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Acid Sulphate Soil Management Plan

Proposed Stormwater Works
and Stage 1 Redevelopment
Warringah Mall
Brookvale

Prepared for
Westfield Design & Construction Pty Ltd

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Table of Contents

Page

Table of Contents

Page

Acid Sulphate Soil Management Plan
Proposed Stormwater Works and Stage 1 Redevelopment
Warringah Mall, Corner Condamine Street and Old Pittwater Road, Brookvale

1. Introduction

This report comprises an acid sulphate soil management plan (ASSMP) for the proposed stormwater works and Stage 1 redevelopment building works at the Warringah Mall Shopping Centre, Brookvale. The assessment was carried out in accordance with DP's proposal dated 9 August 2013 and was commissioned on 11 September 2013 by Westfield Design and Construction Pty Ltd as a variation to the Westfield Consultant Services Contract dated 8 April 2013.

Acid sulphate soils (ASS) comprise naturally occurring soils that produce sulphuric acid when they react with oxygen (which can also mobilise metals in soils). Sulphuric acid and metals can have negative impacts on ecosystems and construction materials. The purpose of this ASSMP is to detail the strategies to be implemented to manage these potential negative impacts, given the presence of ASS at the site.

This ASSMP describes the proposed development, ASS tests undertaken, potential off-site impacts, responsibilities, and operational requirements such as groundwater and surface protection. Data from DP's previous investigations undertaken in 2013 has been incorporated into preparing the ASSMP.

2. Site Identification and Proposed Development

Warringah Mall is a large shopping mall complex at Brookvale, NSW, with significant frontages to Old Pittwater Road, Cross Street and Condamine Street (becoming Pittwater Road), to the south, north and east of the mall respectively. Drawing 1, Appendix A shows a locality plan for Warringah Mall. The 'site', for the purpose of this report, comprises the areas of major buildings works within the Stage 1 redevelopment area and proposed stormwater works.

The proposed Stage 1 redevelopment works at Warringah Mall includes demolition of some structures in the western and northern parts of Warringah Mall, followed by construction of a new mall extension and multi-storey car park. Major building works for the proposed Stage 1 redevelopment are those works that may result in the disturbance of soil at depths close to or below the water table (e.g. structures requiring new piles). The areas of major building works for the proposed Stage 1 redevelopment are currently:

- the eastern part of the existing Starfish car park, which is a multi-level car park; and
- the Palm tree car park, and adjacent loading docks (to the south of the car park) and roundabout (to the south-east of the car park);

These two areas are shown on Drawing 1, Appendix A.

The proposed stormwater works includes:

- Construction of a new underground stormwater culvert (approximately 550 m long within the Warringah Mall boundaries) from the Palm tree car park at the north of the mall, to Condamine Street at the east. The proposed alignment is primarily within areas currently occupied by ground level car parks and associate roadways, although aligns with a commercial building at the east;
- Bank stabilisation works at Brookvale Creek, upstream of Warringah Mall, as well as some channel regrading (within the Warringah Mall property) to tie in with the proposed new culvert. The proposed creek stabilisation works are located at the eastern part of the property occupied by Harrison Manufacturing Co Pty Limited at 75 Old Pittwater Road, Brookvale. The creek section for the proposed bank stabilisation is approximately 100 m long. The existing creek banks slope steeply down, with bank heights of 3 m to 5 m;
- Deepening of the current culvert construction or building of an additional culvert beneath Condamine Street; and
- Some channel regrading at Warringah Golf Course, where Brookvale Creek exits the proposed culvert at the eastern side of Condamine Street.

These proposed stormwater works areas are shown in Drawing 1 and Drawing 2, Appendix A. It is noted that an area of major building works for the Stage 1 redevelopment overlaps with the proposed new culvert alignment at the Palm Tree car park and adjacent roundabout.

3. Previous Assessments

An ASS assessment at Warringah Mall for the proposed new culvert was included in:

- Douglas Partners, Draft *Report on Phase 2 Contamination Assessment, Proposed Stormwater Works (Culvert Realignment) Warringah Mall, Corner of Condamine Street & Old Pittwater Road, Brookvale, NSW,* prepared for Westfield Design and Construction Pty Ltd, July 2013 (DP, 2013).

Relevant results of the ASS assessment for the Stage 1 redevelopment were also summarised in:

- Douglas Partners, Draft *Report on Phase 2 Contamination Assessment, Proposed Stage 1 Warringah Mall Redevelopment, Corner of Condamine Street & Old Pittwater Road, Brookvale, NSW,* prepared for Westfield Design and Construction Pty Ltd, July 2013 (DP, 2013a).

Concurrent geotechnical investigations at Warringah Mall were reported in:

- Douglas Partners, Draft *Report on Geotechnical Investigation, Proposed Warringah Mall Redevelopment, Condamine Street, Brookvale, NSW,* prepared for Westfield Design and Construction Pty Ltd, July 2013 (DP, 2013b).

Testing for acid sulphate soils has not been undertaken for the Brookvale Creek stabilisation works (upstream of Warringah Mall) although a limited contamination assessment was undertaken for the proposed works and reported in:

- Douglas Partners, Draft *Contamination Assessment and Provisional Waste Classification Assessment, Brookvale Creek Stabilisation (Upstream of Warringah Mall), Brookvale, NSW,* prepared for Westfield Design and Construction Pty Ltd, September 2013 (DP, 2013c).

Pertinent information from the above reports is included in relevant sections of this report.

Testing for acid sulphate soils has not been undertaken beneath Condamine Street (at the proposed new culvert alignment) or for the proposed channel regrading at the golf course.

4. Guidelines

This ASSMP is devised on the basis of the following guidelines endorsed by NSW Government Planning and Infrastructure and industry standards:

- Stone Y, Ahern CR, and Blunden B, "Acid Sulfate Soils Manual 1998", Acid Sulfate Soils Management Advisory Committee (ASSMAC), Wollongbar, NSW, August 1998.
- Dear SE, Moore NG, Dobos SK, Watling KM, and Ahern CR, "Soil Management Guidelines", in, "Queensland Acid Sulfate Soil Technical Manual", Department of Natural Resources and Mines, Indooroopilly, Queensland, 2002.
- Ahern CR, McElnea AE and Sullivan LA, "Acid Sulfate Soils Laboratory Methods Guidelines" in "Queensland Acid Sulfate Soils Manual 2004", Department of Natural Resources, Mines and Energy, Indooroopilly, June 2004.
- Dear SE, Ahern CR and Moore NG, "Acid Sulfate Soil Management Plans for Queensland", in, "Acid Sulfate Soils: Environmental Issues, Assessment & Management, Technical Papers", Brisbane, June 2000.

5. Topography, Geology and Groundwater

5.1 Topography and Geology

Brookvale Creek currently enters Warringah Mall at its north-western corner, and is then is culverted to the eastern side of the mall and under Condamine Street, to return to open channel at Warringah Golf Course. The approximate alignment of the culvert is shown in the attached Drawing 1, Appendix A. The historic alignment of Brookvale creek (sourced from 1943 aerial photography, maps.six.nsw.gov.au, NSW government land and property information, accessed 8 May 2013, imagery data by SKM), is also indicated on the drawing. Slopes at Warringah Mall are gentle and are generally down towards the historical alignment of Brookvale Creek.

Reference to the Sydney 1:100 000 Geological Series Sheet indicates that the site is underlain by stream alluvium and estuarine deposits comprising silty to peaty quartz sands, silt and clay with ferruginous and humic cementation in places and common sea shells. The eastern section of the proposed culvert alignment is close to an area mapped as Hawkesbury sandstone which comprises medium to coarse grained quartz sandstone, very minor shale and laminate lenses.

The Sydney 1:100 000 Soil Landscape Sheet shows that the majority of the site is within a soil landscape of disturbed terrain. The landscape is described as level plain to hummocky terrain, extensively disturbed by human activity, including complete disturbance, removal or burial of soil with land fill including soil, rock, building and waste materials. The soil is described as turfed fill areas

commonly capped with up to 40 cm of sandy loam or up to 60 cm of compacted clay over fill or waste materials. The area of the proposed regrading at the golf course encroaches upon the Warriewood swamp landscape which is described as level to gently undulating swales, depressions and infilled lagoons on sands.

From recent investigations (DP, 2013; DP, 2013a; and DP, 2013b) soil conditions at the Warringah Mall part of the site are summarised in Tables 1 – 3.

Table 1: Summary of Subsurface Profile at Starfish Car Park – Stage 1 Redevelopment Area (proposed mall footprint)

Unit	Description
Filling	To typical depths of 0.7 m to 1.7 m and likely to be variable. Filling materials included pavement materials (asphalt and roadbase), crushed sandstone, gravelly sand, sand, sandy clay, clayey sand and clay.
Variable Natural Soil	Highly variable, interbedded soils, including peaty clay and peaty sand, clayey sand, sandy clay and sand.
Peat Clay	Dark grey peaty clay, with some clay and silty sand between depths of 3.5 m to 10.4 m at test locations, with a typical thickness of 5 m and 6 m.
Sand or clayey sand	Sand or clay sand. Some clay and silt layers within medium dense sand. May grade from soil to extremely weathered rock (exhibiting soil properties) with depth. Gravel and ironstone layers would be expected within extremely weathered rock materials.
Sandstone	From depths ranging from 10.2 m to 26 m.

Table 2: Summary of Subsurface Profile at and near Palm Tree Car Park – Stage 1 Redevelopment Area & Proposed Culvert

Unit	Description
Filling	To typical depths of 0.4 m to 2 m, but likely to be variable, with deeper filling expected in the vicinity of the existing services. Deeper filling may also be present due to backfill of underground service tanks that may be associated with past use as a service station. Filling materials were variable, but included pavement materials (asphalt and roadbase), crushed sandstone, sandy clay, gravelly sand, sand, clayey sand and clay. Sandstone boulders are likely to be present in the filling.
Natural soil	Highly variable, interbedded soils, including organic and peaty clays, clayey sands silty sands and sand.
Sandstone	Sandstone with some minor laminate bands, from typical depths of 7 m to 11 m increasing to 13 m at the north-east.

Table 3: Summary of Subsurface Profile at Proposed Culvert Alignment beyond Palm Tree Car Park (outside Stage 1 redevelopment area)

Unit	Description
Filling	To typical depths of 0.4 m to 2.3 m, but likely to be variable. Filling materials were variable, but include pavement materials (asphalt and roadbase), crushed sandstone, clay, sand, sandy gravel, clayey sand, and silty clay.
Natural soil	Variable soils including sand, clay, silty clay, sandy clay, silty sand and peaty clay.
Sandstone	From typical depths of 3 m to 9 m and nearest the surface at the Sand Castle Car Park.

For the upstream bank stabilisation works, shallow (hand-drilled) test bores at the lower parts of the creek banks revealed various natural soil and filling types (DP, 2013c). Filling materials mainly included sand, silty sand, and clayey sand. Natural soils that were encountered at some bores included silty sand, sand and clay.

Test bore logs relevant to the redevelopment works are provided in Appendix C. Test locations are shown on Drawing 1, Appendix A.

5.2 Groundwater

Free groundwater was observed at numerous locations during recent investigations (DP, 2013; DP, 2013a; and DP, 2013b). A summary of measured groundwater levels from selected monitoring wells are shown in Table 4.

Table 4: Groundwater Levels

Well	Ground Surface Level (m AHD)	Date measured	Depth to water (m)	Water Level (m AHD)
506	10.35	22 May 2013	2.11	8.24
507	10.59	17 May 2013	2.30	8.29
507A	10.6	22 May 2013	2.3	8.3
509	10.6	21 May 2013	2.68	7.49
304	10.56	22 May 2013	2.74	7.82
7	9.63	16 May 2013	3.90	5.73
715	10.45	21 May 2013	1.91	8.54
733	9.52	21 May 2013	2.16	7.36
740	9.07	21 May 2013	1.86	7.21
752	9.68	21 May 2013	2.64	7.04

Groundwater flow direction at Warringah Mall is generally towards the old alignment of Brookvale Creek and the current culvert creek alignment (i.e. generally to the east at the Starfish car park; to the south-east at the Palm Tree car park; and to the south-west at the Sand Castle car park)

5.3 Acid Sulphate Soils (Including Investigation Findings)

ASS are naturally occurring sediments that contain iron sulphides, primarily pyrite, commonly deposited in estuarine environments. The occurrence of ASS is associated with areas or regions that have previously been or are currently estuarine environments. Due to changes in sea level or geomorphologic changes to coastal systems, these sediments are often overlain by terrestrial sediments.

When ASS are exposed to air (e.g. due to bulk excavation or dewatering), the oxygen reacts with iron sulphides in the sediment, producing sulphuric acid. This acid can be produced in large quantities and is highly mobile in water. The sulphuric acid can drain into waterways causing severe short and long term socio-economic and environmental impacts, including damage to man-made structures and natural ecosystems.

ASS can either be classified as 'actual acid sulphate soils' (AASS) which are soils that have already reacted with oxygen to produce acid, or 'potential acid sulphate soils' (PASS). PASS are soils containing iron sulphide that have not been exposed to oxygen (e.g. soils below the water table). PASS therefore have not produced sulphuric acid, but have the potential to do so if exposure to oxygen occurs.

Acid Sulphate Soil Risk mapping data (1994-1998) supplied from NSW Department of Environment and Climate Change, a large proportion of the proposed new culvert alignment and the eastern part of the proposed Stage 1 redevelopment works is within an area of low probability of occurrence of acid sulphate soils. Parts of the site within this mapped area include the Condamine Street and golf course sections of the proposed works, but not the section of Brookvale Creek that is upstream of Warringah Mall. The depth to acid sulphate soils is given to be greater than 3 m below the ground surface. The environmental risk is given to be generally not expected to contain acid sulphate soil materials, although highly localised occurrences may occur especially near boundaries with environments with a high probability of acid sulphate soil occurrence. The site is not considered to be close to any areas of high probability of acid sulphate soil occurrence. Figure 1 shows the area of low probability of occurrence of acid sulphate soil materials in relation to Warringah Mall.

