GREATER TAREE CITY COUNCIL - PITT STREET WATERFRONT PRECINCT

GEOTECHNICAL ASSESSMENT - FINAL REPORT

Sinclair Knight Merz

GEOTTUNC01736AB-AD
16 June 2008

Coffey Geotechnics Pty Ltd ABN 93 056 929 483
1/4 Douglas Avenue Tuncurry NSW 2428 Australia

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Sinclair Knight Merz
710 Hunter Street
Newcastle West NSW 2302

Attention: Brian Watson

Dear Brian,

RE: GREATER TAREE CITY COUNCIL - PITT STREET WATERFRONT PRECINCT

GEOTECHNICAL ASSESSMENT - FINAL REPORT

We are pleased to provide our Final Report on the assessment of geotechnical conditions over the area of the proposed Pitt Street Waterfront redevelopment at Taree.

Please do not hesitate to contact the undersigned if you have any questions in relation to this project.

For and on behalf of Coffey Geotechnics Pty Ltd

Steven Morton

Principal

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1 INTRODUCTION

At the request of Sinclair Knight Merz (SKM) on behalf of Greater Taree City Council (GTCC), Coffey Geotechnics Pty Ltd (Coffey) has undertaken investigation and assessment of geotechnical conditions within the Pitt St Waterfront Precinct at Taree. Following previous planning studies of the proposed Pitt Street Waterfront rezoning area, specific geotechnical studies were required to address the feasibility of two of the proposed development areas off the northern end of Pitt Street. The subject areas are shown on Figure 1 and consist of a Marina Complex (MC), and a Mixed Use Complex (MUC) which will include residential and commercial buildings and an additional small marina.

The work was commissioned by Mr Graeme Gardiner of Greater Taree City Council, in response to a brief prepared by SKM and subsequent proposal from Coffey (Ref GEOTTUNC01736AB-AB). The work described herein was conducted in general accordance with the brief and proposal.

The subject site forms part of an overall rezoning area that was investigated by Coffey in 2007 (Ref. GEOTTUNC01736AA-AD). The previous study addressed contamination and acid sulfate soil conditions at the site, and involved extensive review of past reports conducted in the area as well as some targeted drilling and sampling in areas of concern. Relevant information from that report has been re-used where appropriate in this assessment.

2 PURPOSE AND SCOPE OF WORK

The aims of the study were outlined in the project brief provided by SKM. Primarily, the aims were to determine:

- Stratigraphy of the potential sites down to a depth of 10m;
- Depth to bedrock at each site;
- Depth and fluctuations in groundwater levels in the flood prone area adjacent to the river.

3 THE SITE

3.1 Location and landuse

The Pitt Street Waterfront Precinct is located approximately 2km north of Taree city centre, on the Manning River and occupies an area of approximately 20ha. The current study addresses two parts of the rezoning area, known as the Mixed Use Complex and the Marina Complex. The extent of the study area is shown on Figure 1.

At the time of the fieldwork the majority of the study area was in use as grazing land for the agistment of horses

3.2 Topography

The site is located on a low-lying flood plain adjacent to the northern passage of the Manning River. The river flows in a northeasterly direction and forms the southern boundary of the site. The site is elongated parallel to the river. The northwestern part of the site is located on an elevated alluvial terrace, some 5m above river level. This has been modified by some filling where the terrace grades onto lower ground adjacent to the river, and approximately 2m to 3m above river level. This low lying area contains abandoned drainage channels and other low, poorly drained boggy features that run approximately through the centre of the site. Surface water ponding occurred in this area during the fieldwork which was undertaken shortly after prolonged rainfall.

The area has an overall slope towards the east and south. Drainage is directed towards an easterly trending drainage depression that meanders through the site and discharges to the river in the low-lying grassed area between the MUC and MC sites.

The riverbank that defines the southern edge of the site is incised and varies in height from 1m to approximately 3m at the western end. The western end of the riverbank is modified by filling. The river adjacent to the site is tidal.

4 SITE INVESTIGATIONS

Site investigations involved drilling, logging and sampling of twelve boreholes drilled to refusal on rock or a maximum target depth of 10m. Boreholes BH5 and BH9 were drilled to depths exceeding 11m to attempt to reach rock in those locations. Standard penetration testing was undertaken in each borehole and in selected locations U50 tube samples were taken for clay shrink-swell testing.

Borehole logs are presented in Appendix A together with explanation sheets defining the terms and symbols used in their preparation. In borehole BH1a an electronic datalogger was installed to allow monitoring of water level fluctuations over a period of one week. The results are shown in Appendix B.

In addition to the drilling, five cone penetration tests were undertaken using a truck mounted piezocone. The work included dissipation testing in soft or loose layers to assist in the understanding of site settlement properties. The results of cone penetrometer testing are shown in Appendix C.

Locations of field investigations are shown on Figure 1. Co-ordinates and levels are shown in Table 1.

Table 1 - Locations of Field Investigations (MGA Zone 56 Coordinates).

Location	Easting	Northing	RL (mAHD)
Cone Penetration Tests			
CPT1	451052	6470165	4.05
CPT2	451166	6470238	4.86
CPT3	451173	6470301	2.59
CPT4	451260	6470198	2.65
CPT5	451397	6470300	2.60

Table 1 - Locations of Field Investigations (MGA Zone 56 Coordinates). (cont.).

Location	Easting	Northing	RL (mAHD)
Boreholes			
BH1	451101	6470066	4.74
BH1A (Monitoring Well)	451225	6470140	2.90
BH2	451099	6470275	5.61
BH3	451237	6470274	5.06
BH4	451190	6470192	2.40
BH5	451174	6470140	2.89
BH6	451236	6470183	2.11
BH7	451261	6470227	2.39
BH8	451312	6470207	2.64
BH9	451328	6470263	2.36
BH10	451371	6470247	2.18
BH11	451530	6470340	1.1
BH12	451606	6470385	4.3

5 SUBSURFACE CONDITIONS

5.1 Geological Setting

Reference to the Hastings 1:250,000 Geological Series Sheet SH 56-14 indicates the site is underlain by the Byabbara Beds, which consists of lithic sandstones, siltstones, tuffs, shales and limestone and by Quaternary sediments adjacent to the Manning River.

Reference to the Taree 1:25,000 Acid Sulfate Soils Risk map published by the NSW Department of Land and Water Conservation indicates the site contains no known occurrence of ASS in elevated areas of residual soils. Adjacent to the Manning River an alluvial plain with a high probability of ASS between 1m and 3m from ground surface is located in the area between the east flowing Creek and the existing industrial buildings. The low-lying drainage depression is identified as an alluvial channel with a high probability of ASS between 1m and 3m below the ground surface.

5.2 Subsurface profiles

Stratigraphic profiles encountered at each borehole location are shown on the engineering logs in Appendix A. Materials encountered within the profile have been divided into geotechnical soil units, which are described in Table 2.

Table 2. Soil Units encountered by site investigations

Unit	Soil type/origin	Description
1	FILL	Variable composition, Gravels and Clays, generally very stiff. Does not appear to have been placed and compacted as Controlled Fill.
2	TOPSOIL	Clayey SILT topsoil grading into overconsolidated alluvial silts and clays. Generally 0.5m to 1m deep.
3	LOOSE/SOFT ALLUVIUM	Interbedded loose to very loose silts and fine sands, with lenses of soft clay. This layer typically revealed SPT 'N' values of 0 to 1.
4	MD - D ALLUVIAL SAND OR GRAVEL	Interbedded and interlensed sand and gravel deposits, typically medium dense, below the water table. Gravel generally less than 20mm particle size.
5	St – VSt Alluvial CLAY	Isolated lenses of stiff to very stiff alluvial clay overlying residual clay and weathered bedrock.
6	RESIDUAL CLAY	Very stiff CLAY, medium to high plasticity, with some relict rock structure and bands of weathered siltstone and sandstone. Grading into extremely weathered siltstone.
7	BEDROCK	Siltstone and sandstone, interbedded, very low to low rock strength

Groundwater was encountered in holes on the low lying part of the site adjacent to the river, typically at depths of 2.5m to 3m below the ground surface. Groundwater is discussed in further detail in subsequent sections.

6 GEOTECHNICAL MODEL

6.1 Geotechnical Terrain Zones

Based on the surface and subsurface conditions observed, the MUC site and MC site have been divided into geotechnical terrain zones of similar properties. The terrain zones are delineated on Figure 2, and described below:

6.1.1 Terrain Zone A

Elevated ground. Typically RL approximately 5m AHD. Some fill and residual soil profiles overlying sandstone and siltstone bedrock at depths of less than 3.5m. Residual soils consisting of high plasticity, moderately reactive clay. Profiles summarised in Table 3.

Table 3. Profiles encountered in Terrain Zone A (Depths in m)

Unit	Soil Type	BH1	BH2
1	FILL	0.0 – 1.7	-
2	TOPSOIL	-	0.0 – 0.2
5	St – VSt ALLUVIAL CLAY		0.2 – 1.1
6	RESIDUAL CLAY	-	1.1 – 3.5
7	BEDROCK	1.7 – 1.8	3.5 – 4.4

6.1.2 Terrain Zone B

Transitional zone between elevated residual terrain and low lying terrain adjacent to river. Essentially an abandoned river terrace containing alluvial profiles with interbedded loose silts and sands. Groundwater typically 2.5 to 3m below ground level. Profiles encountered in the boreholes are summarised in Table 4.

