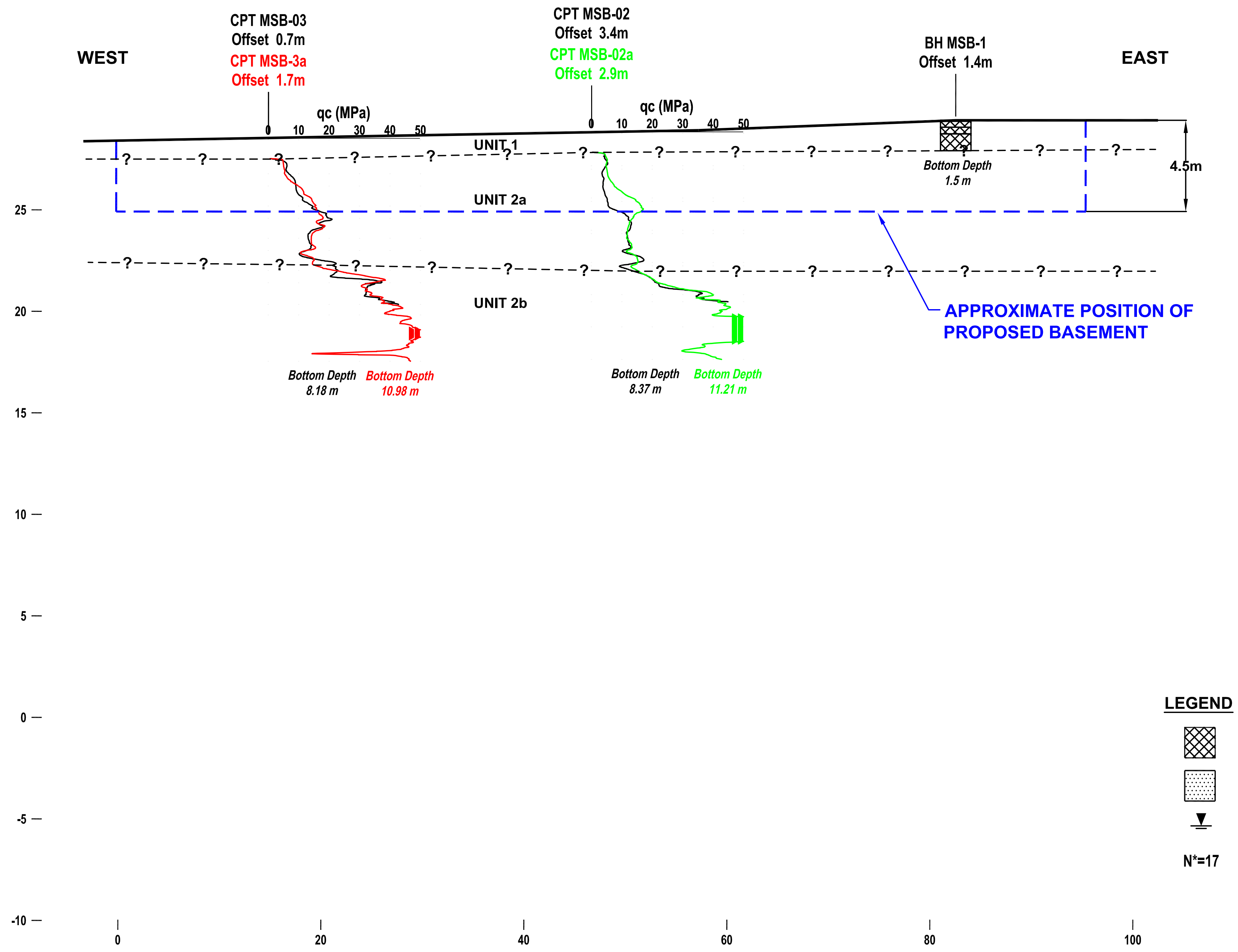
client: UNSW C/- TAYLOR THOMSON WHITTING