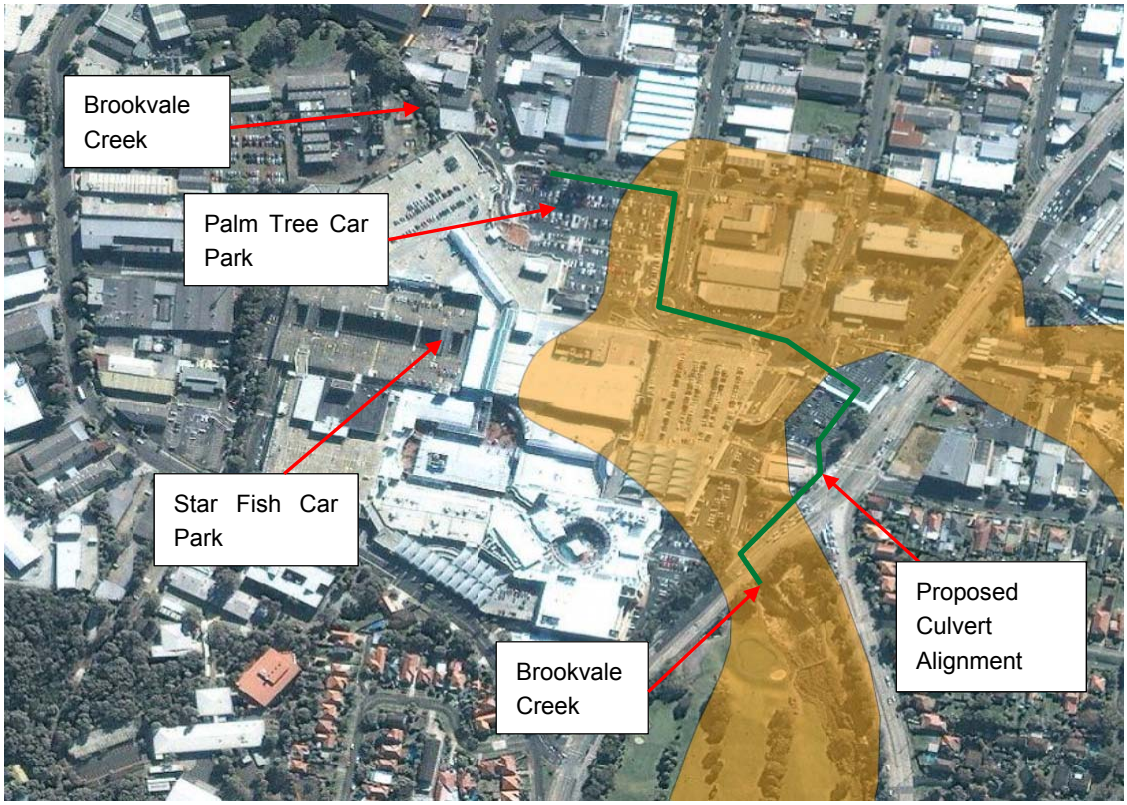


Figure 1: Area in highlighted in orange indicates a low probability of occurrence of ASS (ASS mapping: NSW DECC 1994-1998; Aerial image: Yahoo! maps)

As part of recent investigations (DP, 2013), samples from six test bores (of 6 m maximum depth) along the proposed culvert alignment were subject to ASS field screening tests (pH in water and pH in hydrogen peroxide). Based on a review of screening results, nine selected samples were subject to SPOCAS (suspension peroxide oxidation combined acidity and sulphate) analysis All nine of the samples submitted for SPOCAS analysis returned results above the action criterion of 18 mol H^+ /tonne for net acidity (adopted from Dear SE et al., 2002). This action criterion is based on the presumption that more than 1000 tonnes of soil material will be disturbed as a result from construction of the culvert. Samples with a-Net acidity results well in excess of the action criteria were collected from below the water table and these results are considered definitive of the presence of potential acid sulphate soils (PASS). A summary of results of field screening and SPOCAS analysis is shown in Table A1, Appendix B.

Overall, results of field screening and SPOCAS analysis indicate that:

- PASS is present below the water table along the proposed culvert alignment;
- Some natural soils above the water table are considered to be PASS, although not to the same degree as that identified below the water table;
- Near surface filling such as ripped/crushed sandstone and roadbase (generally within 1 m of the surface) is not considered to be PASS, although may have acidic properties. It is noted, however, that Warringah Mall is within an area of highly disturbed terrain and that pockets of filling may have been sourced locally from areas of acid sulphate soils. In addition, deeper filling (below 1 m) at Test Bore 763 shows 'PASS-like' characteristics. Therefore, filling, other than

near-surface filling materials such as crushed sandstone and roadbase, are considered to be possible PASS, particularly filling close to the groundwater table.

Given that the proposed culvert will disturb soils identified as PASS, it was considered that an Acid Sulphate Soil Management Plan will need to be prepared for the construction of the proposed culvert. In regards to Stage 1 redevelopment works (i.e. not including works for the culvert), it was considered that an Acid Sulphate Soil Management Plan will need to be prepared if the construction approach will disturb PASS or lower the groundwater table (by dewatering).

Given that ASS was identified beyond the mapped area shown in Figure 1, as well as the observed soil profile at the Starfish Car Park and Palm Tree Car Park, ASS are presumed to be present within the proposed major building works areas for the proposed Stage 1 redevelopment.

6. Proposed Development and Potential for Disturbance of ASS

A summary of the proposed works that have the potential to disturb or impact upon ASS are summarised in Table 5.

Table 5: Works that have the Potential to Impact Acid Sulphate Soil

Location	Nature of Works	Potential Impact
Brookvale Creek, Upstream of Warringah Mall (bank stabilisation works)	Excavation of soft/loose soils at creek bed for the proposed culvert	Excavations are expected to be shallow (<0.5 m below creek bed levels) and are not expected to disturb ASS. Disturbance of (unidentified) ASS in natural soils is possible if deeper excavations are required.
	Dewatering to bring groundwater level below excavation	(Unidentified) ASS in the vicinity of the creek could be exposed to air from lowering of groundwater table.
Warringah Mall – proposed new culvert	Piles for culvert	Spoil returns (if any) from piling are likely to contain a mixture of (identified) ASS and non-ASS soils.
	Excavation for culvert	(Identified) ASS is likely to be exposed and excavated.
	Dewatering	(Identified) ASS in the vicinity of the culvert alignment could be exposed to air from lowering of groundwater table.
Proposed Stage 1 redevelopment area (excluding proposed culvert)	Piles for buildings	Spoil returns (if any) from piling are likely to contain a mixture of (identified and unidentified) ASS and non-ASS soils.

Location	Nature of Works	Potential Impact
Condamine Street – existing culvert or proposed new culvert	Excavation for culvert (either for deepening current culvert or for proposed new culvert)	(Unidentified) ASS could be exposed and excavated.
	Dewatering	(Unidentified) ASS in the vicinity of the culvert alignment could be exposed to air from lowering of groundwater table.
Warringah Golf Coarse	Regrading and excavation at base of creek to tie in with Condamine Street works	(Unidentified) ASS could be exposed and excavated
	Dewatering	(Unidentified) ASS in the vicinity of the creek could be exposed to air from lowering of groundwater table.

7. ASS Management Options

ASSMAC (1998) recommends assessment and management of ASS where works involving the disturbance of more than one tonne of soil is proposed in an area identified to potentially be impacted by ASS. The applicable management options are discussed below. Whichever option is adopted, care must be taken to minimise impacts on the local environment.

7.1 Non-Excavation or Minimal Earthworks

Non-excavation or minimisation of invasive earthworks is the principal recommended management option for those areas where:

- deep, bulk excavation is not required;
- ASS materials are too voluminous to remove and rebury;
- ASS materials are too difficult to remove and neutralise with lime; or
- there would be too much risk of contaminating groundwater or run-off.

Given the nature of the proposed development, deeper excavation is considered necessary, and non-excavation of ASS is therefore not considered suitable as a “stand-alone” measure. The potential for minimising disturbance/ excavation in ASS could be reviewed and implemented where possible.

7.2 Treatment – On-Site

This method of management involves the treatment of disturbed ASS by neutralising the acid producing potential. The neutralising agent (e.g. lime) is applied to neutralise any acid that may have been, or will be, produced because of aeration. Thorough mixing with the neutralising agent and

ongoing monitoring to assess the success of treatment are necessary requirements for this option. The treatment process is generally straightforward and this option is feasible for most sites, although it can be difficult on small sites with insufficient space/time for treatment. This option is considered feasible for the site if ASS are impacted during works.

The treated soils could then be re-used on-site or disposed of off-site to a suitably licenced waste management facility (such as a landfill).

7.3 Treatment – Off-Site

This method of management involves the treatment of disturbed ASS as described above, but with the ASS transported off-site for treatment. This option can be suitable for site where there is insufficient time/ space for on-site treatment.

The treatment would need to occur at a facility licensed to undertake this activity by the EPA. It is foreseen that the treated ASS would then be disposed of to a suitably licensed waste management facility (such as a landfill).

7.4 Reburial – On-Site (PASS only)

This method of management involves the rapid replacement of PASS below the water table at the site before it undergoes any significant oxidation. This option is not generally suitable for actual acid sulphate soil (AASS). This needs to be carefully managed to minimise oxidation of the PASS during disturbance and impact on water quality where the PASS is placed.

Given the proposed development, this option may be suitable in some cases for minor quantities of excavated PASS, but, overall, there is unlikely to be sufficient areas to rebury the PASS.

7.5 Reburial – Off-Site (PASS only)

This method of management involves the disposal of PASS below the water table at an appropriately licensed landfill. PASS can be placed beneath the water table at an appropriately licensed landfill if stringent requirements set out by the EPA are met. This option is only allowed for uncontaminated natural *in situ* PASS and is not available for AASS. DECCW *Waste Classification Guidelines* (revised 2009) [DECCW (2009)] set out the requirements for disposal of PASS to a licensed landfill for reburial, and the receiving landfill will also need to meet their specific licence conditions. This option requires careful management of the PASS to minimise oxidation of the PASS during excavation, handling and transport, and impact on water quality where the PASS is placed. Given the stringent requirements for this option (e.g. regarding pH and pH change) a secondary strategy would also be required to manage any materials found not to be suitable for management using this method.

At the time of writing this ASSMP one facility, located at 280-282 Captain Cook Drive, Kurnell Peninsula (the Besmaw Site), was known to DP to be licensed for this option. The acceptance of PASS by this facility is subject to the timing correlating with their on-site operations, and specific review of the generating site. As such whilst this option is considered to be potentially suitable for

uncontaminated PASS at the subject site, it has not been specifically adopted herein. If further investigation indicates that this option is feasible, this ASSMP could be updated to cover the management requirements related to its implementation.

7.6 Separation of ASS Fines

This method of management involves the separation of the fine soil particles (generally comprising the ASS) from the coarse particles with a view to reducing the volume of ASS which needs to be treated/ managed. This option requires careful management and treatability studies and is only feasible for specific sites.

Given the nature of soil conditions at the site, this option is not considered to be suitable.

7.7 Proposed Acid Sulphate Soil Management Strategy

Two options for management of ASS are detailed in the following sections, namely either on or off-site treatment of ASS, as these options are considered to be the most suitable to the proposed development. Regardless of which option is adopted, careful on-site management of soils and water will be required.

8. On-Site Treatment of ASS

Option 1 for management of the ASS is on-site treatment. The management requirements for this strategy are detailed in this section and the following sections (excluding Section 9). On site neutralisation, management, monitoring and validation of ASS should be undertaken as required using the methodology given below.

Where there is any uncertainty regarding the presence/absence of ASS, the subject materials should be treated in accordance with this methodology. If ASS assessment on materials being assumed to contain ASS shows that they do not contain ASS, further management/treatment for ASS will not be required.

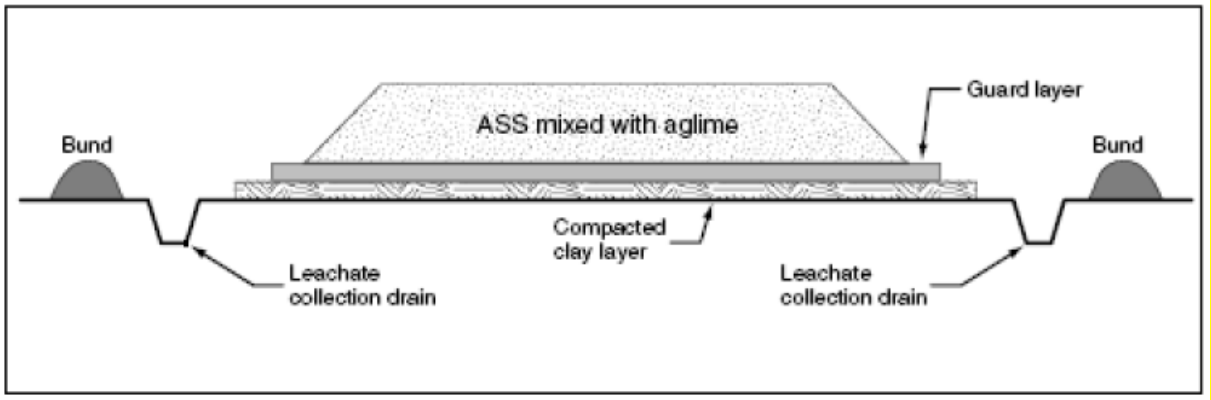
8.1 Prior to Excavation

On-site treatment will require preparation of a Treatment Area(s), Stockpiling Area(s) and Leachate Collection Area(s).