Table 4. Profiles encountered in Terrain Zone B (Depths in m)

Unit	Soil	MUC Site						MC Site	
		BH3	BH4	BH5	BH6	BH7	BH9	BH11	BH12
1	FILL	0.0 – 1.7	-	-	-	-	-	-	0.0 – 3.1
2	TOPSOIL	-	0.0 – 0.7	0.0 – 1.0	0.0 – 1.1	0.0 – 1.0	0.0 – 1.0	0.0 – 0.5	-
3	LOOSE/SOFT ALLUVIUM	-	0.7 – 5.7	2.2 – 4.8	1.1 – 4.8	1.0 – 4.3	2.4 – 7.3	0.5 – 5.0	3.1 – 4.5
4	MD - D ALLUVUM	-	-	4.8 – 9.0	4.8 – 8.5	4.3 – 6.4	-	5.0 – 7.8	-
5	Alluvial CLAY Stiff – Very Stiff	1.7 – 7.7	-	1.0 – 2.2	-	-	-	-	-
6	RESIDUAL CLAY	-	5.7 – 8.9	9.0 –11.9	8.5 –10.0	-	-	7.8-10.25	4.5 – 5.8
7	BEDROCK	7.7 - 8.8	8.9 –10.1	-	-	6.4 –6.65	7.3 – 9.0	-	5.8 – 6.1
	Groundwater	5.8	2.6	2.4	2.4	1.7	2.4	0.4	3.4

6.1.3 Terrain Unit C

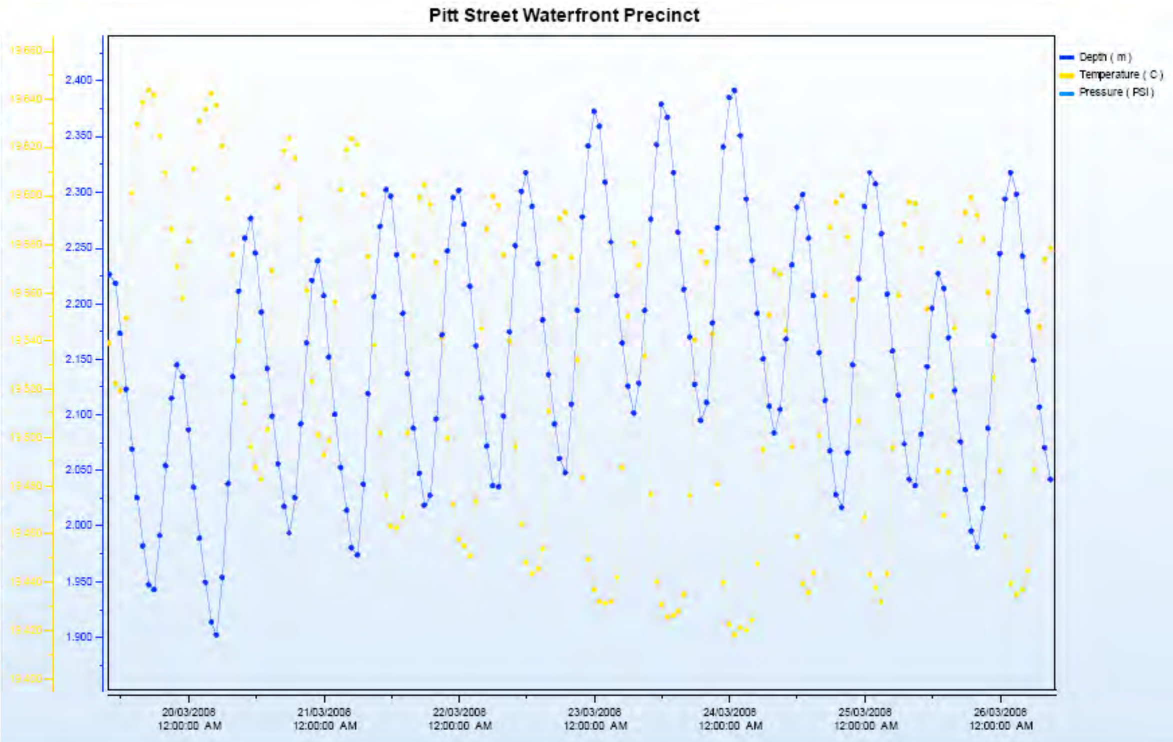
Low lying terrain adjacent to river. Essentially an abandoned river terrace containing alluvial profiles with interbedded loose silts and sands. Groundwater typically 2.0 to 2.5m below ground level. Profiles encountered in the boreholes are summarised in Table 5.

Table 5. Profiles encountered in Terrain Zone B (Depths in m)

Unit	Soil	BH1A	BH8	BH10
2	TOPSOIL	0.0 – 0.7	0.0 – 1.1	0.0 – 0.9
3	LOOSE/SOFT ALLUVIUM	0.7 – 6.0	1.1 – 4.7	0.9 – 4.7
4	MD - D ALLUVIUM	6.0 – 9.05	4.7 – 8.2	4.7 – 8.6
5	ALLUVIAL CLAY Stiff – Very Stiff	9.05 – 10.0	8.2 – 10.7	8.6 – 11.25
6	RESIDUAL	-	10.7 – 10.85	-
	Groundwater	2.7	2.6	2.0

6.2 Groundwater Conditions

A groundwater level datalogger was installed in borehole BH1A and water level fluctuations monitored over a period of one week. The results are attached in Appendix B and plotted below.



The results indicate a strong tidal influence on groundwater levels beneath the low-lying part of the site, with groundwater levels reflecting tidal variations, and varying between 1.9m and 2.4m below the ground surface over the course of the week (20/3/08 to 26/3/08).

7 PROPOSED DEVELOPMENT

The proposed Marina Complex will be located at the northern end of the site. The development will be formed by dredging the low lying ground adjacent to the river. Proposed depths are unknown but likely to be of the order of 3m below river water level (ie. Approximately -3m AHD). The marina will likely involve pontoons supported by piles socketed into the marina bed.

The Mixed Use Complex will comprise a mixture of three to four storey commercial and residential structures and a small marina. The structures are likely to be constructed on concrete platform structures to allow them to maintain height above flood level. It is understood the area below the concrete deck will be used for car parking and for flood storage during major rain events.

8 GEOTECHNICAL CAPABILITY GEOTECHNICAL ZONE A

Zone A occupies the north western part of the MUC site (Figure 2). In this area residual soil profiles and imported fill overlie rock at shallow depths. The area will be suitable for use of high level footings, although care will need to be taken to ensure footings are founded on natural ground below all existing fill. This will require removal of the fill, removal and replacement in layers as Controlled Fill, or piering of structures to natural ground.

8.1 Excavations

Rock in this area is typically less than 3m below ground level. Overburden materials are expected to be excavatable to rock level using conventional bulldozer blades or excavator buckets. Rock strengths were variable where observed and encountered in the investigation. Rippability was not assessed as part of this investigation. Experience in the area indicates rock is likely to be rippable to the depths required for this assessment. It is likely that confined and detailed excavations may require use of rock breakers. If deep bulk excavations are required, rippability should be further investigated.

Excavations in soil are not likely to encounter the groundwater table although localised inflows may occur. Excavations in soil are likely to be self supporting at batters of 1V:2H or flatter. Batters should be protected against erosion. Steeper batters would require temporary or permanent support. Steeper batters in rock are feasible but would require further assessment when the location and depth of excavations are known.

Excavations in Zone A would not be expected to encounter acid sulfate soils. Some existing fill materials may be unsuitable from a geotechnical perspective. The majority of existing fill and natural soils on the site other than topsoil and other organic or deleterious materials would be re-useable as fill within the development.

8.2 Foundations

8.2.1 High Level Footings

Structures could be founded on high level footings within the residual soil profile or on weathered rock. As a general guide, footings founded on the residual clays could be proportioned for allowable bearing pressures of the order of 200kPa. Weathered rock encountered during the investigations would be appropriate for foundation bearing pressures of the order of 600kPa. Foundation conditions at each building site should be investigated in more detail once location and layout of buildings are known.

Based on profiles encountered and the results of shrink-swell testing the majority of Zone A is likely to be classified as Class M “Moderately Reactive, in accordance with AS2870-1996, with free surface movements of the order of 20mm to 40mm. Towards the eastern end of Zone A clay profiles deepen and some Class H areas may be encountered.

Existing fill within this zone has not been placed and compacted as Controlled Fill. Structures in filled areas will require piering to natural ground or else the fill will require removal and replacement in a controlled manner.

8.2.2 Piled Foundations

Piles within Zone A may be required for heavily loaded structures and for structures within areas of fill. Piles may consist of driven piles taken to a refusal set on rock. Alternatively, bored piles may be socketed into weathered rock

9 GEOTECHNICAL CAPABILITY OF ZONES B AND C

9.1 General geotechnical conditions and issues

Section 6 summarizes geotechnical profiles within zones B and C. In general these zones consist of loose and soft alluvial deposits to variable depths overlying residual clays and weathered siltstone and sandstone bedrock. For the type of structure proposed this area is not suitable for the use of high level footings in its natural state and piled foundations are most likely to be required. The low lying nature of this area may necessitate some filling to raise parts of the site above flood levels and achieve desirable surface profiles. Formation of marinas will require excavation below the water table.

The geotechnical conditions and the proposed development within these two zones present geotechnical issues and hazards that will present a risk to the project if not adequately addressed. The main issues that might affect the proposed development of these zones include:

- Rate and magnitude of settlements under filled areas or embankments over alluvial soils, and how these may affect design levels;
- Filling over soil profiles of low strength and likely impacts on batters and stability of embankments constructed over alluvial soils;
- Control of differential settlement between rigid structures and surrounding filled areas;
- Presence of soft ground and variable depth to suitable founding conditions for structures;
- The presence of Acid Sulfate Soils, and the need to reduce the potential for disturbance by excavation within these soils;
- Excavation below water table and support required for excavation batters in marina areas

The potential geotechnical issues / hazards presented above are discussed in the following sub-sections, in relation to the proposed development. Possible solutions to these issues are discussed in Sections 10 and 11.

9.2 Presence of Soft Clays and Loose Sands

9.2.1 Settlement

The investigated ground conditions over the majority of Zones B and C are currently unsuitable for support of shallow foundations. In addition, the ground surface elevation is below the 1 in 100 year flood level, and development may therefore involve significant filling to achieve desirable design levels and surface profiles. Previous and current site investigations have identified the presence of very soft to soft and very loose to loose sediments within the upper 4m to 7m of the soil profile that will undergo consolidation settlements as a result of site filling, even without the addition of building loads.