project: GEOTECHNICAL INVESTIGATION
UNSW, PROPOSED MSB BUILDING
UNSW, RANDWICK, NSW

title: SITE PLAN

project no: GEOTLCOV24080AC

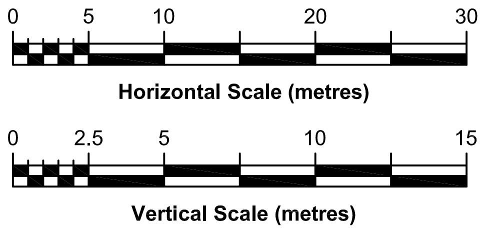
figure no: FIGURE 1



## SECTION A-A'

**LEGEND**

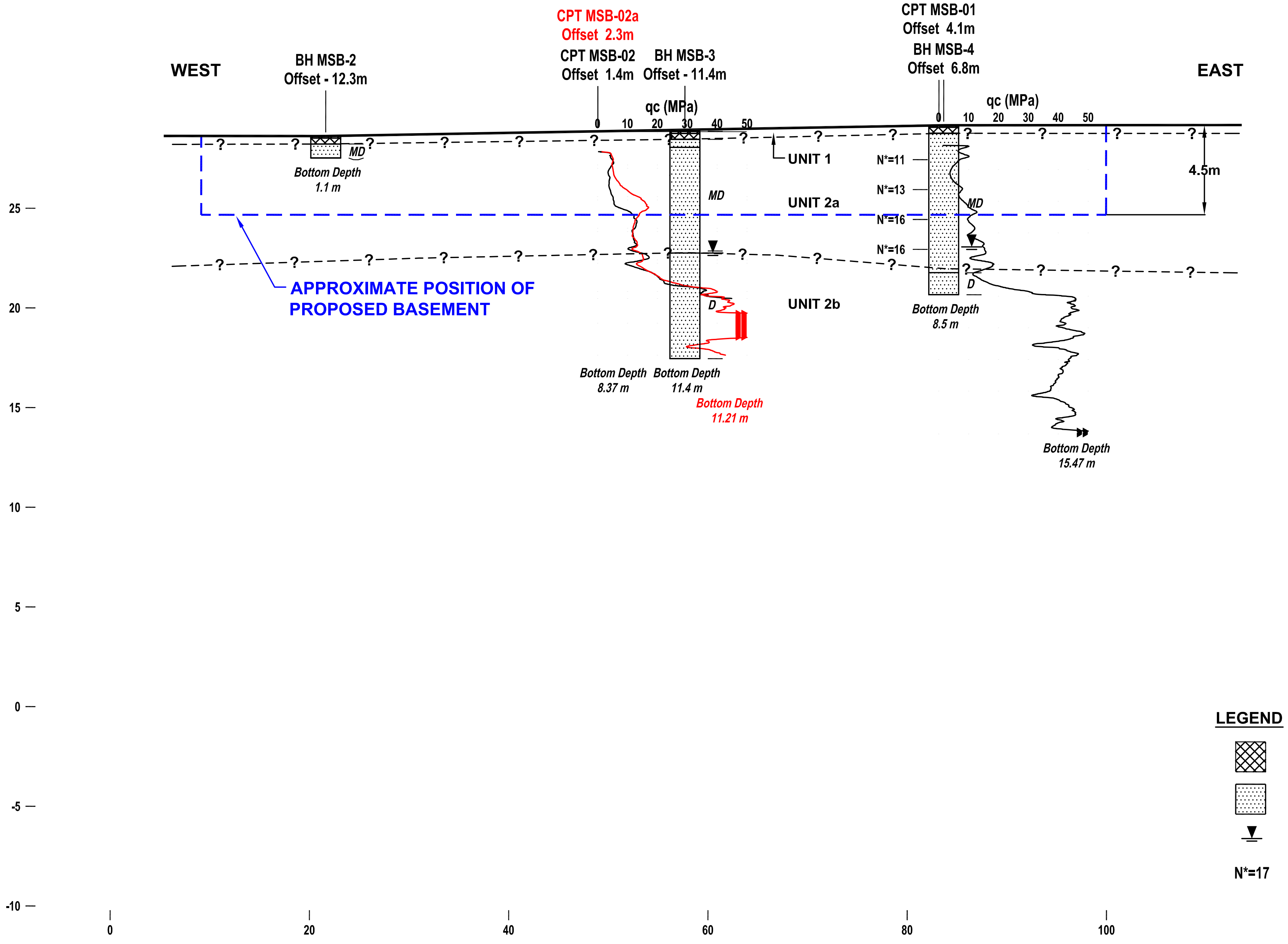
| | |
|---|---|
| ▨ | FILL |
| ░ | SAND |
| ▼ | WATER LEVEL |
| N*=17 | STANDARD PENETRATION TEST RESULT |



| | |
|---|---|
| drawn | DG/AW |
| approved | DG |
| date | 12/10/10 |
| scale | AS SHOWN |
| original size | A3 |

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

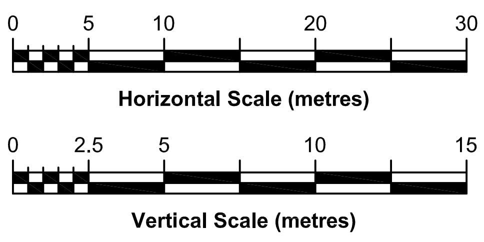
| | |
|---|---|
| client: | UNSW C/- TAYLOR THOMSON WHITTING |
| project: | GEOTECHNICAL INVESTIGATION<br>UNSW, PROPOSED MSB BUILDING<br>UNSW, RANDWICK, NSW |
| title: | GEOTECHNICAL SECTION A-A' |
| project no: | GEOTLCOV24080AC |
| figure no: | FIGURE 2 |