Allowances should be made during construction planning to resume sufficient land to allow for these items. Leachate collection location, lining and construction should be similarly pre-planned.

Figure 2 shows a cross section of a typical treatment pad.

Figure 2: Schematic cross-section of a treatment pad, including clay layer, guard layer, leachate collection system and containment with bunding[1]



These areas should be prepared as follows:

- Prepare a treatment pad and (if required) stockpile pad of appropriate area for the volume of soil to be treated/ stored. The pad should be prepared on relatively level or gently sloping ground to minimise the risk of any potential instability issues, with a natural (or shaped) fall to the local drainage sump. The treatment area should be located as far as practical from any potential ecological receptors such as Brookvale Creek;
- Lining of the surface of the pad with selected compacted clay (at least two layers to a combined compacted thickness of 0.5m) or a geosynthetic liner as approved by the environmental consultant;
- Apply a guard layer of fine agricultural lime ('ag lime') over the compacted clay or geosynthetic liner, to neutralise downward seepage. This guard layer of lime should be applied at a rate of approximately 8 kg ag lime/m^2 of surface area of the pad/ metre height of stockpile, i.e. if a treatment stockpile of 3 m is proposed, the guard layer would need to comprise approximately 24 kg of ag lime per m^2 of surface area. The guard layer should be re-applied following removal of treated soils prior to addition of untreated ASS;
- Liming pads should be bunded and a circumference drain excavated to collect and contain leachate. The drain and inner bund slopes should be covered with a layer of fine lime applied to neutralise any possible leachate migrating from the stockpiled material. The drain should direct soil into an appropriately sized detention basin, the base of which has been prepared in accordance with the liming pad. Alternatively water from the drain can be pumped into on-site tanks for storage, testing and treatment.

If very small quantities of ASS are to be excavated, then the use of a skip bin may be appropriate instead of treatment pad. Any leachate drainage from the skip bin should be avoided, or otherwise will need to be contained and treated as necessary.

[1] Figure reproduced from Dear S E, Moore N G, Dobos S K, Watling K M, and Ahern C R, *"Soil Management Guidelines"* in "*Queensland Acid Sulfate Soil Technical Manual*", Department of Natural Resources and Mines, Indooroopilly, November 2002.

8.2 Neutralising Materials for Soils

Agricultural lime commonly known as ag lime, is the preferred neutralisation material for the management of ASS, as this material is usually the cheapest and most readily available product for acid neutralisation. Furthermore, ag lime is slightly alkaline (pH of 8.5 to 9), non-corrosive, of low solubility and does not present handling problems. Ag lime comprises calcium carbonate ($CaCO_3$), typically made from limestone that has been finely ground and sieved to a fine powder.

It is generally preferable if an ag lime with a purity of 95% or better is used (i.e. NV >95, where NV is the neutralising value, a term used to rate the neutralising power of different forms of materials relative to pure, fine calcium carbonate which is designated NV = 100). The ag lime should be fine and dry, as texture and moisture can also decrease the effective neutralising value. Ag lime with a NV of 95% to 98% is usually used. There could be economic justification for using a less pure grade of ag lime, however, this would require a higher application rate to be adjusted by a factor of 100/NV (see Section 8.3 for application rates). Potential cost savings from using less pure material may be offset by the corresponding increase in the transport and disposal costs.

Coarse grained calcite is not recommended, as one of the products of the neutralisation reaction is gypsum ($CaSO_4.2H_2O$) which has a relatively low solubility and tends to coat the reacting calcite grain, forming a partial barrier against further reaction.

Gypsum may also give off hydrogen sulphide if in reaction with acidic conditions and can itself result in the generation of sulphuric acid.

Dolmitic ag lime, or magnesium blend ag lime, should not be used as these materials impose environmental risks from overdosing with the potential to damage estuarine ecosystems.

An alternative neutralising material can be used subject to prior approval by a suitably qualified scientist or engineer.

8.3 Lime Application Rate and Pre-Treatment Testing

Calculated liming rates from recent investigations (DP, 2013) are shown in Table A1, Appendix B. These should be considered indicative liming rates (or as a “starting point”), and actual liming rates for successful neutralisation of ASS are likely to be variable for the following reasons:

- Acid production will vary both horizontally and vertically through the ASS profile due to the variability of natural systems;
- The natural soil profile at Warringah Mall has been observed to be highly variable, particularly at depths at or near the groundwater table; and
- Sufficient testing for delineation of ASS across the entire site has not been undertaken.

It is also noted that testing for ASS has not been undertaken within the Starfish Car Park, Warringah golf course, the upstream section of Brookvale Creek or beneath Condamine Street. It is therefore recommended that some pre-treatment testing, where possible, be undertaken to determine liming rates prior to treatment of ASS. Results of pre-treatment testing may reveal that some excavated soils will not require treatment prior to disposal/re-use.

Some excavation and, in particular, pile returns are likely to contain a mix of ASS and non-ASS soils. Soils may be temporality stored in stockpile pads (see Section 8.1) or in skip bins (if in smaller quantities) so that the soil can be tested as 'batches' prior to treatment. Testing of samples for SPOCAS or Chromium Suite should be undertake at rate of between 1 sample per 100 m^3 and 1 sample per 300 m^3 of soil (typically a minimum of three samples) depending on the size of the batch and homogeneity of the material. Possible overtreatment of soils may be avoided with pre-treatment testing. It is noted that the fastest turnaround of results for SPOCAS testing is three days from receipt of the sample at the laboratory (with the timing generally commencing from the morning after the samples are received by the laboratory), and this timing may not always be available from the laboratory.

Material will only be considered to have been successfully treated when all soil has been validated in accordance with Section 8.5.

If an alternate neutralising product is used, a specific dosing rate will need to be calculated. The required dosing rate should be calculated from the following formula:

Neutralising Material Required (kg)

per unit volume of soil (m^3) = $\left(\frac{\%\,S \times 623.7}{19.98}\right) \times \frac{100}{ENV\,(\%)} \times D \times FOS$

Where: *%S = net acidity (% S units). This value is obtained from the SPOCAS/ chromium suite analytical results and should be the "worst case" result of the acid or sulphur trails of all samples;*
623.7 = % S to mol H^+/t;
19.98 = mol H^+/t to kg $CaCO_3$/t;
D = Bulk density of soil (as measured, or else assume 2 t/m^3);
FOS (factor of safety) = a minimum value of 1.5 needs to be adopted, although values of up to 2 can be suitable;
ENV = Effective Neutralising Value (e.g. Approx. 95% for fine ag lime).

Notes:

- The ENV is calculated based on the molecular weight, particle size and purity of the neutralising agent and should be assessed for proposed materials in accordance with ASSMAC (1998);
- The "worst case" of the acid or sulphur trail results should be used. Where the acid trail is used the mol H+/t should be converted to %S as per the formula given above.

Whilst the above formula is provided, the environmental consultant will provide the liming rate based on the soil analysis.

8.4 Treatment Process

The process for the treatment of ASS is as follows:

- Prepare a treatment/ stockpiling pad in accordance with Section 8.1;
- Excavate and segregate any non-ASS overburden (such as crushed sandstone and roadbase, as described in Section 5.3) from the area containing ASS if material types can be separated during works. [Given the variability of the soil profile (see Section 5.1), all excavated natural soils, close to or below the groundwater table, should be considered as PASS until otherwise determined by pre-treatment testing (Section 8.3). Similarly, at Warringah Mall, filling of similar appearance to natural local soils should be considered as PASS until otherwise determined by pre-treatment testing];
- Transport ASS material requiring treatment to the treatment area in sealed trucks;
- Manage ASS during stockpiling and treatment to minimise dust and leachate generation (e.g. by covering, or lightly conditioning with water). If wet weather prevails, stop works and cover the stockpiled material with a plastic sheet to reduce the formation of leachate;
- Spread the ASS onto the guard layer in a layer of 0.2 to 0.3 m thickness, leaving a 1 m flat area between the toe of the spread soil and the containment bund or drain. When spreading the first soil layer, care should be taken not to churn up the lime guard layer;
- Let the ASS dry to facilitate lime mixing (if too wet, then adequate mixing of lime cannot be achieved);
- Apply ag lime to the stockpiled soil (see Section 8.3 for liming rate) and harrow/ mix thoroughly prior to spreading the next layer;
- Continue the spreading/liming/mixing cycle. This can be done one layer at a time, or with multiple ASS layers placed on top of each other;
- Assess the success of the treatment using verification testing (in accordance with Section 8.5). Samples will need to be collected from all layers, which is likely to require use of plant for sampling. The verification testing has two components: field screening and laboratory analysis. It is likely that laboratory analysis will only be undertaken after the field screening results have passed;
- If verification sampling indicates that additional neutralisation is required, add additional lime and mix;
- When verification testing indicates that lime neutralisation is complete, then the stockpiled soil may be removed from the treatment pad;
- Re-use the treated ASS on-site or dispose off-site in accordance with waste classification (refer to Section 8.7); and
- Management of leachate water and groundwater (in accordance with Section 10).

8.5 Verification Testing

Verification testing should be conducted as follows:

- During and following neutralisation, the soils will require pH screening to confirm that the appropriate quantities of lime have been added and the soils have been suitably mixed/blended prior to disposal. The pH testing (field and oxidised pH screening tests) should be undertaken on the treated material at a frequency of between one sample per 25 m^3 and one sample per 100 m^3 of treated soil or a minimum of six samples per treatment batch (depending on the volume and homogeneity of the batch);
- Once the pH screening results all meet the criteria (given in Section 8.6), laboratory verification testing will be required at a rate of between one sample per 100 m^3 and one sample per 300 m^3 (or typically a minimum of three per batch) of treated material. The laboratory testing can comprise SPOCAS, or as an alternate method if no jarosite was present in the ASS prior to treatment, the Chromium Suite analytical method can be used. The Chromium Suite analytical method is not considered to be suitable if jarosite was present in the ASS. It is noted that the fastest turnaround of results for SPOCAS testing is three days from receipt of the sample at the laboratory (with the timing generally commencing from the morning after the samples are received by the laboratory), and this timing may not always be available from the laboratory. This should be taken into account to ensure adequate on site storage is available for treated and untreated ASS; and
- Compare the validation results with the acceptance criteria (given in Section 8.6). If all results meet the acceptance criteria, the ASS will be considered to have been successfully treated.

8.6 Acceptance Criteria for Treated ASS

The acceptance criteria are based on the results of "field" and peroxide pH testing and laboratory testing. ASS will be considered to have been successfully treated when all of the following are met:

- field pH (i.e. field pH in water) is ≥ 5.5 (and ≤ 8.5 for any materials to be re-used on site)
- peroxide pH (i.e. pH after forced oxidation) is ≥ 6.5;
- pH_{KCL} is ≥ 6.5;
- TAA = 0;
- TPA = 0 (preferably, although TPA<ANC may be considered suitable subject to specific assessment); and
- Net acidity is ≤ 0.

The net acidity is calculated from SPOCAS/ chromium suite analytical results as follows:

$$\text{Net Acidity } (\%_{Sulphur}) = (S_{pos} \text{ or } S_{Cr}) + \text{a-TAA} + (S_{RAS} \text{ or } S_{NAS}) - \text{ANC / FF}$$

Note: S_{pos} or S_{Cr} is potential acidity (from SPOCAS suite or chromium suite)
a-TAA is actual acidity
S_{RAS} or S_{NAS} or is retained acidity (from SPOCAS suite or chromium suite)
ANC is acid neutralising capacity
FF is Fineness Factor of soils
TPA is total potential acidity

Further treatment of the soil will be required if any of the above conditions are not met.

8.7 Disposal of Treated ASS

Waste classification of treated ASS material to be disposed of off-site is to be conducted in accordance with DECCW (2009) and the *Protection of the Environment Operations (POEO) Act* 1997.

With regard to ASS, Part 4 (Acid Sulphate Soils) of DECCW (2009) states that ASS must be treated (neutralised) prior to acceptance by a landfill operator (unless it is to be disposed of as "PASS" to an appropriately licensed landfill). After treatment the soil should be chemically assessed in accordance with Step 5 in Part 1 of DECCW (2009). This will determine whether any other contaminants are present in the material. When the classification has been established, the soil should be disposed of to a landfill that can lawfully accept that class of waste. The treated ASS would (at a minimum) be classifiable as General Solid Waste, however, chemical testing needs to be conducted to confirm the classification prior to disposal and a higher classification could apply. In this regard, provisional waste classification of soil materials has been determined from recent investigations (DP, 2013; DP, 2013a; DP 2013c) and this data may be used for final waste classification purposes.

Prior arrangements should be made with the landfill to ensure that it is licensed to accept the waste. The landfill should be informed that the ASS has been treated in accordance with the neutralising techniques outlined in an ASSMP produced in accordance with ASSMAC (1998) and that the waste has also been classified in accordance with the DECCW (2009).

9. Off-Site Treatment

Option 2 for management of the ASS is off-site treatment. The management requirements for this strategy are detailed in this section and the following sections.

Where there is any uncertainty regarding the presence/absence of ASS, the subject materials should be treated in accordance with this methodology. If ASS assessment on materials being assumed to contain ASS shows that they do not contain ASS, further management/treatment for ASS will not be required.

9.1 Prior to Excavation

Prior to disturbance of potential ASS, the following will be undertaken:

- Identification of a suitable, appropriately licenced treatment facility. It is advised that the waste generator is responsible for ensuring that waste is disposed to a facility/ site which is legally able to accept it, as required by the POEO Act;
- Provision of test results to the facility;
- Determining and addressing any specific requirements of the treatment facility, and amending this ASSMP as required to check that all requirements are met; and

- Confirming that the treatment facility will accept ASS from the site on the dates required.