The variability of the thickness of the loose/soft soil units would result in varying amount of consolidation that may result in differential settlements. It is noted though, that the majority of the loose/soft soils are non-cohesive (sand) and these soils consolidate to a lesser degree and more rapidly than fine grained clays.

To minimise the impact of settlements on future development, feasible means of ground improvement for the site include:

i. Surcharge preloading to complete a minimum 90% of primary consolidation before removal of the preload & commencement of building and construction. This is achieved by mounding up an appropriate height of sand fill over the site and leaving it in place until the appropriate amount of settlement has occurred, then cutting the mound back to design level for construction. Given the generally sandy nature of the loose soils and of the underlying sand/gravel alluvium it is likely that consolidation and dissipation of soil pore pressures would occur rapidly. Total settlements in 4m to 7m of loose sand with 1m to 2m of fill placed over are likely to be of the order of 300mm to 600mm. Experience on similar sites indicates settlements of this nature are likely to occur within 3 to 6 months of placing fill. Rates of settlement can be enhanced using wick drains. Further analysis of potential settlements should be undertaken once fill heights and fill locations are known.

ii. Ground reinforcement which transfers the weight of the fill through the soft layers and into the underlying medium dense sands and gravels. This process may involve the construction of piles or columns on a grid pattern, founded with the medium dense to dense sand layers beneath all soft or loose zones. A geogrid is then installed to transfer the uniformly distributed load of the sand fill to the pile heads.

9.2.2 Seismicity

Earthquake induced liquefaction requires consideration on this site, as there are significant deposits of soft/loose alluvial sediments that are susceptible to liquefaction.

For the subject area it would be reasonable to use a design earthquake with a Richter magnitude of 6 for the site. Liquefaction of loose sand layers is likely to occur under seismic events of the above magnitude. Based on the Australian Standard Earthquake Code AS1170.4-1993, an acceleration coefficient of 0.11 could be adopted for the area and a Site Factor of 1 would apply for the depth of rock at this site, giving a surface acceleration of 0.11 (or 11%g).

This could lead to failure of foundations and/or settlement of structures founded on these sediments. The risk of liquefaction could be reduced by deep ground improvement techniques as discussed above, or the use of piled foundations. Piled foundations are also the preferred option in this area to manage the potential settlement and bearing capacity issues associated with the soft/loose alluvial soils.

Analysis of the effect of seismic activity on piled foundations should be carried out at the design phase. The following two aspects must be considered:

- Additional lateral load on the pile head due to ground surface acceleration;
- Interaction effects on the pile shaft due to lateral movement of the ground profile.

9.3 Excavations

9.3.1 Depth to rock

The main excavations required on site will be dredging for the marina at the MC site (Boreholes BH11 and BH12), and the smaller marina at the MUC site (Boreholes BH1a and BH5). At both locations the excavations are likely to extend to approximately RL -3m AHD. At the MC site, BH12 indicates that the northern fringes of the marina excavation may require excavation into rock below the water table. The rock was penetrated to approximately RL-1.8m by auger drilling techniques, and as such it may be excavatable to a similar level using heavy hydraulic excavation equipment equipped with a ripper tyne and a toothed bucket. The extent of rock around the perimeter of this marina excavation should be further investigated.

Elsewhere, excavation to the proposed depths will involve dredging of the loose silts and sands in Unit 3. Based on this investigation these materials should be dredgable by equipment such as long reach excavators or cutter suction dredges.

9.3.2 Excavation Support

Batters in loose and soft alluvium will need to be less than 6H:1V to maintain stability. Due to the confined space available for these marinas, such batters may not be achievable and therefore support will be required by sheet piles or similar.

Sheet piles should be socketed into medium dense alluvium and residual clays below the excavation. For a 3m deep excavation, additional socket depths of the order of 3m to 5m would be required and would generally be achievable. Shorter sheet piles could be adopted, with tie back anchors socketed into rock where rock depths are relatively shallow.

9.4 Foundations

9.4.1 Piled Foundations

For a piled footing system, some suitable options may include driven displacement Hardwood piles, or driven cast insitu piles founded in medium dense to dense sands and gravels or underlying weathered rock profiles. Bored cast insitu piles may be either Grout Injected CFA piles or conventional bored piles. Conventional bored piers would be difficult to install on this site and the use of mud drilling and casing would be essential due to the potential for collapse of the sands below the water table. Bored non-displacement piles should be closely supervised by experienced persons to ensure adequate construction practices are followed.

To maximise the allowable bearing capacity, the piles should not be founded too deep within the Unit 4 sands and gravels. This depth limitation is to avoid the zone of influence of the pile toe from being within the Unit 5 and 6 clay soils that have a lower ultimate bearing capacity. The extent of the zone of influence can be taken as being to three maximum pile diameters below the pile toe for a single pile. For pile groups, this zone of influence becomes larger. Hence, for a 0.3m diameter pile, the zone of influence can be taken as approximately 1m. The toe of such a pile should not therefore be any deeper than 1m above the base of Unit 4. For a 1m diameter pile, the zone of influence would extend about 3m below the toe of the pile. A more practical alternative may be to take the piles through the soil profile to found on weathered rock.

Driven piles would be particularly practical for the support of structures in the Marina Complex following dredging. Options include driven displacement Hardwood piles, or driven cast insitu piles. The piles would be driven to a design refusal set in medium dense to dense sands/gravels or underlying rock. Depths to the required design refusal set will be dependent on the required capacity and size of piles and would be best evaluated by driving test piles. The capacity of piles driven to refusal set will be controlled by the structural capacity of the pile and the limitations of readily available pile driving equipment. For practical reasons it is generally advisable to limit pile working loads to about 500kN, although larger capacities are possible with larger pile driving equipment. The ultimate bearing capacity of the pile may be determined from Hiley pile driving formulae or wave equation analysis once the hammer type and size, and pile size and lengths are known.

Driven displacement piles carry the risk of causing vibration induced damage to adjacent buildings or structures. Dilapidation surveys and vibration monitoring would be required on all structures within 100m of the site. Table 6 summarises the advantages and disadvantages of various pile types that would be suitable for this site.

TABLE 6– ADVANTAGES / DISADVANTAGES OF VARIOUS PILE TYPES

PILE TYPE	ADVANTAGES	DISADVANTAGES
Precast Concrete Driven Piles	• Cost; • Can cope with variable ground conditions by varying penetration depth; • Can drive to a design set; • No spoil removal required.	• Possible construction vibrations on adjacent properties; • Greater number of piles required.
Driven Timber Piles	• Cost; • Can cope with variable ground conditions by varying penetration depth; • Can drive to a design set; • No spoil removal required.	• Possible construction vibrations on adjacent properties; • Greater number of piles required.
Driven Steel Tube Piles	• High capacity with larger diameters; • Can cope with variable ground conditions by varying penetration depth; • Can drive to a design set; • No spoil removal required.	• Cost; • Possible construction vibrations on adjacent properties; • Durability Issues.
Grout Injected CFA Piles	• Cost	• Lower shaft capacity (smear); • Limit depth to reinforcement; • Spoil removal / acid sulfate soil issues.
Bored Piles		• Cost; • Requires casing and drilling with mud (polymer, bentonite); Spoil removal / disturbance of acid sulfate soils.

As a guide for feasibility/concept purposes, piles founded in the medium dense to dense sands (Unit 4) or residual/weathered rock (Unit 6/7) may be proportioned for the ultimate capacities of the order of those presented in Table 7

TABLE 7 - ULTIMATE GEOTECHNICAL STRENGTH PARAMETERS

PILE TYPE	FOUNDING UNIT	ULTIMATE END BEARING (f_b) (MPa)	ULTIMATE SIDE ADHESION (f_s) (kPa)
Non Displacement Piles - Grout Injected (CFA) Piles	UNIT 4	3.0 MPa	25 kPa
	UNIT6/7*	3.5 MPa	35 kPa
Displacement Piles - Driven Piles	UNIT 4	5.0 MPa	50 kPa
	UNIT 6/7*	5.5 MPa	85 kPa
* *Parameters for rock should be further investigated by rock coring prior to design*			

The following points should be borne in mind in evaluating the use of piles on this site:

- Where the founding stratum is underlain by a weaker layer, the pile toe should be located at least three pile diameters above the top of the weaker layer as previously discussed;
- The effects of earthquakes on lateral capacity and structural capacity of piles foundations must also be taken into account;
- Piles should be no closer than 2.5 pile diameters apart. If closer than this, interaction effects between piles should be taken into account and pile group assessed;
- Pile design should be in accordance with Australian Standard AS 2159-1995, *Piling – Design and Installation.* Appropriate geotechnical reduction factors should be applied to the ultimate parameters provided in Table 7;
- More accurate ultimate bearing capacities and settlement estimates can be obtained by undertaking additional investigations and/or static load tests on trial piles;
- Where uplift is critical, it is recommended that uplift load tests be conducted.
- Additional investigations should be undertaken at each building location to allow detailed pile design and refinement of strength parameters outlined above.

9.4.2 Aggressivity

Samples from boreholes BH6 and BH9 were submitted for analysis for chemical aggressivity to buried structural elements. Results are presented in Appendix D and indicate the soil conditions within the alluvial profile to be moderately aggressive towards concrete and steel.

10 ASS MANAGEMENT STRATEGIES

It is understood some possible development for the site includes dredging a marina in the low lying eastern part of the site adjacent to the Manning River. Testing as summarised in the previous Coffey Report titled “Acid Sulfate Soil and Contamination Assessment and Review, GEOTTUNC01736AA-AD” indicates the approximate extent of Potential ASS as shown approximately on Figure 6. These results indicate the ASS potential to be predominantly in the silty Sands and Clays below 1m depth. There is therefore a high likelihood that bulk excavation or dredging and r detailed excavations for service trenches etc will expose Potential ASS.