## SECTION B-B'

**LEGEND**

| | |
|---|---|
| ☒ | **FILL** |
| ▨ | **SAND** |
| ▼ | **WATER LEVEL** |
| N*=17 | **STANDARD PENETRATION TEST RESULT** |



| | |
|---|---|
| drawn | DG/AW |
| approved | DG |
| date | 12/10/10 |
| scale | AS SHOWN |
| original size | A3 |

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client: UNSW C/- TAYLOR THOMSON WHITTING

project: GEOTECHNICAL INVESTIGATION
UNSW, PROPOSED MSB BUILDING
UNSW, RANDWICK, NSW

title: GEOTECHNICAL SECTION B-B'

project no: GEOTLCOV24080AC

figure no: FIGURE 3

# Appendix A

## Engineering Borehole Logs and Explanation Sheets

coffey

# **Soil Description** Explanation Sheet (1 of 2)

## DEFINITION:

In engineering terms soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

## CLASSIFICATION SYMBOL & SOIL NAME

Soils are described in accordance with the Unified Soil Classification (UCS) as shown in the table on Sheet 2.

## PARTICLE SIZE DESCRIPTIVE TERMS

| NAME | SUBDIVISION | SIZE |
|---|---|---|
| Boulders | | >200 mm |
| Cobbles | | 63 mm to 200 mm |
| Gravel | coarse | 20 mm to 63 mm |
| | medium | 6 mm to 20 mm |
| | fine | 2.36 mm to 6 mm |
| Sand | coarse | 600 µm to 2.36 mm |
| | medium | 200 µm to 600 µm |
| | fine | 75 µm to 200 µm |

## MOISTURE CONDITION

| | |
|---|---|
| **Dry** | Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands. |
| **Moist** | Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere. |
| **Wet** | As for moist but with free water forming on hands when handled. |

## CONSISTENCY OF COHESIVE SOILS

| TERM | UNDRAINED STRENGTH $s_u$ (kPa) | FIELD GUIDE |
|---|---|---|
| Very Soft | <12 | A finger can be pushed well into the soil with little effort. |
| Soft | 12 - 25 | A finger can be pushed into the soil to about 25mm depth. |
| Firm | 25 - 50 | The soil can be indented about 5mm with the thumb, but not penetrated. |
| Stiff | 50 - 100 | The surface of the soil can be indented with the thumb, but not penetrated. |
| Very Stiff | 100 - 200 | The surface of the soil can be marked, but not indented with thumb pressure. |
| Hard | >200 | The surface of the soil can be marked only with the thumbnail. |
| Friable | – | Crumbles or powders when scraped by thumbnail. |

## DENSITY OF GRANULAR SOILS

| TERM | DENSITY INDEX (%) |
|---|---|
| Very loose | Less than 15 |
| Loose | 15 - 35 |
| Medium Dense | 35 - 65 |
| Dense | 65 - 85 |
| Very Dense | Greater than 85 |

## MINOR COMPONENTS

| TERM | ASSESSMENT GUIDE | PROPORTION OF MINOR COMPONENT IN: |
|---|---|---|
| Trace of | Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component. | Coarse grained soils: <5%<br>Fine grained soils: <15% |
| With some | Presence easily detected by feel or eye, soil properties little different to general properties of primary component. | Coarse grained soils: 5 - 12%<br>Fine grained soils: 15 - 30% |

## SOIL STRUCTURE

| ZONING | | CEMENTING | |
|---|---|---|---|
| Layers | Continuous across exposure or sample. | Weakly cemented | Easily broken up by hand in air or water. |
| Lenses | Discontinuous layers of lenticular shape. | Moderately cemented | Effort is required to break up the soil by hand in air or water. |
| Pockets | Irregular inclusions of different material. | | |

## GEOLOGICAL ORIGIN

### WEATHERED IN PLACE SOILS

| | |
|---|---|
| Extremely weathered material | Structure and fabric of parent rock visible. |
| Residual soil | Structure and fabric of parent rock not visible. |

### TRANSPORTED SOILS

| | |
|---|---|
| Aeolian soil | Deposited by wind. |
| Alluvial soil | Deposited by streams and rivers. |
| Colluvial soil | Deposited on slopes (transported downslope by gravity). |
| Fill | Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils. |
| Lacustrine soil | Deposited by lakes. |
| Marine soil | Deposited in ocean basins, bays, beaches and estuaries. |