9.2 Management and Transport

The general procedure for the management and transport of ASS is as follows:

- Excavate and segregate or dispose of any non-ASS overburden (such as crushed sandstone and roadbase, as described in Section 5.3) from the area containing ASS if material types can be separated during works. [Given the variability of the soil profile (see Section 5.1), all excavated natural soils, close to or below the groundwater table, should be considered as PASS. Similarly, at Warringah Mall, filling of similar appearance to natural local soils should be considered as PASS];
- Any ASS material requiring transport to the treatment facility should be loaded directly into sealed trucks (sufficient to contain any water draining from the soils) and covered. Given that the soil is likely to be wet, and as such heavier than dry soils, it is critical that an accurate estimate of the weight of the material is made so that trucks are not overloaded;
- Transport of the ASS to the waste facility by a direct route to minimise transport time; and
- Management of leachate water and groundwater (in accordance with Section 10).

9.3 Treatment

The treatment facility must manage, treat and dispose of the ASS in accordance with their licence conditions.

10. Water and Groundwater Management

Water is the main mechanism by which acid and metals from oxidised ASS are mobilised and transported. Careful management of water is therefore paramount to effective management of potential adverse impacts from ASS.

The below sections provide strategies for management, assessment and disposal of water leaching from ASS, surface water and water from groundwater dewatering.

10.1 Leachate and Surface Water Collection

All water that has been in contact with ASS/ assumed ASS must be managed, assessed, treated and appropriately disposed of.

Water from the ASS treatment/ storage area should be collected in the lined drains/ detention basin c (in accordance with Section 8.1) or in a tank. Any other water which may have come into contact with ASS should be collected in an on-site detention basin/ tank.

All water which has potentially come into contact with ASS requires management in accordance with the below sections.

10.2 Dewatering Management

Dewatering is expected to be required for the proposed stormwater works as noted in Section 6.

Dewatering a site with ASS is a high environmental risk activity. The reduction of the groundwater table may expose sulphidic soils to oxygen which may generate acidic leachate. The greater the spatial area exposed and the longer the groundwater is lowered from its usual state, the higher the risk of acidic leachate entering the environment.

10.2.1 Proposed Dewatering Methods

The extent of dewatering will depend on the groundwater levels encountered during site works. Measured groundwater levels at Warringah Mall are shown on Table 4 (Section 5), however, groundwater levels fluctuate with weather conditions.

At this stage the dewatering method or extent, quantitative details of the dewatering system, including proposed duration of discharge and the hourly and total quantities of water to be discharged is not known. However, it is anticipated that dewatering will be kept localised as much as practical to reduce potential impacts on ASS. Discharge rates may be evaluated during on-site field trials.

10.2.2 Risks Associated With Dewatering

There are numerous risks associated with dewatering in areas underlain by ASS. These risks include:

- Acidification of *in situ* soils drained within the dewatering cone of depression and difficulties associated with neutralising these *in situ* soils;
- Acidification of groundwater remaining within the dewatering cone of depression after the system has re-flooded;
- Iron, aluminium and heavy metal contamination of groundwater arising from mobilisation of these compounds under low pH conditions; and
- Acidification and contamination of surface water bodies which receive groundwater.

10.2.3 Dewatering Risk Management

The following dewatering risk management methods are recommended for the project:

- Staging soil excavation to minimise the amount of dewatering at any one time;
- Monitoring groundwater inflow rates into excavations and groundwater levels around the excavations to assess the likely impact on surrounding groundwater levels; and
- Monitoring groundwater quality within excavations and treating groundwater prior to discharge from the site (see below).

10.3 Water Storage and Treatment

Water potentially impacted by ASS must be stored in a lined on-site detention basin or tank. The available storage capacity must take into account potential rainfall to minimise the risk of overflows during heavy rain. The storage facilities and volumes being stored must be managed to ensure that no water overflows from the storage, including over close down-periods (including weekends).

10.4 Water Assessment

All water which has potentially come into contact with ASS requires assessment (and if necessary treatment) for the parameters listed in Table 6, as a minimum. This table also details the recommended monitoring frequencies and target thresholds.

Table 6: Suggested Water Monitoring Frequencies and Target Levels for Disposal to Stormwater

Test	Frequency	Target Level for Disposal to Stormwater
pH	Field measurement: • During storage as required to allow timely treatment; • immediately prior to disposal; and • daily checks during discharge period.	• pH 6.5 – 8.5
Total Suspended Solids (TSS)	Field measurement: • immediately prior to disposal; and • as required based on visual observations; and Visual assessment: • daily during discharge period.	• water observed to be clear; • Turbidity <50 NTU
Iron (total and soluble)	Laboratory analysis: • immediately prior to disposal; and • weekly checks during discharge period; and • as required based on visual observations; and Visual assessment: • daily during discharge	• ≤ 0.3 mg/L filterable iron • No obvious sign of iron staining/ settlement
Metals (aluminium, arsenic, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, zinc)	Laboratory analysis: • One round of testing before first disposal; • If first round of testing exceeds target levels then further testing prior to disposal is required.	• ANZECC & ARMCANZ (2000) trigger values for 95% Level of Protection for freshwater ecosystems [99% level protection in the case of mercury]

Note to Table 6:
ANZECC & ARMCANZ (2000): Australian and New Zealand Conservation Council and Agriculture, and Resource Management Council of Australia and New Zealand *Australian Water Quality Guidelines 2000*

The analytical suite listed in Table 6 may need to be expanded in the case that signs of contamination are identified in the water.

10.5 Treatment

10.5.1 General

Treatment of water from construction sites is commonly required for pH and TSS. Aeration and removal of TSS also generally decreases metal concentrations in the water. Standard industry treatment methods and commercial treatment products are suitable for the site and are likely to provide the most efficient treatment, however an alternate treatment method for pH is provided below.

If a suitable treatment method for man-made contaminants in the water (e.g. oil and grease or metals) cannot be implemented, an alternate disposal method may be required (e.g. trucking off-site to a liquid waste disposal facility or disposal to sewer in accordance with a specific Trade Waste Agreement which would need to be obtained from Sydney Water).

10.5.2 Alternate pH Treatment Method

Due to its low solubility in water, ag lime is not suitable for the neutralisation of leachate, which requires a product with a very quick reaction and high solubility. The most suitable neutralising agent for leachate and stockpile drainage water is generally slaked lime or quicklime (calcium hydroxide). These have a typical NV of about 135%.

A slaked (hydrated lime) solution can be produced by stirring quicklime into water, in a container of sufficient volume (for example, a plastic 200 litre drum). The slurry should be allowed to settle, and the clear solution (which will be caustic, with a pH of approximately 12.5 to 13) can be pumped or sprayed into the standing water in small amounts, with some agitation and monitoring. This procedure should be continued until the pH is adjusted to acceptable levels. Great care should be taken not to overshoot the desired pH with calcium hydroxide.

It is recommended that the contractor has several large bags of quicklime readily available at all times, subject to site constraints, with necessary equipment to produce, transport and apply the hydroxide solution as required.

Quicklime is very reactive, and relatively corrosive due to its caustic nature. When quicklime is mixed with water, the resulting reaction generates heat. Therefore, the material should be added in increments to a large amount of water to control the reaction. Slaked or quicklime should not be allowed to come into contact with the skin or be inhaled during use.

The amount of neutraliser required to be added to the discharged groundwater can be calculated from the equation below:

$$\textit{Alkali Material Required (kg)} = \frac{M_{Alkali} \times 10^{-pH\ initial}}{2 \times 10^{3}} \times V$$

Where: *M_{Alkali} = molecular weight of alkali material (g/mole)*
pH initial = initial pH of leachate
V = volume of leachate (litres)

Note: *molecular weight of slaked lime ($Ca(OH)_2$) = 74 g/mole.*

As a guide, the approximate quantities of slaked lime required to neutralise acidic water are provided in Table 7.

Table 7: Approximate Liming Rates for Water (kg, based on slaked lime (kg of $Ca(OH)_2$))

Water pH	Volume of Water		
	1 m^3	5 m^3	10 m^3
2	0.37	1.85	3.7
3	0.037	0.185	0.37
4	0.0037	0.0185	0.037
5	0.00037	0.00185	0.0037
6	0.000037	0.000185	0.00037

10.6 Disposal Options

In general site water can be disposed on site, through infiltration into the soil or disposed off-site.

Water requiring off-site discharge should be disposed of in accordance with relevant guidelines and licences. Consent for discharge should be obtained from the relevant authorities, where appropriate. The approval body for discharge into the stormwater system is Warringah Council. Sydney Water is responsible for discharge into sewer, and discharge can only be conducted in accordance with a Trade Waste Agreement. Sydney Water generally only accepts waters which have been contaminated by human activities, and it is the responsibility of the local government authority (Warringah Council) to accept water impacted only by ASS into the local stormwater system, subject to the water quality/ disposal management meeting their requirements. Alternatively water can be disposed to a licenced liquid waste facility, although this is generally an expensive option.

It is assumed herein that water will preferentially be disposed to stormwater in accordance with Warringah Council's approval requirements. If the water is to be disposed on-site through infiltration into site soils the methodology described below will still apply with the exception of the need to measure/ treat for TSS, which is not relevant for re-absorption. If the water is found not to be suitable

for either of these disposal methods, specific disposal requirements/ approvals will need to be sought from Sydney Water or the receiving facility.

10.7 Water Discharge

Appropriate approvals must be sought from Council prior to discharge.

Once site water has been effectively treated and assessed to meet the discharge criteria, it can be discharged to the local stormwater system in accordance with Council requirements.

11. Guard Layers in Excavations

If engineered materials which are sensitive to acid are to be installed in excavations near where ASS has been exposed a "guard layer" should be placed to protect these materials. Following completion of the excavation, the newly exposed ASS should be covered with a guard layer (which can also serve as a working platform) to counteract the generation of acidic leachate due to the soils being exposed to air. This layer could be constructed of crushed recycled concrete mixed with limestone to form a 300 mm thick layer.

12. Emergency Response Procedures

Construction activities which may cause potential environmental threats are summarised in Table 8 below together with recommendations for "Emergency Response Procedures".

Table 8: Emergency Response Procedures

Construction Activity	Potential Environmental Threat	Emergency Response
Excavation	Flooding of open excavation causing adjacent groundwater levels to rise, leading to potential acid leachate once the excavation is drained	• Inform site foreman and project manager/environmental officer; • Determine pH of groundwater / floodwater in excavation; • Correct groundwater / floodwater pH to bring pH in range of 6.5 to 8.5; • Drain pit to tanks/ basins for water quality assessment prior to discharge.

Construction Activity	Potential Environmental Threat	Emergency Response
Stockpiling / Neutralisation	Stockpile washes or slips outside of bunded lime pad	• Inform site foreman and project manager/environmental officer; • Estimate volume of material breeching bund; • Conduct pH analysis of adjacent watercourses/ drains/ ponds (if any potentially impacted); • Correct pH in any adjacent watercourses/ drains/ ponds (if potentially impacted); • Remove breeched soil into a bunded limed pad; • Over-excavate contaminated area to 0.2m depth, apply and mix lime at rate as for guard layers (approximately 8 kg ag lime per m^2 of surface).
	Breach in stockpile containment bund	• Inform site foreman and project manager/environmental officer; • Close breach in bund; • Conduct pH analysis of adjacent watercourses/ drains/ ponds (if potentially impacted); • Correct pH in any adjacent watercourses/ drains/ ponds (if potentially impacted);

For all construction incidents which pose an environmental threat, an incident report must be completed in order that:

- the cause of the incident may be determined; additional control measures may be implemented; and
- work procedures may be modified to reduce the likelihood of the incident re-occurring.

13. Responsibilities

The responsible party for the main issues relating to ASS management are presented in Table 9. This section does not cover responsibilities related to general construction site activities.

Table 9: Responsibilities

Issue	Responsibility	Verified by/ Subject to the Approval of:-
Implementation of this ASSMP	Contractor	Principal
Monitoring	Contractor/ Environmental Consultant	Environmental Consultant
Liaison with authority/treatment facility	Contractor	Principal
Record keeping	Contractor	Principal/ Environmental Consultant
Alleviation of non-compliance issue	Contractor	Principal/ Environmental Consultant
Changes to ASSMP	Environmental Consultant	Principal

14. Reporting

ASSMAC does not require formal reporting of ASS management, however, it is important to keep records of the management and validation process to show compliance with the guidelines.

A record of management, treatment, monitoring, validation and disposal of ASS should therefore be maintained by the contractor and should include the following details:

- Date(s) of works involving ASS;
- Location/area and depth of excavated ASS material;
- Off-site treatment location and copy of licence (if applicable)
- Neutralisation process undertaken (if applicable);
- Liming material and rate utilised (if applicable);
- Results of field and analytical testing and comparison to acceptance criteria;
- Re-use/ Disposal location (on or off-site);
- Tonnages of material treated/disposed and landfill dockets;
- Results of water monitoring; and
- Water discharge records.

These records should be provided to the Principal as requested and upon completion of works.

15. Conclusion

This ASSMP details the requirements to manage ASS during the proposed development works. If ASS is not detected in soils to be disturbed by the proposed development (from pre-treatment testing), no further ASS management will be required.