There are several options for managing ASS. One method is to design the development in such a way that excavation of ASS is avoided. This however, is not always practical and for the purposes of the proposed development such a strategy would sterilize a significant proportion of otherwise developable waterfront land.

The most common method of treating ASS is to treat the excavated soil with lime, as per the Acid Sulfate Soil Management Guidelines. This then allows the soil to either be disposed of, or if suitable from a geotechnical perspective, be re-used on the site as fill, once neutralised to acceptable levels. The results of the testing undertaken to date indicate large quantities of lime may be required for this option to be effective.

An alternative that would seem to be available on this site is to delineate the lateral and vertical extents of ASS, then excavate soils as required. In ASS areas, over-excavate, removing non-ASS soil from beneath the ASS layer, and bury the potential ASS back below the water table so that oxidation cannot occur. For bulk excavation such as in the proposed marina this may be more economic that the alternative treatments such as liming.

Other technologies are available and could be explored once more details of the proposed development are known. It is recommended that more detailed investigations be undertaken to define the extent and concentrations of ASS prior to developing a management plan once more details of the proposed development are known.

11 LIMITATIONS

This assessment of geotechnical conditions should be considered as preliminary as it is based on limited subsurface information. The report has been prepared in accordance with generally accepted consulting practice and is intended to alert interested parties to the geotechnical conditions, associated hazards, and possible solutions for the proposed development. As such the document is provided for use in preliminary planning and to provide direction to further investigations. No other warranty, expressed or implied, is made as to the professional advice included in this report.

The extent of testing associated with this assessment is limited to borehole and CPT data at discrete locations. To the best of our knowledge, they represent a reasonable interpretation of the general condition of the site. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points. It should be noted that significant variations in ground conditions can occur between test locations in the alluvial / estuarine environment. Specific, detailed geotechnical investigations should be undertaken prior to developing concept or detailed design.

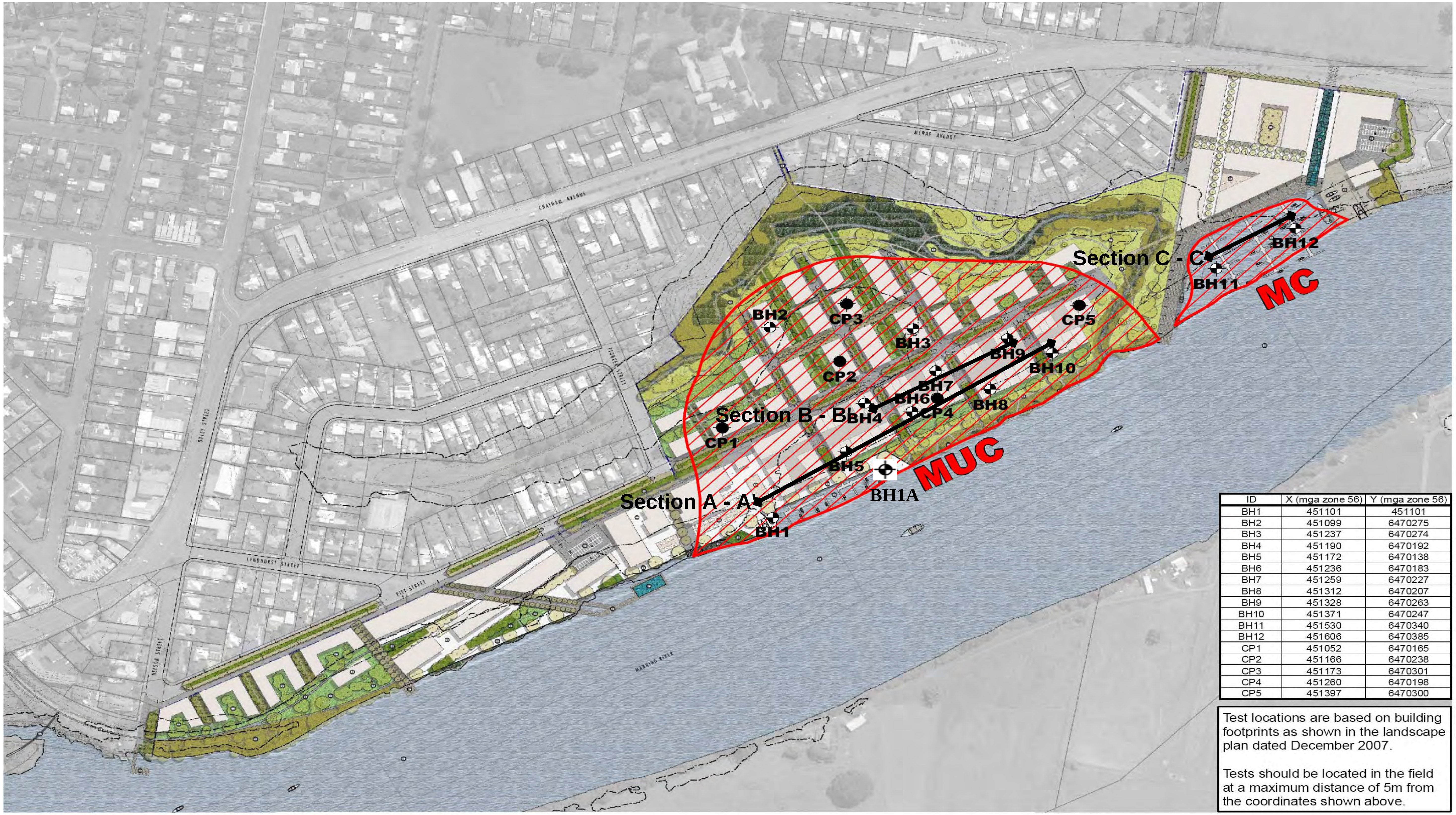
Coffey would be pleased to assist in such investigations, management of geotechnical risk, and geotechnical design work.

For and on behalf of Coffey Geotechnics Pty Ltd

Steven Morton

Principal

Figures



ID	X (mga zone 56)	Y (mga zone 56)
BH1	451101	451101
BH2	451099	6470275
BH3	451237	6470274
BH4	451190	6470192
BH5	451172	6470138
BH6	451236	6470183
BH7	451259	6470227
BH8	451312	6470207
BH9	451328	6470263
BH10	451371	6470247
BH11	451530	6470340
BH12	451606	6470385
CP1	451052	6470165
CP2	451166	6470238
CP3	451173	6470301
CP4	451260	6470198
CP5	451397	6470300

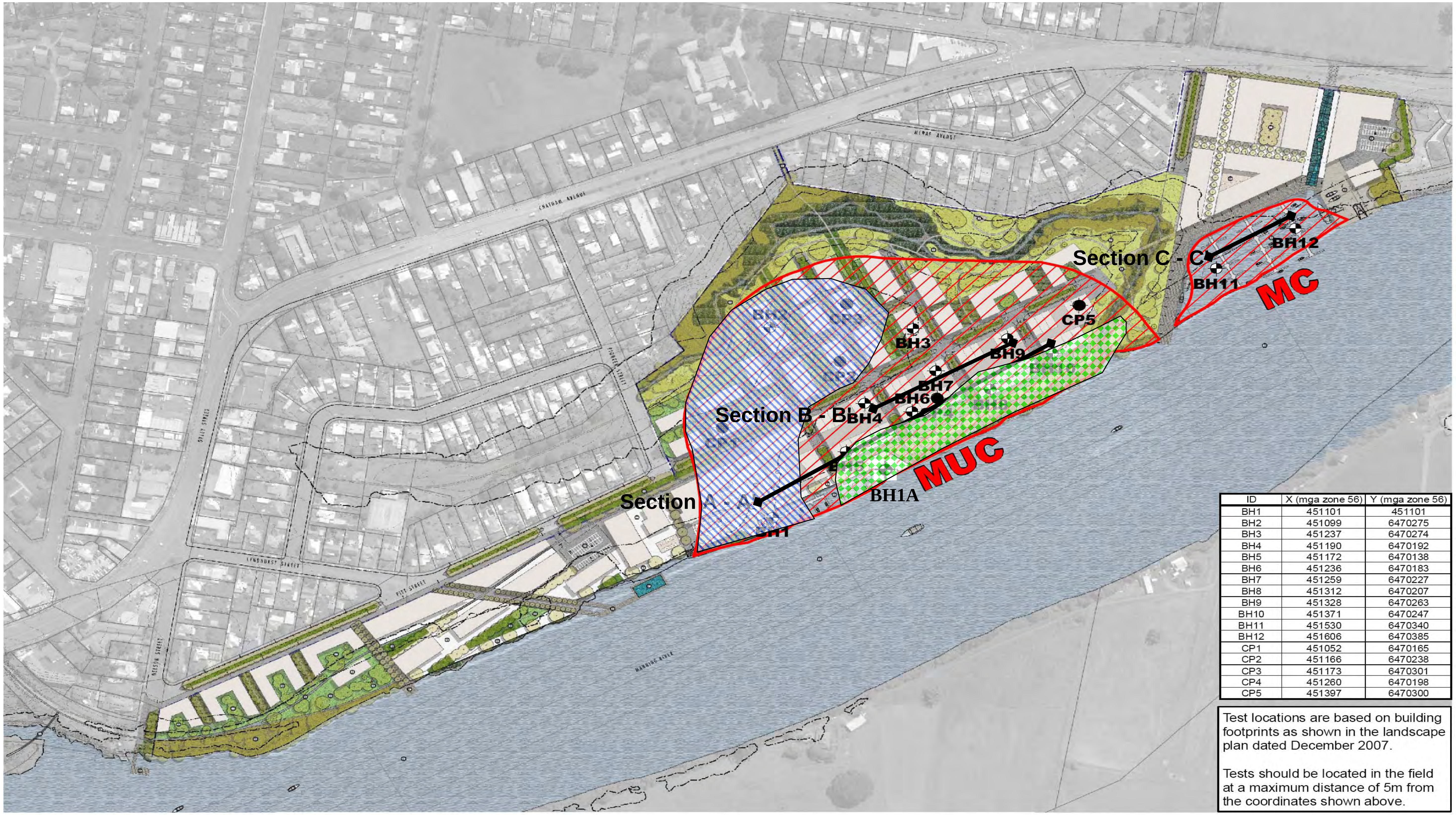
Test locations are based on building footprints as shown in the landscape plan dated December 2007.