It is considered that implementation of this ASSMP will enable appropriate management of the associated potential risk to the surrounding water bodies, including the local groundwater and the Brookvale Creek

16. Limitations

Douglas Partners (DP) has prepared this report (or services) for the proposed Stage 1 redevelopment and Stormwater Works in accordance with DP's proposal dated 9 August 2013 and was commissioned on 11 September 2013 by Westfield Design and Construction Pty Ltd as a variation to the Westfield Consultant Services Contract dated 8 April 2013. This report is provided for the exclusive use of Westfield Design and Construction Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

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

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

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

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

DP. Any such risk assessment would, however, be necessarily restricted to the (geotechnical / environmental / groundwater) components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

Drawings

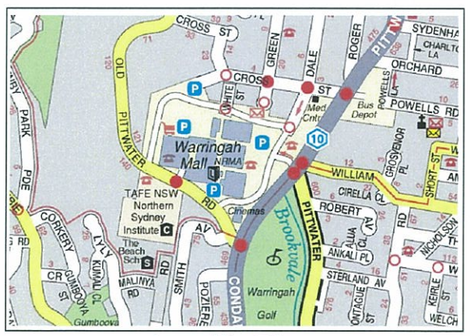
BROOKVALE CREEK
(See Drawing 2)
Harrison Maufacturing

CROSS STREET
GREEN STREET
DALE STEET
PITTWATER ROAD
OLD PITTWATER ROAD
CONDAMINE STREET
Old Pittwater Rd
William St
Warringah

PALM TREE CAR PARK
STARFISH CAR PARK
SHIPS WHEEL CAR PARK
SAND CASTLE CAR PARK
CRAB CAR PARK
Child Care Centre
Littles Dry Cleaner

714 620 715 737 716 621 717 718 719 720 721 722 723 724 736 729 622 725 726 727 728 730 731 732 733 509 623 734 735 739 624 740 745 626 627 752 754 628 763
711 712 713 506A 506 709 710 707 629 630 303 708 704 705 304 706 507A 507 701 702 703

LEGEND
- STAGE 1 REDEVELOPMENT (MAJOR BUILDING WORKS)
- APPROXIMATE AREA OF CHANNEL REGRADING
- APPROXIMATE ALIGNMENT OF PROPOSED CULVERT
- BROOKVALE CREEK PRE-DEVELOPMENT OF MALL (Approxmate alignment)
- BROOKVALE CREEK POST-DEVELOPMENT OF MALL (Approxmate alignment)
- BOREHOLE LOCATION (2013)
- PREVIOUS BOREHOLE LOCATION
- P PIEZOMETER (Groundwater monitoring well)



Locality Plan

Note: Base aerial photograph from www.nearmap.com (accessed 18/3/2013)

0 10 20 30 40 60 80 100 150 200m

1:2000 @ A3

Douglas Partners
Geotechnics / Environment / Groundwater

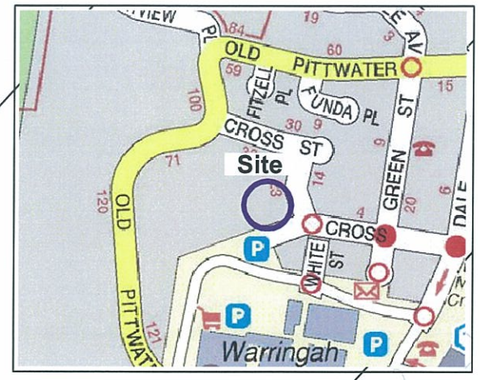
CLIENT:	Westfield Design and Construction Pty Ltd		
OFFICE:	Sydney	DRAWN BY:	PSCH
SCALE:	1:2000	DATE:	4.10.2013

TITLE: **Proposed Stormwater Works and Stage 1 Redevelopment**
Acid Sulphate Soil Management Plan
Warringah Mall, Brookvale

MGA

PROJECT No:	71015.20
DRAWING No:	1
REVISION:	A

P:\71015.20 BROOKVALE_ASSMP for Culvert LR\Drawings\71015.20-1.dwg, 8/10/2013 11:11:07 AM



Locality Plan

H101
H102
H103
H104
H105
H106
CHG 100
CHG 90
CHG 80
CHG 70
CHG 60
CHG 50
CHG 40
CHG 30
CHG 20
CHG 10
CHG 0
BROOKVALE CREEK
TOP OF BANK
BOTTOM OF BANK
EDGE OF WATER

NOTE: Base drawing provided by Cardno
(Drawing 116457 Combined Files.dwg, dated 25.9.2013)

0 1 2 3 4 6 8 10 15 20 25m
1:250 @ A3

LEGEND

Test Bore Location (Hand auger)

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Westfield Design & Construction Pty Ltd		
OFFICE: Sydney	DRAWN BY: PSCH	
SCALE: As shown	DATE: 4.10.2013	

TITLE: **Proposed Bank Stabilisation (Upstream of Warringah Mall)**
Acid Sulphate Soil Management Plan
Brookvale Creek, 75 Old Pittwater Road, BROOKVALE

PROJECT No:	71015.20
DRAWING No:	2
REVISION:	0

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Appendix B

Summary of Previous Analytical Results

from Acid Sulphate Soil Investigations

Table A1: Summary of Results for Acid Sulphate Soils Testing

Sample Location	Depth (m)	Soil Description (see logs for full description)	Screening Tests			sPOCAS Laboratory Results											
			pH_F	pH_{FOX}	Strength of Reaction (1,2,3,4; F)*	pH_{KCl}	pH_{Ox}	TAA (moles H^+/t)	TSA (moles H^+/t)	TPA (moles H^+/t)	a-S_{NAS} (moles H^+/t)	a-ANC_E (moles H^+/t)	a-Net Acidity (moles H^+/t)	S_{KCl} (%w/w S)	S_{POS} (%w/w S)	S_P (%w/w S)	Liming rate (kg $CaCO_3$/t_j
715	0.4-0.5	Silty sand, trace clay & rootlets	3.9	2.6	1F	-	-	-	-	-	-	-	-	-	-	-	-
	0.9-1.0	Sand, humid to damp	4.4	2.7	1F	-	-	-	-	-	-	-	-	-	-	-	-
	1.4-1.5		4.7	3.3	1F	-	-	-	-	-	-	-	-	-	-	-	-
	1.9-2.0	Sand, some clay & trace gravel, saturated	4.2	2.7	1	-	-	-	-	-	-	-	-	-	-	-	-
	2.4-2.5		4.7	2.6	2F	-	-	-	-	-	-	-	-	-	-	-	-
	2.9-3.0		4.4	1.7	2-3F	4.5	2.5	100	590	690	<5	<5	**260**	0.009	0.26	0.27	20
	3.4-3.5	Sand, trace clay, saturated	4.7	2.5	2-3F	-	-	-	-	-	-	-	-	-	-	-	-
	3.9-4.0		4.5	1.9	1	-	-	-	-	-	-	-	-	-	-	-	-
	4.4-4.5		4.6	1.9	1F	-	-	-	-	-	-	-	-	-	-	-	-
	4.9-5.0		4.6	2.3	1	-	-	-	-	-	-	-	-	-	-	-	-
	5.4-5.5	Sand clay	4.5	2.6	1	-	-	-	-	-	-	-	-	-	-	-	-
	5.9-6.0		4.3	2.5	1	-	-	-	-	-	-	-	-	-	-	-	-
717	0.4-0.5	Sand filling, trace rock fragments	4.6	1.3	3-4F	-	-	-	-	-	-	-	-	-	-	-	-
	0.9-1.0	Sand filling	6.3	6.5	3-4F	-	-	-	-	-	-	-	-	-	-	-	-
	1.4-1.5		6.3	4.7	1	-	-	-	-	-	-	-	-	-	-	-	-
	1.9-2.0	Silty clay, trace sand & rootlets, wet to saturated, very slight sufurous odour	5.9	3.3	4F	4.3	2.2	100	860	970	<5	<5	**430**	0.01	0.52	0.53	33
	2.4-2.5		5.3	2.1	3-4F	-	-	-	-	-	-	-	-	-	-	-	-
	2.9-3.0		5.1	1.7	3-4F	-	-	-	-	-	-	-	-	-	-	-	-
	3.4-3.5	Sandy Clay, trace silt, saturated, very slight sulfurous odour	4.6	2.0	3-4F	-	-	-	-	-	-	-	-	-	-	-	-
	3.9-4.0		4.6	2.1	1-2	-	-	-	-	-	-	-	-	-	-	-	-
	4.4-4.5		4.7	1.8	2-3F	-	-	-	-	-	-	-	-	-	-	-	-
	4.9-5.0		4.3	1.5	2-3F	-	-	-	-	-	-	-	-	-	-	-	-
	5.4-5.5		4.4	1.8	2-3F	-	-	-	-	-	-	-	-	-	-	-	-
	5.9-6.0		4.1	1.2	2-3F	4.4	2.0	72	640	710	<5	<5	**570**	0.01	0.80	0.81	43
733	0.4-0.5	Sand filling, some rock fragments, trace clay (ripped sandstone)	5.3	6.3	1	-	-	-	-	-	-	-	-	-	-	-	-
	0.9-1.0		5.4	6.3	1	-	-	-	-	-	-	-	-	-	-	-	-
	1.4-1.5		4.8	2.9	1	-	-	-	-	-	-	-	-	-	-	-	-
	1.9-2.0		4.7	4.9	1	-	-	-	-	-	-	-	-	-	-	-	-
	2.4-2.5	Sand, trace clay, saturated, slight hydrocarbon odour	4.9	3.8	1F	8.7	5.1	<5	<5	<5	NT	<5	**25**	0.01	0.04	0.05	1.9
	2.9-3.0		5.1	5.0	1F	-	-	-	-	-	-	-	-	-	-	-	-
	3.4-3.5	Clayey sand, trace silt & organic mater, saturated	5.2	3.5	3F	-	-	-	-	-	-	-	-	-	-	-	-
	3.9-4.0		4.7	1.8	3	-	-	-	-	-	-	-	-	-	-	-	-
	4.4-4.5		4.9	1.9	4F	4.3	2.0	160	1800	2000	<5	<5	**540**	0.02	0.60	0.62	41
	4.9-5.0		4.9	1.6	4F	-	-	-	-	-	-	-	-	-	-	-	-
	5.4-5.5		4.6	1.9	2/3F	-	-	-	-	-	-	-	-	-	-	-	-
	5.9-6.0		4.7	1.4	4F	-	-	-	-	-	-	-	-	-	-	-	-
740	0.4-0.5	Clay filling, trace silt, sand & gravel	7.1	4.6	1	-	-	-	-	-	-	-	-	-	-	-	-
	0.9-1.0	Sand filling, some gravel, trace brick, terracotta, glass	6.5	4.3	1	-	-	-	-	-	-	-	-	-	-	-	-
	1.4-1.5	Sand and clay filling (possibly reworked natural)	6.4	4.0	1	-	-	-	-	-	-	-	-	-	-	-	-
	1.9-2.0	Clayey sand, moist	10.7	10.7	2-3F	-	-	-	-	-	-	-	-	-	-	-	-
	2.4-2.5		11.2	10.3	2-3F	-	-	-	-	-	-	-	-	-	-	-	-
	2.9-3.0		10.0	7.0	2-3F	-	-	-	-	-	-	-	-	-	-	-	-
	3.4-3.5		9.4	5.4	1	-	-	-	-	-	-	-	-	-	-	-	-
	3.9-4.0		9.2	6.8	1	-	-	-	-	-	-	-	-	-	-	-	-
	4.4-4.5	Clayey sand, saturated	8.8	3.8	2-3F	-	-	-	-	-	-	-	-	-	-	-	-
	4.9-5.0	Clayey sand, saturated, very slight hydrocarbon odour	8.4	2.9	1	3.9	4.3	25	<5	17	<5	<0.05	**25**	0.02	<0.005	0.02	1.9
	5.4-5.5		7.9	3.1	2-3F	-	-	-	-	-	-	-	-	-	-	-	-
	5.9-6.0		7.8	3.0	2-3F	-	-	-	-	-	-	-	-	-	-	-	-
752	0.4-0.5	Sandy gravel filling (roadbase)	7.2	2.4	2-3F	-	-	-	-	-	-	-	-	-	-	-	-
	0.6-0.7	Clayey sand filling, trace rock fragments (ripped sandstone)	7.4	3.0	2-3F	-	-	-	-	-	-	-	-	-	-	-	-
	0.9-1.0	Clayey sand, moist	7.2	3.0	2-3F	-	-	-	-	-	-	-	-	-	-	-	-
	1.4-1.5	Sandy clay, moist	7.0	3.2	2-3F	4.1	4.5	5	32	37	6	<5	**19**	0.02	0.01	0.03	1.5
	1.9-2.0	Clayey sand , moist	6.6	6.9	1	-	-	-	-	-	-	-	-	-	-	-	-
	2.4-2.5		8.3	7.4	1	-	-	-	-	-	-	-	-	-	-	-	-
	2.9-3.0	Sandstone	8.1	6.2	1	-	-	-	-	-	-	-	-	-	-	-	-
763	0.4-0.5	Sandy gravel filling (roadbase)	6.7	4.2	1	-	-	-	-	-	-	-	-	-	-	-	-
	0.9-1.0		6.5	3.4	1-2	-	-	-	-	-	-	-	-	-	-	-	-
	1.4-1.5	Sand filling, trace clay and sandstone fragments	5.1	3.5	3-4	-	-	-	-	-	-	-	-	-	-	-	-
	1.9-2.0		5.4	3.6	3-4	-	-	-	-	-	-	-	-	-	-	-	-
	2.1-2.3	Sand filling, trace rock fragments	5.3	3.6	3-4	-	-	-	-	-	-	-	-	-	-	-	-
	2.4-2.5	Sand, trace silt (possible filling)	5.1	3.5	3	-	-	-	-	-	-	-	-	-	-	-	-
	2.9-3.0		5.2	3.6	1	-	-	-	-	-	-	-	-	-	-	-	-
	3.4-3.5	Sand, trace silt & clay, moist to wet	5.1	3.0	1	5.8	3.5	10	12	22	NT	<5	**27**	<0.005	0.03	0.03	2.1
	3.9-4.0		5.1	3.5	1	-	-	-	-	-	-	-	-	-	-	-	-
	4.4-4.5	Sand, some silt & clay, wet to saturated	10.0	9.0	3-4F	5.6	2.5	<5	590	600	NT	<5	**250**	0.01	0.4	0.41	19
	4.9-5.0	Sandy clay (probably with some peat), saturated	8.8	7.1	1	-	-	-	-	-	-	-	-	-	-	-	-
	5.4-5.5		8.6	5.5	1	-	-	-	-	-	-	-	-	-	-	-	-
	5.9-6.0		8.2	4.5	1	-	-	-	-	-	-	-	-	-	-	-	-

Notes:

pH_F	Field pH (pH of soil and deionised water solution)
pH_{FOX}	Field pH (pH of soil and hydrogen peroxide solution)
pH_{Ox}	pH of soil and hydrogen peroxide solution
pH_{KCl}	pH of solution of soil and KCl
*(1,2,3,4; F)	1 - denotes no or slight effervescence
	2 - denotes moderate effervescence
	3 - denotes vigorous effervescence
	4 - denotes very vigorous effervescence with gas evolution and heat
	F - denotes "frothy" reaction, indicative of organics
TAA	Total Actual Acidity
TSA	Total Sulphidic Acidity (TPA - TAA)
TPA	Total Potential Acidity
a-S_{NAS}	Retained Acidity
a-ANC_E	Acid Neutralising Capacity
S_{KCl}	KCl extractable sulfur
S_{POS}	Peroxide oxidisable sulfur
S_P	Peroxide oxidation sulfur
NT	Not tested
-	Not analysed / not applicable
BOLD	Exceedance of *Action Criteria* (a-Net Acidity of 18 moles H^+/tonne) for the disturbance of more than 1000 tonnes of material for all soil textures (ASSMAC)

Appendix C

Test Bore Logs

from Recent and Previous Investigations

Notes About this Report

Sampling

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

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

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

Test Pits

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

Large Diameter Augers

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

Continuous Spiral Flight Augers

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

Non-core Rotary Drilling

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

Continuous Core Drilling

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

Standard Penetration Tests

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

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

The test results are reported in the following form.