Tests should be located in the field at a maximum distance of 5m from the coordinates shown above.

- Bore Hole
- Cone Penetrometer
- Investigation Area

As per Supplied Drawing "Figure 1.1 Borehole and Cone Penetrometer Locations"

drawn	TLM	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	SINCLAIR KNIGHT MERZ
approved			project:	PITT STREET WATERFRONT PRECINCT TAREE
date	17/06/2008		title:	SITE LOCATION PLAN
scale			project no:	GEOTTUNC01736AB-AD
original size	A3		figure no:	FIGURE 1



ID	X (mga zone 56)	Y (mga zone 56)
BH1	451101	451101
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CP1	451052	6470165
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CP3	451173	6470301
CP4	451260	6470198
CP5	451397	6470300

Test locations are based on building footprints as shown in the landscape plan dated December 2007.

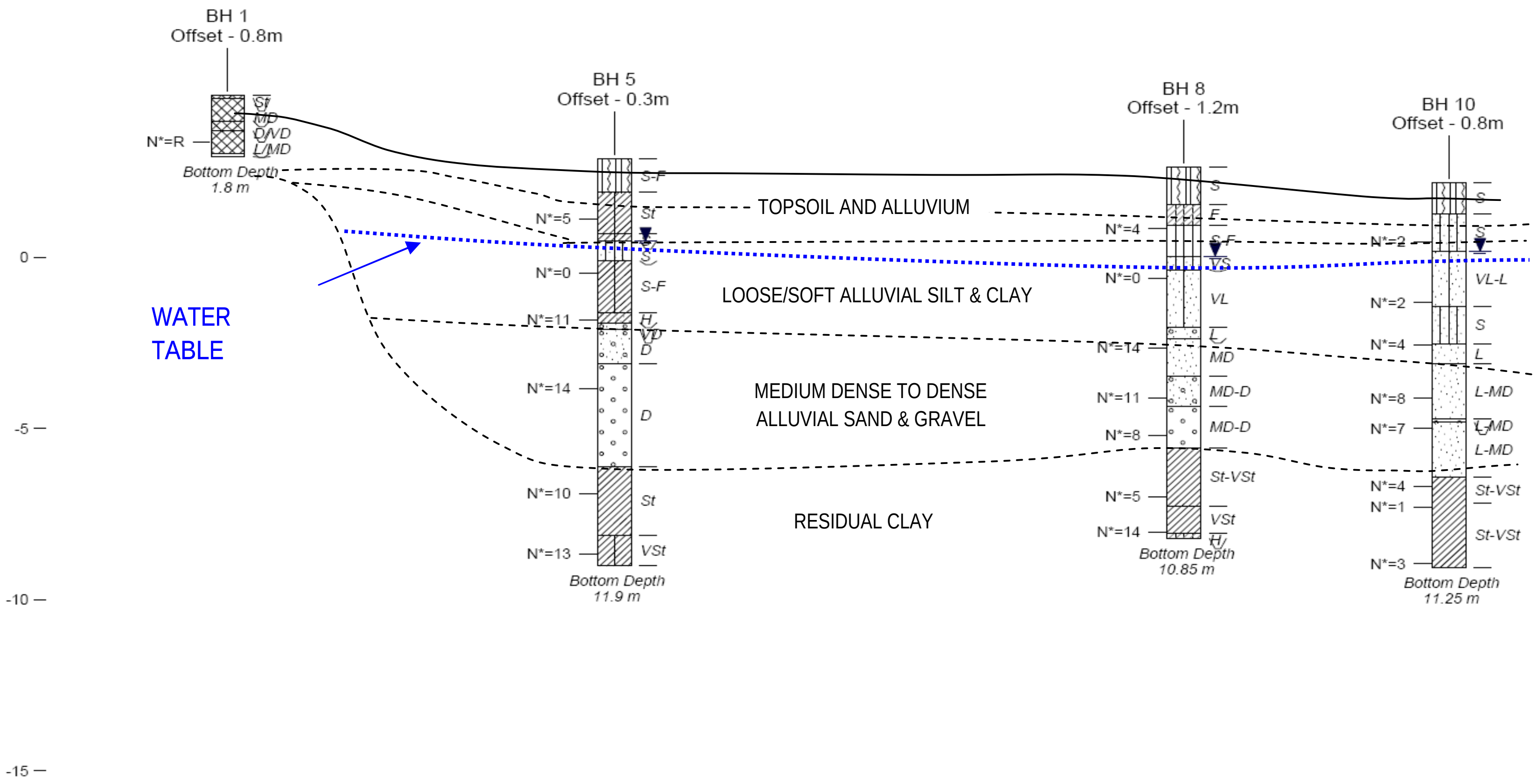
Tests should be located in the field at a maximum distance of 5m from the coordinates shown above.

Bore Hole
Cone Penetrometer
Investigation Area

Zone A - Shallow Bedrock (<3.5m)
Zone B - Alluvial Profile. Residual / Rock <10m deep
Zone C - Alluvial Profile. Resdiual / Rock >10m deep

drawn	TLM	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	SINCLAIR KNIGHT MERZ
approved			project:	PITT STREET WATERFRONT PRECINCT TAREE
date	17/06/2008			
scale			title:	GEOTECHNCIAL TERRAINS
original size	A3		project no: GEOTTUNC01736AB-AD	figure no: FIGURE 2

As per Supplied Drawing "Figure 1.1 Borehole and Cone Penetrometer Locations"

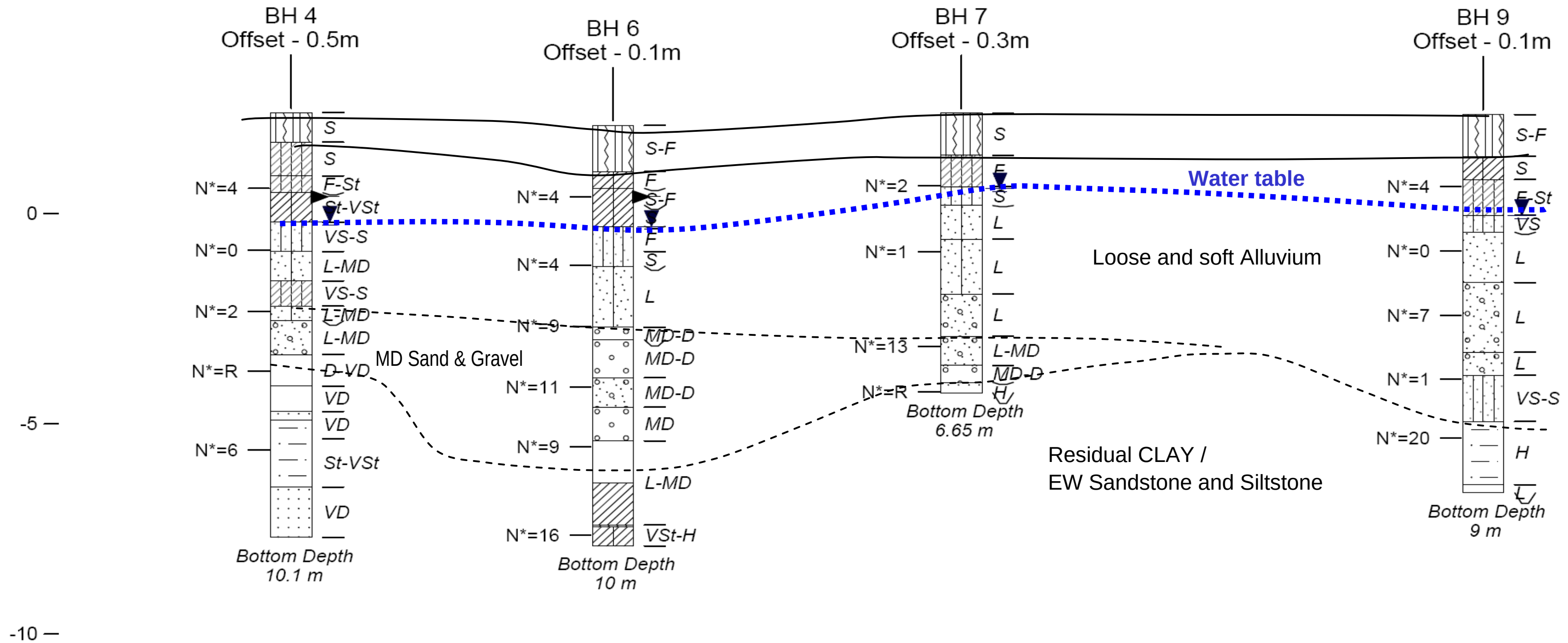


▼ WATER LEVEL

N*=17 STANDARD PENETRATION TEST RESULT

drawn	SRM	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	SINCLAIR KNIGHT MERZ
approved			project:	PITT STREET WATERFRONT PRECINCT, TAREE GEOTECHNICAL INVESTIGATION
date				
scale	AS SHOWN		title:	SECTION A - A'
original size	A4		project no: GEOTTUNC01736AB-AD	figure no: FIGURE 3

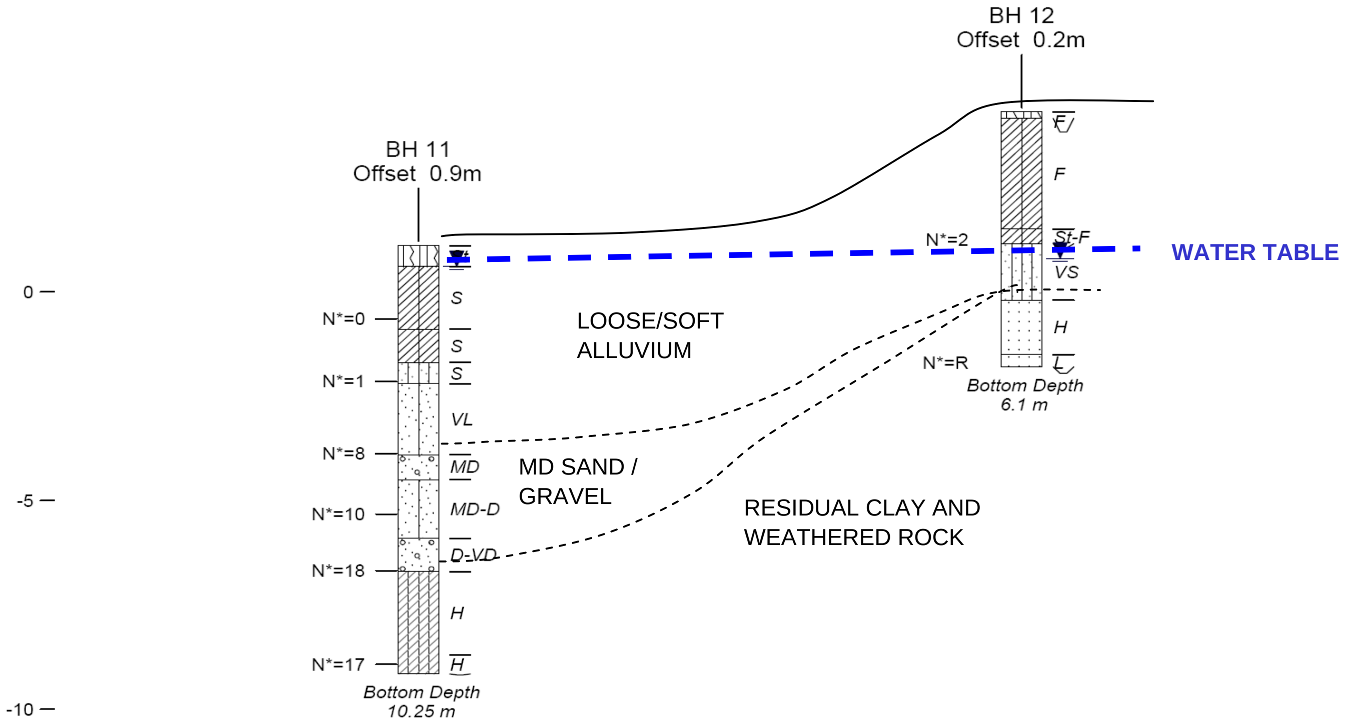
F:\Taree Working Folder\GEOTTUNC01736AB- Pitt Street\Final report\[TUNC01736AB-AD Fig 3.xls]A4 Landscape Figure



WATER LEVEL

N*=17 STANDARD PENETRATION TEST RESULT

drawn	SRM	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	SINCLAIR KNIGHT MERZ
approved			project:	PITT STREET WATERFRONT PRECINCT, TAREE GEOTECHNICAL INVESTIGATION
date				
scale	AS SHOWN		title:	SECTION B - B'
original size	A4		project no: GEOTTUNC01736AB-AD	figure no: FIGURE 4



WATER LEVEL

N*=17 STANDARD PENETRATION TEST RESULT

drawn	SRM	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client:	SINCLAIR KNIGHT MERZ
approved			project:	PITT STREET WATERFRONT PRECINCT, TAREE GEOTECHNICAL INVESTIGATION
date				
scale	AS SHOWN		title:	Section C - C' (MC Site)
original size	A4		project no: GEOTTUNC01736AA-AD	figure no: FIGURE 5

LEGEND:

- Groundwater well
- Contamination sample
- ASS Sample
- Inferred extent of ASS

Note: Borehole information from Coffey Report GEOTTUNC01736AA-AD.

drawn	SRM	client:	GREATER TAREE CITY COUNCIL
approved		project:	PITT STREET MARINA PRECINCT TAREE
date	14/9/07		
scale	nts	title:	INFERRED ZONE OF POTENTIAL ASS
original size	A4	project no: GEOTTUNC01736AB-AD	figure no: FIGURE 6

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SPECIALISTS MANAGING THE EARTH

Appendix A

Borehole logs and explanation sheets

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Rock Description Explanation Sheet (1 of 2)

The descriptive terms used by Coffey are given below. They are broadly consistent with Australian Standard AS1726-1993.

DEFINITIONS: Rock substance, defect and mass are defined as follows:

Rock Substance In engineering terms roch substance is any naturally occurring aggregate of minerals and organic material which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Effectively homogenous material, may be isotropic or anisotropic.

Defect Discontinuity or break in the continuity of a substance or substances.

Mass Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

SUBSTANCE DESCRIPTIVE TERMS:

ROCK NAME Simple rock names are used rather than precise geological classification.

PARTICLE SIZE Grain size terms for sandstone are:

Coarse grained	Mainly 0.6mm to 2mm
Medium grained	Mainly 0.2mm to 0.6mm
Fine grained	Mainly 0.06mm (just visible) to 0.2mm

FABRIC Terms for layering of penetrative fabric (eg. bedding, cleavage etc.) are:

Massive	No layering or penetrative fabric.
Indistinct	Layering or fabric just visible. Little effect on properties.
Distinct	Layering or fabric is easily visible. Rock breaks more easily parallel to layering of fabric.

CLASSIFICATION OF WEATHERING PRODUCTS

Term	Abbreviation	Definition
Residual Soil	RS	Soil derived from the weathering of rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely Weathered Material	XW	Material is weathered to such an extent that it has soil properties, ie, it either disintegrates or can be remoulded in water. Original rock fabric still visible.
Highly Weathered Rock	HW	Rock strength is changed by weathering. The whole of the rock substance is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Some minerals are decomposed to clay minerals. Porosity may be increased by leaching or may be decreased due to the deposition of minerals in pores.
Moderately Weathered Rock	MW	The whole of the rock substance is discoloured, usually by iron staining or bleaching , to the extent that the colour of the fresh rock is no longer recognisable.
Slightly Weathered Rock	SW	Rock substance affected by weathering to the extent that partial staining or partial discolouration of the rock substance (usually by limonite) has taken place. The colour and texture of the fresh rock is recognisable; strength properties are essentially those of the fresh rock substance.
Fresh Rock	FR	Rock substance unaffected by weathering.

Notes on Weathering:

1. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between XW and SW. For projects where it is not practical to delineate between HW and MW or it is judged that there is no advantage in making such a distinction. DW may be used with the definition given in AS1726.
2. Where physical and chemical changes were caused by hot gasses and liquids associated with igneous rocks, the term "altered" may be substituted for "weathering" to give the abbreviations XA, HA, MA, SA and DA.

ROCK SUBSTANCE STRENGTH TERMS

Term	Abbreviation	Point Load Index, I_{S50} (MPa)	Field Guide
Very Low	VL	Less than 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; pieces up to 30mm thick can be broken by finger pressure.
Low	L	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show with firm bows of a pick point; has a dull sound under hammer. Pieces of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	M	0.3 to 1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	H	1 to 3	A piece of core 150mm long by 50mm can not be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	VH	3 to 10	Hand specimen breaks after more than one blow of a pick; rock rings under hammer.
Extremely High	EH	More than 10	Specimen requires many blows with geological pick to break; rock rings under hammer.

Notes on Rock Substance Strength:

1. In anisotropic rocks the field guide to strength applies to the strength perpendicular to the anisotropy. High strength anisotropic rocks may break readily parallel to the planar anisotropy.
2. The term "extremely low" is not used as a rock substance strength term. While the term is used in AS1726-1993, the field guide therein makes it clear that materials in that strength range are soils in engineering terms.
3. The unconfined compressive strength for isotropic rocks (and anisotropic rocks which fall across the planar anisotropy) is typically 10 to 25 times the point load index (Is50). The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.

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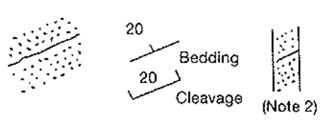
Rock Description Explanation Sheet (2 of 2)

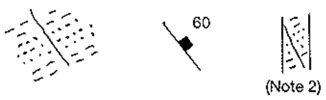
COMMON DEFECTS IN ROCK MASSES

Term / Definition / Diagram / Map Symbol / Graphic Log (Note 1)

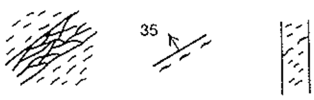
Parting — A surface or crack across which the rock has little or no tensile strength. Parallel or sub parallel to layering (eg bedding) or a planar anisotropy in the rock substance (eg, cleavage). May be open or closed.



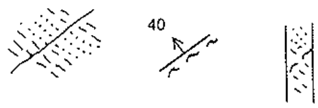
Joint — A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.



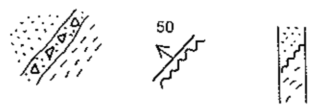
Sheared Zone (Note 3) — Zone of rock substance with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge shaped blocks.



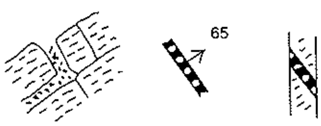
Sheared Surface (Note 3) — A near planar, curved or undulating surface which is usually smooth, polished or slickensided.



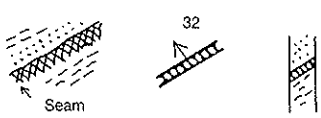
Crushed Seam (Note 3) — Seam with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock substance which may be more weathered than the host rock. The seam has soil properties.



Infilled Seam — Seam of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface.



Extremely Weathered Seam — Seam of soil substance, often with gradational boundaries. Formad by weathering of the rock substance in place.



DEFECT SHAPE TERMS

Planar	The defect does not vary in orientation
Curved	The defect has a gradual change in orientation
Undulating	The defect has a wavy surface
Stepped	The defect has one or more well defined steps
Irregular	The defect has many sharp changes of orientation

Note: The assessment of defect shape is partly influenced by the scale of the observation.