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

  4,6,7
  N=13

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

  15, 30/40 mm

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

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

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

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

Description and Classification Methods

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

Soil Types

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

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

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

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

The proportions of secondary constituents of soils are described as:

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

Definitions of grading terms used are:

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

Cohesive Soils

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

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

Cohesionless Soils

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

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

Soil Descriptions

Soil Origin

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

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

Transported soils may be further subdivided into:

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

Rock Strength

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

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

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

Degree of Weathering

The degree of weathering of rock is classified as follows:

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

Degree of Fracturing

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

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

Rock Descriptions

Rock Quality Designation

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

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

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

Stratification Spacing

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

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

Symbols & Abbreviations

Douglas Partners

Introduction

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

Drilling or Excavation Methods

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

Water

▷	Water seep
▽	Water level

Sampling and Testing

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

Description of Defects in Rock

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

Defect Type

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

Orientation

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

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

Coating or Infilling Term

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

Coating Descriptor

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

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

Graphic Symbols for Soil and Rock

General


Asphalt


Road base


Concrete


Filling

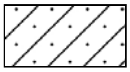
Soils


Topsoil

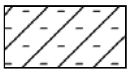

Peat


Clay

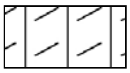

Silty clay

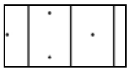

Sandy clay

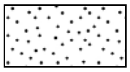

Gravelly clay

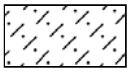

Shaly clay

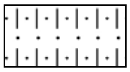

Silt


Clayey silt


Sandy silt


Sand

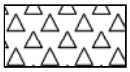

Clayey sand


Silty sand


Gravel


Sandy gravel


Cobbles, boulders

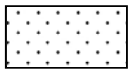

Talus

Sedimentary Rocks

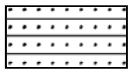

Boulder conglomerate

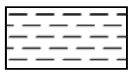

Conglomerate


Conglomeratic sandstone

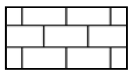

Sandstone


Siltstone


Laminite

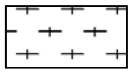

Mudstone, claystone, shale

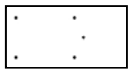

Coal


Limestone

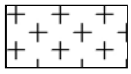
Metamorphic Rocks

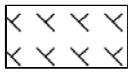

Slate, phyllite, schist

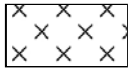

Gneiss

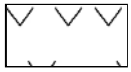

Quartzite

Igneous Rocks


Granite


Dolerite, basalt, andesite


Dacite, epidote


Tuff, breccia


Porphyry

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.68 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 701
PROJECT No: 71015.18
DATE: 16/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.15	FILLING - grey, sandy gravel filling (roadbase)							
		FILLING - light brown sand filling with trace of clay and rock fragments (ripped sandstone filling)		*E	0.4 0.5		PID<1 ppm		
				E	0.9 1.0		PID<1 ppm		
	1.1	Bore discontinued at 1.1m - Refusal on sandstone boulder in filling							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS: *BD2-160413 is blind replicate of 701/0.4-0.5

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.65 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 702
PROJECT No: 71015.18
DATE: 16/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.2	FILLING - grey sandy gravel filling (roadbase)							
		FILLING - brown sand filling with some rock fragments and trace blue metal gravel		E	0.4 0.5		PID<1 ppm		
				E	0.9 1.0		PID<1 ppm		
	1.1	FILLING - brown gravelly sand filling		E	1.2 1.3		PID<1 ppm		
	1.6	SAND - dark brown, medium grained sand with some clay, moist		E	1.8 2.0		PID<1 ppm		
	2.3	Bore discontinued at 2.3m - Refusal on tree root?							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.78 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 703
PROJECT No: 71015.18
DATE: 16/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.2	FILLING - grey sandy gravel filling (roadbase)							
		FILLING - light brown sand filling with some clay and rock fragments (crushed sandstone filling)		*E	0.4 0.5		PID<1 ppm		
				E	0.8 1.0		PID<1 ppm		
		- probable sandstone boulder at 1.0m							
				E	1.4 1.5		PID<1 ppm		
	1.6	Bore discontinued at 1.6m - Refusal on sandstone boulder in filling?							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS: *BD1 - 160413 is blind replicate of 703/0.4-0.5

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.50 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 704
PROJECT No: 71015.18
DATE: 16/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.15	FILLING - grey, sandy gravel filling (roadbase)		E	0.4 0.5		PID<1 ppm		
	0.7	FILLING - light brown sand filling with trace clay and rock fragments (ripped sandstone filling) - ironstone boulder at 0.6m		E	0.9 1.0		PID<1 ppm		
		FILLING - dark brown, sand filling with trace clay and gravel (possibly natural)		E	1.4 1.5		PID<1 ppm		
	1.8	SAND - grey, medium grained sand, moist		E	1.9 2.0		PID<1 ppm		
		- wet to saturated from 2.7m		E	2.9 3.0		PID<1 ppm	▼	
	3.0	Bore discontinued at 3.0m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: Free groundwater observed at 2.7m whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.47 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 705
PROJECT No: 71015.18
DATE: 16/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.04	ASPHALT							
	0.2	FILLING - grey, sandy gravel filling (roadbase)							
	0.6	FILLING - brown sand filling with trace clay and rock fragments (ripped sandstone filling)		*E	0.4 0.5		PID<1 ppm		
	1.0	FILLING - grey-brown, gravelly sand filling (roadbase)		E	0.9 1.0		PID<1 ppm		
		SAND - grey, medium grained sand, moist - brown at 1.3m to 1.5m		E	1.4 1.5		PID<1 ppm		
	1.5	Bore discontinued at 1.5m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS: *BD3 - 160413 is blind replicate of 705/0.4-0.5

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.70 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 706
PROJECT No: 71015.18
DATE: 17/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.25	FILLING - grey, sandy gravel filling (roadbase)							
		FILLING - light brown, sand filling with trace clay and rock fragments (ripped sandstone filling)		*E	0.4 0.5		PID<1 ppm		
				E	0.9 1.0		PID<1 ppm		
				E	1.4 1.5		PID<1 ppm		
	1.8	FILLING - dark brown sand filling with trace clay and gravel (possibly natural)		E	1.9 2.0		PID<1 ppm		
	2.2	Bore discontinued at 2.2m - refusal on tree root							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS: *BD1 - 170413 is blind replicate of 706/0.4-0.5

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.36 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 707
PROJECT No: 71015.18
DATE: 17/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.1	FILLING - grey sandy gravel filling (roadbase)							
	0.5	FILLING - brown sand filling (possibly natural)		E	0.4 0.5		PID<1 ppm		
		SAND - grey and brown, medium grained sand, moist		E	0.9 1.0		PID<1 ppm		
	1.5			E	1.4 1.5		PID<1 ppm		
		Bore discontinued at 1.5m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.36 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 708
PROJECT No: 71015.18
DATE: 17/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.15	FILLING - grey and brown sandy gravel filling (roadbase)							
				*E	0.4		PID<1 ppm		
	0.6	FILLING - brown sand with trace clay and rock fragments (ripped sandstone filling)			0.5				
				E	0.7		PID<1 ppm		
	1.0	FILLING - brown, gravelly sand filling (roadbase gravel)			0.8				
		FILLING - grey sand and red clay filling							
				E	1.4		PID<1 ppm		
	1.7	SAND - grey, medium grained sand, moist			1.5				
				E	1.9		PID<1 ppm		
		- becoming wet at 2.5m			2.0				
				E	2.4		PID<1 ppm		
	2.5	Bore discontinued at 2.5m - target depth reached			2.5				

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS: *BD2-170413 is blind replicate of 708/0.4-0.5

SAMPLING & IN SITU TESTING LEGEND

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

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.26 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 709
PROJECT No: 71015.18
DATE: 17/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.06	ASPHALT							
	0.25	FILLING - grey, sandy gravel filling (roadbase)							
		FILLING - brown, clayey sand filling		E	0.4 0.5		PID<1 ppm		
	0.8	SAND - grey, medium grained sand, moist		E	0.9 1.0		PID<1 ppm		
	1.5	Bore discontinued at 1.5m - target depth reached		E	1.4 1.5		PID<1 ppm		

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.27 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 710
PROJECT No: 71015.18
DATE: 17/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.2	FILLING - grey, sandy gravel filling (roadbase)							
		FILLING - brown, sand filling with some clay and trace rock fragments and roadbase gravel (ripped sandstone filling)		*E	0.4 0.5		PID<1 ppm		
	0.9			E	0.8 0.9		PID<1 ppm		
	1.2	FILLING - red-brown clay filling with trace silt and ironstone gravel		E	1.1 1.2		PID<1 ppm		
		FILLING - brown sand filling with trace sandstone fragments		E	1.4 1.5		PID<1 ppm		
	1.7	SAND - grey, medium grained sand, moist		E	1.9 2.0		PID<1 ppm		
	2.5	Bore discontinued at 2.5m - target depth reached		E	2.4 2.5		PID<1 ppm		

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS: *BD4-170413 is blind replicate of 710/0.8-0.9

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.40 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 711
PROJECT No: 71015.18
DATE: 17/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.1	FILLING - grey, sandy gravel filling (roadbase)		E	0.4 0.5		PID<1 ppm		
	0.6	FILLING - dark brown, sand filling with trace root fragments (possibly natural)							
		CLAYEY SAND - dark brown, medium grained clayey sand, moist		E	0.9 1.0		PID<1 ppm		
				E	1.4 1.5		PID<1 ppm		
	1.5	Bore discontinued at 1.5m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.24 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 712
PROJECT No: 71015.18
DATE: 17/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.25	FILLING - grey, sandy gravel filling (roadbase)							
		FILLING - brown, sand filling with trace roadbase gravel		*E	0.4 0.5		PID<1 ppm		
				E	0.9 1.0		PID<1 ppm		
				E	1.4 1.5		PID<1 ppm		
	1.6	SAND - medium grained, grey sand with trace clay, wet		E	1.9 2.0		PID<1 ppm		
	2.3	SILTY CLAY - soft, grey, silty clay, moist		E	2.4 2.5		PID<1 ppm		
	2.6	Bore discontinued at 2.6m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS: *BD3-170413 is blind replicate of 712/0.4-0.5

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.16 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 713
PROJECT No: 71015.18
DATE: 17/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.2	FILLING - grey, sandy gravel filling (roadbase)							
		FILLING - brown sand filling with trace roadbase gravel		E	0.4 0.5		PID<1 ppm		
				E	0.9 1.0		PID<1 ppm		
	1.1	SAND - dark brown, medium grained sand, humid		E	1.4 1.5		PID<1 ppm		
	1.9	SAND - grey, medium grained sand with some clay, moist		E	1.9 2.0		PID<1 ppm		
		- becoming wet at 2.6m		E	2.7 2.8		PID<1 ppm		
	2.8	Bore discontinued at 2.8m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.52 AHD
EASTING: 339380.01
NORTHING: 6262466.97
DIP/AZIMUTH: 90°/--

BORE No: 714
PROJECT No: 71015.18
DATE: 18/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.07	ASPHALT							
		FILLING - grey, gravelly sand filling (roadbase)		E	0.4 0.5		PID<1 ppm		
	0.5	FILLING - brown, sand filling with some rock fragments and trace clay (ripped sandstone filling)		E	0.9 1.0		PID<1 ppm		
	1.2	CLAYEY SAND - brown and light brown, medium grained clayey sand, moist (possible filling)		E	1.4 1.5		PID<1 ppm		
	1.6	SAND - yellow-brown, medium grained sand, damp		E	1.9 2.0		PID<1 ppm		
		- becoming wet at 2.3m		E	2.4 2.5		PID<1 ppm		
	2.5	Bore discontinued at 2.5m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.45 AHD
EASTING: 339410.78
NORTHING: 6262472.5
DIP/AZIMUTH: 90°/--