ROUGHNESS TERMS

Slickensided	Grooved or striated surface, usually polished
Polished	Shiny smooth surface
Smooth	Smooth to touch. Few or no surface irregularities
Rough	Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.
Very Rough	Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.

COATING TERMS

Clean	No visible coating
Stained	No visible coating but surfaces are discoloured
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	A visible coating up to 1mm thick. Thicker soil material is usually described using appropriate defect terms (eg, infilled seam). Thicker rock strength material is usually described as a vein.

BLOCK SHAPE TERMS

Blocky	Approximately equidimensional
Tabular	Thickness much less than length or width
Columnar	Height much greate than cross section

Notes on Defects:

1. Usually borehole logs show the true dip of defects and face sketches and sections the apparent dip.
2. Partings and joints are not usually shown on the graphic log unless considered significant.
3. Sheared zones, sheared surfaces and crushed seams are faults in geological terms.

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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% 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% 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.

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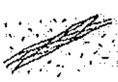
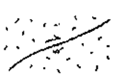
Soil Description Explanation Sheet (2 of 2)

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)						USC	PRIMARY NAME
COARSE GRAINED SOILS More than 50% of materials less than 63 mm is larger than 0.075 mm (A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.0 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.			GW	GRAVEL
			Predominantly one size or a range of sizes with more intermediate sizes missing.			GP	GRAVEL
		GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)			GM	SILTY GRAVEL
			Plastic fines (for identification procedures see CL below)			GC	CLAYEY GRAVEL
	SANDS More than half of coarse fraction is smaller than 2.0 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes missing			SW	SAND
			Predominantly one size or a range of sizes with some intermediate sizes missing.			SP	SAND
		SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).			SM	SILTY SAND
			Plastic fines (for identification procedures see CL below).			SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm		IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm.					
			DRY STRENGTH	DILATANCY	TOUGHNESS		
	SILTS & CLAYS Liquid limit less than 50		None to Low	Quick to slow	None	ML	SILT
			Medium to High	None	Medium	CL	CLAY
			Low to medium	Slow to very slow	Low	OL	ORGANIC SILT
	SILTS & CLAYS Liquid limit greater than 50		Low to medium	Slow to very slow	Low to medium	MH	SILT
			High	None	High	CH	CLAY
			Medium to High	None	Low to medium	OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS			Readily identified by colour, odour, spongy feel and frequently by fibrous texture.			Pt	PEAT

• Low plasticity – Liquid Limit W_L less than 35%. • Modium plasticity – W_L between 35% and 50%.

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM
PARTING	A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.	
JOINT	A surface or crack across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. The term 'fissure' may be used for irregular joints <0.2 m in length.	
SHEARED ZONE	Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.	
SHEARED SURFACE	A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.	

TERM	DEFINITION	DIAGRAM
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	
TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter	
TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	
INFILLED SEAM	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open joints.	

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Engineering Log - Borehole

Borehole No.	*BH 1*
Sheet	1 of 1
Project No:	*GEOTTUNC01736AB*
Date started:	*14.3.2008*
Date completed:	*14.3.2008*
Logged by:	*P.E*
Checked by:	*SRM*

Client:	*SINCLAIR KNIGHT MERZ*
Principal:	*GREATER TAREE CITY COUNCIL*
Project:	*PITT ST, WATERFRONT PRECINCT, TAREE*
Borehole Location:	*SEE FIGURE 2*

drill model and mounting: JACKRO TRAILER Easting: 451101 slope: -90° R.L. Surface: 4.74

hole diameter: 100 mm Northing 6470066 bearing: 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 penetrometer kPa 100 200 300 400	structure and additional observations
AST		N	NIL					SM	**TOPSOIL** Silty SAND, fine to medium, dark grey, some organics (motlets).	M/Wp	St		TOPSOIL/FILL
								GP	**FILL** Sandy Gravel fine to medium, brown, some organics (rootlets) and low plasticity.	D	MD		FILL
					4			GP	**FILL**Sandy Gravel medium coarse, brown, some low plasticity Silt, brick rubble and Sandstone fragments.	D	D/VD		
				SPT 1,3,r N*=R		1		SM	**FILL**Silty SAND medium coarse, dark grey, some shell grit and trace low plasticity Clay and ash.	M	L/MD		
					3				**Siltstone/ Sandstone** fine grained, pale brown.	D			ROCK (ESTIMATED STRENGTH LOW- MEDIUM) SPT BOUNCING ON ROCK
						2			Borehole BH 1 terminated at 1.8m				
					2								
						3							
					1								
						4							
					0								
						5							
					-1								
						6							
					-2								
						7							
					-3								
						8							

BOREHOLE GEOTTUNC01736AB.GPJ COFFEY.GDT 14.4.08

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

coffey geotechnics

Engineering Log - Borehole

Borehole No.	*BH 1A*
Sheet	1 of 2
Project No:	*GEOTTUNC01736AB*
Client:	*SINCLAIR KNIGHT MERZ*
Principal:	*GREATER TAREE CITY COUNCIL*
Project:	*PITT ST, WATERFRONT PRECINCT, TAREE*
Borehole Location:	*SEE FIGURE 2*
Date started:	*14.3.2008*
Date completed:	*14.3.2008*
Logged by:	*P.E*
Checked by:	*SRM*

drill model and mounting:	JACKRO TRAILER	Easting:		slope:	-90°	R.L. Surface:	2.9
hole diameter:	100 mm	Northing		bearing:		datum:	AHD

drilling information / material substance

method	support	water	notes samples, tests, etc	RL	depth metres	classification symbol	material (soil type: plasticity or particle characteristics, colour, secondary and minor components)	moisture condition	consistency/density index	structure and additional observations
AST	N				0	ML	**Clayey SILT** low to medium, brown, some organics (rootlets), trace fine Sand.	M/Wp	St/f	TOPSOIL AND ALLUVIUM
				2	1	CL	**Silty CLAY** low to medium plasticity, brown, trace of organics (rootlets).	M/Wp	St	ALLUVIAL
			SPT 0,2,1 N*=3	1	2	ML	**Clayey SILT** low plasticity, brown.	M/Wp	S	ALLUVIAL
		▼	SPT 0,0,0 N*=0	0	3	ML	**Sandy SILT** low plasticity, grey, trace organics (rootlets)	M/Wl	VS VS/S	ALLUVIAL
			SPT 0,0,0 N*=0	-1	4	SM	**Silty SAND** fine to medium, grey	W	VL/L	ALLUVIAL
				-2	5	ML	**Sandy SILT** low plasticity, grey, trace organics (rootlets)	M/Wl	S	ALLUVIAL
				-3	5.5	GP	**Sandy GRAVEL** fine to medium, dark grey, some low plasticity Silt.	W	L/MD	ALLUVIAL GRAVEL
			SPT 4,6,5 N*=11		6	GP	**Sandy GRAVEL** fine to medium, dark grey, some low plasticity fines (Silt).	W	MD/D	ALLUVIAL
				-4	7	GP	**Silty GRAVEL/ Gravelly SILT** fine to medium, dark grey, some Clay.	W	L/MD	ALLUVIAL
						CH	**Silty CLAY** medium to high plasticity, grey,	W		ALLUVIAL (CLAY LENSE)
			SPT 3,4,6 N*=10	-5	8	GP	**GRAVEL** fine to medium, grey, trace of Sand and Clay lenses.	W	MD/D	ALLUVIAL (NOTE: NO SAMPLE RECOVERED) (GRAVEL- FINE TO MEDIUM-PARTICLES)

pocket penetrometer kPa: 100 200 300 400

method		support		notes, samples, tests		consistency/density index	
AS	auger screwing*	M	mud	U_{50}	undisturbed sample 50mm diameter	VS	very soft
AD	auger drilling*	C	casing	U_{63}	undisturbed sample 63mm diameter	S	soft
RR	roller/tricone	N	nil	D	disturbed sample	F	firm
W	washbore			N	standard penetration test (SPT)	St	stiff
CT	cable tool			N*	SPT - sample recovered	VSt	very stiff
HA	hand auger			Nc	SPT with solid cone	H	hard
DT	diatube			V	vane shear (kPa)	Fb	friable
B	blank bit			P	pressuremeter	VL	very loose
V	V bit			Bs	bulk sample	L	loose
T	TC bit			E	environmental sample	MD	medium dense
*bit shown by suffix				R	refusal	D	dense
e.g.	ADT					VD	very dense

penetration 1 2 3 4 — no resistance ranging to refusal

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

classification symbols and soil description based on unified classification system

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

BOREHOLE GEOTTUNC01736AB.GPJ COFFEY.GDT 14.4.08

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Engineering Log - Borehole

Borehole No.	*BH 1A*
Sheet	2 of 2
Project No:	*GEOTTUNC01736AB*
Client:	*SINCLAIR KNIGHT MERZ*
Principal:	*GREATER TAREE CITY COUNCIL*
Project:	*PITT ST, WATERFRONT PRECINCT, TAREE*
Borehole Location:	*SEE FIGURE 2*
Date started:	*14.3.2008*
Date completed:	*14.3.2008*
Logged by:	*P.E*
Checked by:	*SRM*

drill model and mounting: JACKRO TRAILER | Easting: | slope: -90° | R.L. Surface: 2.9
hole diameter: 100 mm | Northing | bearing: | 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
AST		N						GP	**GRAVEL** fine to medium, grey, trace of Sand and Clay lenses. *(continued)*	W	MD/D		
								CH	**CLAY** high plasticity, grey,	M/Wp	F		ALLUVIAL (CLAY LENSE)
					-6	9		GP	**GRAVEL** fine to medium, grey, trace of coarse sand.	W	MD		ALLUVIAL
				SPT 1,1,2 N*=3	-7	10		CH	**CLAY** high plasticity, grey and grey mottle, some Silt, trace organic (decomposed roots).	M/Wp	S/F		
									Borehole BH 1A terminated at 10m				
					-8	11							
					-9	12							
					-10	13							
					-11	14							
					-12	15							
					-13	16							

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

coffey geotechnics

Engineering Log - Borehole

Borehole No.	BH 2
Sheet	1 of 1
Project No:	GEOTTUNC01736AB
Client:	SINCLAIR KNIGHT MERZ
Date started:	14.3.2008
Principal:	GREATER TAREE CITY COUNCIL
Date completed:	14.3.2008
Project:	PITT ST, WATERFRONT PRECINCT, TAREE
Logged by:	P.E
Borehole Location:	SEE FIGURE 2
Checked by:	SRM

drill model and mounting:	JACKRO TRAILER	Easting:	451099	slope:	-90°	R.L. Surface:	5.61
hole diameter:	100 mm	Northing	6470275	bearing:		datum:	AHD

drilling information / **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	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
AST		N					ML	**TOPSOIL** Clayey Silt, low to medium, dark brown, some organics (rootlets) trace fine Sand.	M/Wp	St		TOPSOIL
							CL	**Silty CLAY** low to medium, brown, trace organics (rootlets) and fine Sand.	M/Wp	VSt		ALLUVIAL
				U50	5	1	CH	**Clay** medium to high, light brown, trace Silt.	M/Wp	VSt/H		ALLUVIAL
				SPT 5,5,8 N*=13	4		ML	**Clayey SILT** low to medium, light brownand light grey, trace fine Sand.	M/Wp	H		RESIDUAL
				SPT 4,5,6 N*=11	3	2, 3	ML	**Clayey SILT** low to medium, light grey, trace fine Sand.	M/Wp	St/VSt		RESIDUAL
					2	4	ML	**Silt** low to medium, light brown, some fine Sand.	M/Wp	H		RELIC, ROCK, SILTSTONE
				SPT 4,R N*=R	1, 0, -1	5, 6	SW	**Siltstone**highly fractured, fine grained, brown.	D	VL		SILTSTONE (ROCK) SPT BOUNCING
					-2	7, 8		Borehole BH 2 terminated at 6.9m				

method		support		notes, samples, tests		classification symbols and soil description	consistency/density index	
AS	auger screwing*	M mud	N nil	U50	undisturbed sample 50mm diameter	based on unified classification system	VS	very soft
AD	auger drilling*	C casing		U63	undisturbed sample 63mm diameter		S	soft
RR	roller/tricone	**penetration** 1 2 3 4		D	disturbed sample		F	firm
W	washbore	no resistance ranging to refusal		N	standard penetration test (SPT)		St	stiff
CT	cable tool			N*	SPT - sample recovered	**moisture**	VSt	very stiff
HA	hand auger	**water**		Nc	SPT with solid cone	D dry	H	hard
DT	diatube	10/1/98 water level on date shown		V	vane shear (kPa)	M moist	Fb	friable
B	blank bit			P	pressuremeter	W wet	VL	very loose
V	V bit			Bs	bulk sample	Wp plastic limit	L	loose
T	TC bit	water inflow		E	environmental sample	WL liquid limit	MD	medium dense
*bit shown by suffix		water outflow		R	refusal		D	dense
e.g.	ADT						VD	very dense

BOREHOLE GEOTTUNC01736AB.GPJ COFFEY.GDT 14.4.08

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Engineering Log - Borehole

Borehole No.	BH 3
Sheet	1 of 2
Project No:	GEOTTUNC01736AB
Date started:	14.3.2008
Date completed:	14.3.2008
Logged by:	P.E
Checked by:	SRM

Client: SINCLAIR KNIGHT MERZ

Principal: GREATER TAREE CITY COUNCIL

Project: PITT ST, WATERFRONT PRECINCT, TAREE

Borehole Location: SEE FIGURE 2

drill model and mounting:	JACKRO TRAILER	Easting:	451237	slope:	-90°	R.L. Surface:	5.06
hole diameter:	100 mm	Northing	6470274	bearing:		datum:	AHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/density index	pocket penetrometer kPa (100 200 300 400)	structure and additional observations
AST		N					ML	**TOPSOIL** Clayey SILT; low to medium, dark brown, some organics (rootlets), traces fine Sand.	M>Wp	F/St		TOPSOIL
							CL	**Silty CLAY** low plasticity, brown, trace fine Sand.	M>Wp	St/VSt		FILL
					4	1	ML	**Clayey SILT**; low plasticity, light brown and grey mottled, trace fine Sand.	M>Wp	H	550	
				SPT 13,12 N*=R								
					3	2	CL	**Silty CLAY** brown and grey mottled, some fine sand.	M>Wp	St		ALLUVIAL
					2	3						
				SPT 3,3,5 N*=8			CH	**Silty CLAY** medium to high plasticity, grey/ blue, trace organics (rootlets).	M>Wp	VSt	600	ALLUVIAL
								GRAVEL highly fractured, fine Gravel, brown	D	VL		GRAVEL BAND
					1	4	CH	**Silty CLAY** medium to high, grey/ blue, trace organics and fine Sand.	M>Wp	VSt		ALLUVIAL
							CH	**Clay** high plasticity, grey/ blue, trace organics (rootlets) and Silt.	M<Wp	H		ALLUVIAL
				SPT 4,6,9 N*=15	0	5						
			►		-1	6						
				SPT 4,6,9 N*=15			ML	**Clayey SILT** low to medium, grey/ blue and green mottled, trace fine Gravel and fine Sand	M<Wp	H		ALLUVIAL
					-2	7						
			►	SPT 10,9 N*=R		8		**Siltstone** extremely weathered, highly fractured, fine grained, brown.	W	VL	600	RELIC ROCK

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 GEOTTUNC01736AB.GPJ COFFEY.GDT 14.4.08

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coffey geotechnics

Engineering Log - Borehole

Borehole No.	*BH 3*
Sheet	2 of 2
Project No:	*GEOTTUNC01736AB*
Date started:	*14.3.2008*
Date completed:	*14.3.2008*
Logged by:	*P.E*
Checked by:	*SRM*

Client: *SINCLAIR KNIGHT MERZ*

Principal: *GREATER TAREE CITY COUNCIL*

Project: *PITT ST, WATERFRONT PRECINCT, TAREE*

Borehole Location: *SEE FIGURE 2*

drill model and mounting:	JACKRO TRAILER	Easting:	451237	slope:	-90°	R.L. Surface:	5.06
hole diameter:	100 mm	Northing	6470274	bearing:		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
AST		N							**Siltstone** extremely weathered, highly fractured, fine grained, brown. *(continued)*	W	VL		
					-4	9			Borehole BH 3 terminated at 8.8m				
					-5	10							
					-6	11							
					-7	12							
					-8	13							
					-9	14							
					-10	15							
						16							

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 GEOTTUNC01736AB.GPJ COFFEY.GDT 14.4.08

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Engineering Log - Borehole

Borehole No.	*BH 4*
Sheet	1 of 2
Project No:	*GEOTTUNC01736AB*
Client:	*SINCLAIR KNIGHT MERZ*
Principal:	*GREATER TAREE CITY COUNCIL*
Project:	*PITT ST, WATERFRONT PRECINCT, TAREE*
Borehole Location:	*SEE FIGURE 2*
Date started:	*14.3.2008*
Date completed:	*14.3.2008*
Logged by:	*P.E*
Checked by:	*SRM*

drill model and mounting: JACKRO TRAILER | Easting: 451190 | slope: -90° | R.L. Surface: 2.4

hole diameter: 100 mm | Northing 6470192 | bearing: | datum: AHD

drilling information / material substance

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	classification symbol	material (soil type: plasticity or particle characteristics, colour, secondary and minor components)	moisture condition	consistency/density index	structure and additional observations
AST		N			2		ML	**TOPSOIL** Clay Silt **low plasticity, brown, some organics (rootlets), trace fine Sand.**	M+Wp	S	TOPSOIL
					1	1	GW	**Clayey SILT** low plasticity, brown, trace organics (rootlets).	M+Wp	S	ALLUVIAL
			water inflow	SPT 2,2,2 N*=4			ML	**Clayey SILT** low to medium plasticity, brown and grey mottled, trace organics (rootlets), fine Sand.	M+Wp	F-St	ALLUVIAL
			water level		0	2	CH	**Silty CLAY** low to medium plasticity, brown, trace fine Sand.	M+Wp	St-VSt	ALLUVIAL
						3	ML	**Sandy SILT** low plasticity, grey, trace Clay and organics (rootlets).	M+Wl	VS-S	ALLUVIAL
				SPT 0,0,0 N*=0	-1						ALLUVIAL
							SM	**Silty SAND** fien to medium, dark grey.	W	L-MD	ALLUVIAL
					-2	4	ML	**Clayey SILT**low to medium, dark grey and brown mottled, some fine Sand.	M+Wp	VS-S	ALLUVIAL
				SPT 0,0,2 N*=2			SM	**Silty SAND** fine to medium, dark grey, trace of fine Gravel.	W	L-MD	ALLUVIAL
					-3	5	GP	**Sandy GRAVEL** fine to medium, dark grey, some Silt.	W	L-MD	ALLUVIAL
				SPT 14,11 N*=R	-4	6	SP	Extremely weathered, orange/ brown, coarse Gravel Sandstone, some Silt and fine Gravel.	M	D-VD	RESIDUAL RELIC ROCK
						7		highly weathered, orange/ brown, coarse Gravel Sandstone, some Silt and fine Gravel.	D	VD	RESIDUAL ROCK
					-5			**SANDSTONE/SILTSTONE** moderatly weathered medium coarse, pale brown trace fine gravel.	D	VD	ROCK
						8		**SILTSTONE** eltremly weathered, pale brown, some coarse Sand, fine Gravel.	M+Wp	St-VSt	RESIDUAL

Pocket penetrometer (kPa 100/200/300/400) readings marked at approx. 1.5 m, 3.1 m, 4.6 m and 7.9 m.

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