BORE No: 715
PROJECT No: 71015.18
DATE: 18/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.07	ASPHALT							Gatic Cover & concrete
	0.35	FILLING - grey sandy gravel filling (roadbase)							Bentonite 0.2-0.6m
	0.7	SILTY SAND - brown silty sand with trace clay and rootlets. damp (possible old topsoil horizon)		*E	0.4 0.5		PID<1 ppm		Blank PVC pipe
	1	SAND - brown, medium grained sand, humid to damp		E	0.9 1.0		PID<1 ppm		
				E	1.4 1.5		PID<1 ppm		
	1.7	SAND - grey, medium gravel sand with some clay and trace gravel, saturated		E	1.9 2.0		PID<1 ppm	21-05-13	
	2			A	2.4 2.5				Gravel 0.6-4.0m Machine slotted PVC screen 1.0-4.0m
				A	2.9 3.0				
	3.0	SAND - brown, medium grained sand with some clay, saturated							
	3.4	SAND - white and grey, medium grained sand with trace clay, saturated		A	3.4 3.5				
	4			A	3.9 4.0				End cap
				A	4.4 4.5				
				A	4.9 5.0				
	5.0	SANDY CLAY - firm, grey sandy clay		A	5.4 5.5				
				A	5.9 6.0				
	6.0	Bore discontinued at 6.0m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: Free groundwater observed at 1.7m whilst drilling

REMARKS: *BD2-180413 is blind replicate of 715/0.4-0.5

SAMPLING & IN SITU TESTING LEGEND

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

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 9.93 AHD
EASTING: 339459.02
NORTHING: 6262467.89
DIP/AZIMUTH: 90°/--

BORE No: 716
PROJECT No: 71015.18
DATE: 18/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.4	FILLING - grey sandy gravel (roadbase)		E	0.4 0.5		PID<1 ppm		
	0.6	FILLING - brown sand filling with trace rock and brick fragments		A	0.6 0.7				
	0.7	FILLING - brick and concrete gravel filling with trace steel		E	0.9 1.0		PID<1 ppm		
		SAND - yellow, mottled grey, medium grained sand with trace clay, moist - becoming wet at 1.3m		E	1.4		PID<1 ppm		
	1.5	Bore discontinued at 1.5m - target depth reached			1.5				

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 9.53 AHD
EASTING: 339486.82
NORTHING: 6262464.16
DIP/AZIMUTH: 90°/--

BORE No: 717
PROJECT No: 71015.18
DATE: 22/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.25	FILLING - grey, sandy gravel filling (roadbase)							
	0.5	FILLING - brown sand filling with trace rock fragments - piece of wire at 0.5m		E	0.4 0.5		PID<1		
	1	FILLING - light brown sand filling - possibly natural from 1.0m		E	0.9 1.0		PID<1		
	1.2	SILTY CLAY - soft, dark brown, silty clay with trace sand and rootlets, wet to saturated. Very slight sulfurous odour.		E	1.4 1.5		PID<1	▼	
	2			E	1.9 2.0		PID<1		
				A	2.4 2.5				
	3			A	2.9 3.0				
	3.2	SANDY CLAY - very soft to soft, dark brown, medium grained sandy clay with trace of silt, saturated. Very slight sulfurous odour.		A	3.4 3.5				
	4			A	3.9 4.0				
		- possible interbedded layers of clay and sand		E	4.4 4.5				
	5			A	4.9 5.0				
				A	5.4 5.5				
	6			A	5.9 6.0				
	6.0	Bore discontinued at 6.0m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: Free groundwater observed at 1.5m whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.49 AHD
EASTING: 339382.77
NORTHING: 6262454.97
DIP/AZIMUTH: 90°/--

BORE No: 718
PROJECT No: 71015.18
DATE: 18/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.07	ASPHALT							
	0.35	FILLING - grey, sandy gravel filling (roadbase)		E	0.4 0.5		PID<1 ppm		
	0.6	FILLING - brown, sand filling with trace clay and rock fragments (ripped sandstone filling)							
	1.0	FILLING - brown sand filling (possibly reworked natural)		*E	0.9 1.0		PID<1 ppm		
		SAND - grey, medium grained sand with trace of clay, humid		E	1.4 1.5		PID<1 ppm		
	2.0	Bore discontinued at 2.0m - target depth reached		E	1.9 2.0		PID<1 ppm		

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS: *BD1-180413 is blind replicate of 718/0.9-1.0

SAMPLING & IN SITU TESTING LEGEND

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

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.38 AHD
EASTING: 339339.28
NORTHING: 6262450.44
DIP/AZIMUTH: 90°/--

BORE No: 719
PROJECT No: 71015.18
DATE: 18/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.4	FILLING - grey sandy gravel filling (roadbase)							
		FILLING - brown sand filling with trace rock fragments, clay and roadbase gravel		E	0.4 0.5		PID<1 ppm		
				*E	0.9 1.0		PID<1 ppm		
	1.2	CLAYEY SAND - yellow-brown, medium grained, clayey sand, moist		E	1.4 1.5		PID<1 ppm		
	1.7	SAND - light grey, medium grained sand, moist		E	1.9 2.0		PID<1 ppm		
	2.0	Bore discontinued at 2.0m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS: *BD3-180413 is blind replicate of 719/0.9-1.0

SAMPLING & IN SITU TESTING LEGEND

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

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.13 AHD
EASTING: 339417.95
NORTHING: 6262447.24
DIP/AZIMUTH: 90°/--

BORE No: 720
PROJECT No: 71015.18
DATE: 18/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.15	FILLING - grey, sandy gravel filling (roadbase)		E	0.2		PID<1 ppm		
	0.35	FILLING - dark grey, clay filling with trace sand and gravel. Mild hydrocarbon odour.			0.3				
	1	CLAYEY SAND - light brown, medium grained clayey sand, moist		E	0.9		PID<1 ppm		1
					1.0				
	1.3	SILTY CLAY - firm, light brown, silty clay, moist		E	1.4		PID<1 ppm		
	1.6	SAND - light brown and grey, medium grained sand, moist to wet			1.5				
	2			E	1.9		PID<1 ppm		2
	2.0	Bore discontinued at 2.0m - target depth reached			2.0				

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 9.89 AHD
EASTING: 339439.2
NORTHING: 6262443.31
DIP/AZIMUTH: 90°/--

BORE No: 721
PROJECT No: 71015.18
DATE: 22/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.07	ASPHALT							
	0.3	FILLING - grey-brown, sandy gravel filling (roadbase)		E	0.3		PID<1		
	0.4	FILLING - yellow-brown, sand filling with trace clay (ripped sandstone filling)		E	0.4 0.5		PID<1		
	0.7	SAND - dark brown, medium grained sand with trace clay, damp		E	0.9 1.0		PID<1		
		SANDY CLAY - soft, grey, fine to medium grained, sandy clay, moist to wet		E	1.4 1.5		PID<1		
	1.5	Bore discontinued at 1.5m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 9.62 AHD
EASTING: 339466.1
NORTHING: 6262440.18
DIP/AZIMUTH: 90°/--

BORE No: 722
PROJECT No: 71015.18
DATE: 22/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
		FILLING - brown, sandy gravel filling (roadbase gravel)		E	0.4		PID<1		
	0.5	FILLING - yellow-brown sand filling with some clay (possibly reworked natural)			0.5				
				*E	0.9		PID<1		
1	1.0	SAND - orange-brown, medium grained sand with trace clay, damp to moist		E	1.0		PID<1		1
	1.3				1.1				
		CLAY - soft to firm, orange-brown mottled grey clay with trace fine to medium grained sand		E	1.2		PID<1		
	1.7				1.4				
		SAND - grey, medium grained sand with some clay, moist to wet		E	1.5		PID<1		
2	2.0				1.9				2
		Bore discontinued at 2.0m - target depth reached			2.0				

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS: *BD2-220413 is blind replicate of 722/0.9-1.0

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 9.50 AHD
EASTING: 339480.51
NORTHING: 6262433.99
DIP/AZIMUTH: 90°/--

BORE No: 723
PROJECT No: 71015.18
DATE: 22/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.1	FILLING - grey, gravelly sand filling (roadbase)							
		FILLING - brown, sand filling with trace clay and gravel		*E	0.4 0.5		PID<1 ppm		
	0.8	FILLING - yellow and grey, sand filling with trace of rock fragments - sandstone boulder at 1.0m		E	0.9 1.0		PID<1 ppm		
	1.3	SANDY CLAY - soft to firm brown, fine to medium grained sandy clay, moist		E	1.4 1.5		PID<1 ppm		
	1.6	CLAY - soft to firm, grey, mottled brown clay with trace of fine grained sand, moist		E	1.9 2.0		PID<1 ppm		
				E	2.4 2.5		PID<1 ppm		
	2.5	SAND - grey, medium grained sand with some clay, moist to wet		E	2.9 3.0		PID<1 ppm		
	3.0	Bore discontinued at 3.0m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS: *BD3-220413 is blind replicate of 723/0.4-0.5

SAMPLING & IN SITU TESTING LEGEND

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

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.29 AHD
EASTING: 339387.28
NORTHING: 6262433.04
DIP/AZIMUTH: 90°/--

BORE No: 724
PROJECT No: 71015.18
DATE: 22/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
		FILLING - grey, sandy gravel filling (roadbase)		E	0.4 0.5		PID<1		
	0.5	FILLING - light brown, sand filling with some rock fragments (ripped sandstone filling)							
	0.8	SAND - dark brown, medium grained sand, damp		E	0.9 1.0		PID<1		
	1.1	SAND - dark brown, medium grained sand with trace clay, moist		E	1.4 1.5		PID<1		
	1.6	SAND - grey, medium grained sand, moist		E	1.9 2.0		PID<1		
	2.0	Bore discontinued at 2.0m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.35 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 725
PROJECT No: 71015.18
DATE: 22/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
10.33	0.02	ASPHALT							
		FILLING - grey, sandy gravel filling (roadbase)		E	0.4		PID<1		
9.85	0.5	Bore discontinued at 0.5m - refusal on concrete			0.5				

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.13 AHD
EASTING: 339410.84
NORTHING: 6262416.64
DIP/AZIMUTH: 90°/--

BORE No: 726
PROJECT No: 71015.18
DATE: 22/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.07	ASPHALT							
		FILLING - grey and brown, sandy gravel filling (roadbase)		E	0.4 0.5		PID<1		
	0.6	FILLING - brown, sand filling with trace clay and gravel		*E	0.7 0.8		PID<1		
	0.9	SAND - dark brown and light brown, medium grained sand with trace clay, damp to moist		E	0.9 1.0		PID<1		
				E	1.4 1.5		PID<1		
	2.0	Bore discontinued at 2.0m - target depth reached		E	1.9 2.0		PID<1		

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS: *BD1-220413 is blind replicate of 726/0.7-0.8

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 9.76 AHD
EASTING: 339430.82
NORTHING: 6262412.4
DIP/AZIMUTH: 90°/--

BORE No: 727
PROJECT No: 71015.18
DATE: 23/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.3	FILLING - grey, sandy gravel filling with trace clay (roadbase)		*E	0.4 0.5		PID<1		
	0.6	FILLING - dark brown, sand filling with trace gravel and clay (possibly reworked natural)		E	0.9 1.0		PID<1		
		SANDY CLAY - soft, dark brown, fine to medium grained sandy clay with some silt and trace organic matter, moist to wet		E	1.4 1.5		PID<1		
	2.0	Bore discontinued at 2.0m - target depth reached		E	1.9 2.0		PID<1		

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS: *BD1-230413 is blind replicate of 727/0.4-0.5

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 9.53 AHD
EASTING: 339458.69
NORTHING: 6262406.6
DIP/AZIMUTH: 90°/--

BORE No: 728
PROJECT No: 71015.18
DATE: 23/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.1	ASPHALT							
		FILLING - grey, sandy gravel filling with trace clay (roadbase)		E	0.4 0.5		PID<1		
	0.6	SAND - dark brown, fine to medium grained sand, humid to damp		*E	0.9 1.0		PID<1		
	1			E	1.4 1.5		PID<1		
		- grey from 1.7m - wet to saturated from 1.8m		E	1.9 2.0		PID<1	▼	
	2	- some clay from 2.0 to 3.0m							
	3			E	2.9 3.0		PID<1		
	3.0	Bore discontinued at 3.0m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: Free groundwater observed at 1.8m whilst drilling

REMARKS: *BD2-230413 is blind replicate of 728/0.9-1.0

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 9.37 AHD
EASTING: 339480.95
NORTHING: 6262421.65
DIP/AZIMUTH: 90°/--

BORE No: 729
PROJECT No: 71015.18
DATE: 22/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.25	FILLING - grey, gravelly sand filling (roadbase)							
		FILLING - dark grey, sand filling with trace of clay and rock fragments		E	0.4 0.5		PID<1		
				E	0.9 1.0		PID<1		
	1.1	CLAYEY SAND - soft, brown and grey, fine to medium grained, clayey sand, moist to wet		E	1.2 1.3		PID<1		
	1.3	SAND - grey, medium grained sand with trace clay		E	1.4 1.5		PID<1		
	1.6	SANDY CLAY - soft to firm, fine to medium grained, sandy clay, moist		E	1.9 2.0		PID<1	▼	
	2.0	SAND - grey, medium grained sand, wet to saturated							
	2.1	CLAY - firm, grey, clay with trace of fine grained sand, moist							
	2.7	SAND - grey, medium grained sand with trace of clay, wet to saturated		E	2.9 3.0		PID<1		
	3.0	Bore discontinued at 3.0m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: Free groundwater observed at 2m whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.19 AHD
EASTING: 339429.97
NORTHING: 6262396.27
DIP/AZIMUTH: 90°/--

BORE No: 730
PROJECT No: 71015.18
DATE: 23/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.07	ASPHALT							
	0.2	FILLING - grey, sandy gravel filling (roadbase)		E	0.4		PID<1 ppm		
	0.5	FILLING - brown, sand filling with some clay		E	0.5 0.6		PID<1 ppm		
	0.7	SAND - brown, fine to medium gravel sand, humid			0.7				
	1	SANDY CLAY - firm, brown and grey, fine to medium grained sandy clay, damp to moist		E	0.9 1.0		PID<1 ppm		1
	1.3	CLAYEY SAND - yellow-brown, medium grained clayey sand, damp		E	1.4 1.5		PID<1 ppm		
	1.5	SANDY CLAY - firm, grey and light brown, fine grained sandy clay, damp		E	1.9 2.0		PID<1 ppm		
	2 2.0	Bore discontinued at 2.0m - target depth reached							2
	3								3
	4								4
	5								5
	6								6
	7								7
	8								8
	9								9

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 9.84 AHD
EASTING: 339444.15
NORTHING: 6262390.9
DIP/AZIMUTH: 90°/--

BORE No: 731
PROJECT No: 71015.18
DATE: 23/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.15	FILLING - grey, sandy gravel filling (roadbase)							
		FILLING - brown, clayey sand filling with trace gravel		*E	0.4 0.5		PID<1		
	0.6	SAND - grey, fine to medium grained sand, humid		E	0.9 1.0		PID<1		
				E	1.4 1.5		PID<1		
	1.6	CLAY - soft to firm, dark brown, clay with some fine to medium grained sand, wet		E	1.9 2.0		PID<1	▼	
		- saturated from 2.5m							
		- very slight sulfurous odour at 2 to 3m		E	2.9 3.0		PID<1		
	3.0	Bore discontinued at 3.0m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: Free groundwater observed at 2.5m whilst drilling

REMARKS: *BD3-230413 is blind replicate of 731/0.4-0.5

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 9.59 AHD
EASTING: 339457.9
NORTHING: 6262391.59
DIP/AZIMUTH: 90°/--

BORE No: 732
PROJECT No: 71015.18
DATE: 23/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.06	ASPHALT							
	0.25	FILLING - grey, sandy gravel filling (roadbase)							
		FILLING - dark grey, sand filling with some clay and trace gravel and terracotta. Mild hydrocarbon odour.		E	0.4 0.5		PID=9		
				E	0.9 1.0		PID=34		
	1.1	CLAYEY SAND - dark grey, fine to medium grained clayey sand, moist. Slight hydrocarbon odour.		E	1.4 1.5		PID=17		
	1.7	SAND - dark grey, fine to medium grained sand with trace clay, wet. Slight hydrocarbon odour.		E	1.9 2.0		PID=10		
		- saturated from 2.5m		E	2.4 2.5		PID=17	▼	
		- some clay at 2.8 to 3.0m		E	2.9 3.0		PID=17		
	3.0	Bore discontinued at 3.0m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: Free groundwater observed at 2.5m whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 9.52 AHD
EASTING: 339477.12
NORTHING: 6262393.69
DIP/AZIMUTH: 90°/--

BORE No: 733
PROJECT No: 71015.18
DATE: 23/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							Flush gatic cover and concrete
	0.2	FILLING - grey, sandy gravel filling (roadbase)							Bentonite
		FILLING - yellow-brown sand filling with some rock fragments and trace clay (ripped sandstone filling)		E	0.4 0.5		PID<1		Blank PVC pipe
		- sandstone boulders from 1.0m		E	0.9 1.0		PID<1		
				E	1.4 1.5		PID<1		
				E	1.9 2.0		PID<1		
	2.1	SAND - grey, medium grained sand with trace of clay, saturated. Slight hydrocarbon odour.		E	2.4 2.5		PID=2	21-05-13	Gravel 0.45-3.9m Machine slotted PVC screen 0.9-3.9m
	3.0	CLAYEY SAND - soft to firm, dark brown, medium grained, clayey sand with trace silt and organic matter, saturated		E	2.9 3.0		PID=2		
				E	3.4 3.5				
				E	3.9 4.0		PID<1		End Cap
				E	4.4 4.5				
				E	4.9 5.0				
				E	5.4 5.5				
				E	5.9 6.0				
	6.0	Bore discontinued at 6.0m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: Free groundwater observed at 2.1m whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 9.53 AHD
EASTING: 339434.35
NORTHING: 6262366.47
DIP/AZIMUTH: 90°/--

BORE No: 734
PROJECT No: 71015.18
DATE: 24/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.07	ASPHALT							
	0.2	FILLING - grey, sandy gravel filling (roadbase)							
	0.6	FILLING - red-brown, clay filling with trace silt, ironstone gravel and charcoal		*E	0.4 0.5		PID<1		
	1.1	FILLING - brown, sand filling with some clay		E	0.9 1.0		PID<1		
	1.4	SAND - brown-grey, medium grained sand, humid		E	1.4 1.5		PID<1		
	1.6	CLAYEY SAND - dark brown, fine to medium grained, clayey sand, moist							
	2.2	CLAY - soft, grey clay with trace sand, moist		E	1.9 2.0		PID<1		
	3.0	SAND - grey, medium grained sand with some clay, wet to saturated		E	2.9 3.0		PID<1	▼	
		Bore discontinued at 3.0m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: Free groundwater observed at 2.5m whilst drilling

REMARKS: *BD1-240413 is blind replicate of 734/0.4-0.5

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 9.00 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 735
PROJECT No: 71015.18
DATE: 24/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
		FILLING - brown, sandy gravel filling with trace clay (roadbase)		E	0.4 0.5		PID<1		
	0.6	SAND - dark brown, fine to medium grained sand with some clay, damp (possibly reworked to 1m)		E	0.9 1.0		PID<1		
	1.3	SAND - yellow, medium grained sand, moist		E	1.4 1.5		PID<1		
	1.6	SANDY CLAY - soft, dark brown, fine to medium sandy clay, wet to saturated						▼	
	2.0	Bore discontinued at 2.0m - target depth reached		E	1.9 2.0		PID<1		

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: Free groundwater observed at 1.7m whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 9.74 AHD
EASTING: 339449.64
NORTHING: 6262431.06
DIP/AZIMUTH: 90°/--

BORE No: 736
PROJECT No: 71015.18
DATE: 22/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.2	FILLING - grey, gravelly sand filling (roadbase)		E	0.3 0.4		PID<1		
	0.4	FILLING - brown, sand filling with some roadbase gravel		E	0.5 0.6		PID<1		
		CLAYEY SAND - dark brown, medium grained clayey sand, damp		E	0.9 1.0		PID<1		
	1.1	SANDY CLAY - dark grey, fine to medium grained sandy clay, moist to wet		E	1.4 1.5		PID<1		
	1.5	SAND - grey, medium grained sand with some clay, wet		E	1.9 2.0		PID<1		
	2.0	Bore discontinued at 2.0m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.10 AHD
EASTING: 339431.68
NORTHING: 6262462.86
DIP/AZIMUTH: 90°/--

BORE No: 737
PROJECT No: 71015.18
DATE: 18/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							
	0.15	FILLING - grey, sandy gravel filling (roadbase)							
		FILLING - brown, sand filling with trace gravel and clay		E	0.4 0.5		PID<1 ppm		
				E	0.9 1.0		PID<1 ppm		
	1.1	CLAYEY SAND - dark grey, medium grained clayey sand, moist		E	1.4 1.5		PID<1 ppm		
		- slight sulfurous odour and saturated at 2.0m							
	2.2	SAND - light grey, medium grained sand, saturated		E	2.4 2.5		PID<1 ppm		
	2.5	Bore discontinued at 2.5m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: Free groundwater observed at 2m whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 9.30 AHD
EASTING: 339516.05
NORTHING: 6262346.77
DIP/AZIMUTH: 90°/--

BORE No: 739
PROJECT No: 71015.18
DATE: 24/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.03	ASPHALT							
		FILLING - brown, gravelly sand filling (roadbase)		E	0.4 0.5		PID<1		
	0.5	FILLING - brown, clayey sand filling with trace gravel							
	1			*E	0.9 1.0		PID<1		1
	1.1			E	1.1		PID<1		
	1.2	SILTY CLAY - soft, brown, silty clay with trace sand, moist			1.2				
		SAND - grey, medium grained sand, moist		E	1.4 1.5		PID<1		
	2			E	1.9 2.0		PID<1		2
	2.0	Bore discontinued at 2.0m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS: *BD2-240413 is blind replicate of 739/0.9-1.0

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 9.07 AHD
EASTING: 339535.08
NORTHING: 6262342.84
DIP/AZIMUTH: 90°/--

BORE No: 740
PROJECT No: 71015.18
DATE: 24/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALT							Gatic cover and concrete
	0.25	FILLING - grey, gravelly sand filling (roadbase)							
	0.6	FILLING - red-brown clay filling with trace silt, sand and gravel		E	0.4 0.5		PID<1		Bentonite 0.25-0.75m
	1.1	FILLING - red-brown, sand filling with some gravel and trace brick, terracotta and glass		E	0.9 1.0		PID<1		Blank PVC pipe
	1.6	FILLING - grey, sand and clay filling (possibly reworked natural)		E	1.4 1.5		PID<1		
		CLAYEY SAND - grey, mottled yellow-brown, fine to medium grained clayey sand, moist		E	1.9 2.0		PID<1	21-05-13	
				A	2.4 2.5				
				E	2.9 3.0		PID<1		
				A	3.4 3.5				Gravel 0.75-5.8m
		- saturated from 4.0m		A	3.9 4.0				Machine slotted PVC screen 1.3-5.8m
		- very slight hydrocarbon odour at 4.5m (associated with water)		A	4.4 4.5				
				A	4.9 5.0				
				A	5.4 5.5				
				A	5.9 6.0				End Cap
	6.0	Bore discontinued at 6.0m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: Free groundwater observed at 4.0m whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 9.89 AHD
EASTING: 339597.38
NORTHING: 6262326.43
DIP/AZIMUTH: 90°/--

BORE No: 745
PROJECT No: 71015.18
DATE: 24/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	FILLING - woodchips		E	0.05 - 0.1		PID<1		
	0.1	FILLING - dark brown, sand filling with trace silt, clay and rootlets		E	0.4 - 0.5		PID<1		
	0.8	FILLING - brown, sand filling with trace clay and gravel							
	1	FILLING - brown, sandy gravel filling with trace clay (roadbase)		E	0.9 - 1.0		PID<1		
	1.2	SAND - grey, fine to medium grained, sand with trace clay, moist		E	1.4 - 1.5		PID<1		
	2.0	CLAY - very stiff, grey clay with some fine grained sand and silt							
	3.0	Bore discontinued at 3.0m - target depth reached		E	2.9 - 3.0		PID<1		

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 9.68 AHD
EASTING: 339613.05
NORTHING: 6262266.98
DIP/AZIMUTH: 90°/--

BORE No: 752
PROJECT No: 71015.18
DATE: 29/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.07	ASPHALT							Flush gatic cover and concrete
		FILLING - brown, sandy gravel filling (roadbase)		E	0.4 0.5		PID<1 ppm		
	0.5	FILLING - yellow-brown, clayey sand filling with trace rock fragments (ripped sandstone)		E	0.6 0.7		PID<1 ppm		Bentonite 0.4-1.0m
	0.8	CLAYEY SAND - grey and brown, fine to medium grained clayey sand, moist		E	0.9 1.0		PID<1 ppm		
	1.1	SANDY CLAY - stiff, brown and grey, fine to medium grained sandy clay, moist		E	1.4 1.5		PID<1 ppm		Blank PVC pipe
	1.6	CLAYEY SAND - grey, medium grained clayey sand, moist		E	1.9 2.0		PID<1 ppm		Gravel 1.0-3.1m
				E	2.4 2.5		PID<1 ppm	21-05-13	Machine slotted PVC screen 1.6m-3.1m
	2.7	SANDSTONE - very low strength, yellow-white, fine to medium grained sandstone		E	2.9 3.0		PID<1 ppm		End Cap
	3.15	Bore discontinued at 3.15m - refusal on sandstone							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: Water seepage observed at 2.6m whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 10.19 AHD
EASTING: 339604.71
NORTHING: 6262245.57
DIP/AZIMUTH: 90°/--

BORE No: 754
PROJECT No: 71015.18
DATE: 29/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.02	ASPHALT							
	0.4	FILLING - brown, gravelly sand filling (roadbase)		E	0.4 0.5		PID<1 ppm		
	0.6	FILLING - brown, clayey sand filling with trace rock fragments							
	1	SANDY CLAY - stiff, yellow-brown, sandy clay with trace ironstone gravel and tree roots, damp		*E	0.9 1.0		PID<1 ppm		
	1.3	CLAYEY SAND - light yellow-brown, medium grained clayey sand, damp to moist (extremely low strength sandstone)		E	1.4 1.5		PID<1 ppm		
	2			E	1.9 2.0		PID<1 ppm		
	2.0	Bore discontinued at 2.0m on sandstone bedrock - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: No free groundwater observed whilst drilling

REMARKS: *BD3-290413 is blind replicate of 754/0.9-1.0

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 9.58 AHD
EASTING: 339555.15
NORTHING: 6262168.49
DIP/AZIMUTH: 90°/--

BORE No: 763
PROJECT No: 71015.18
DATE: 29/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.03	ASPHALT							
		FILLING - brown, sandy gravel filling (roadbase)		E	0.4 0.5		PID<1 ppm		
	1.0			E	0.9 1.0		PID<1 ppm		
		FILLING - dark grey and brown, sand filling with trace clay and sandstone fragments		E	1.4 1.5		PID<1 ppm		
				E	1.9 2.0		PID<1 ppm		
	2.1			E	2.1 2.3		PID<1 ppm		
	2.3	FILLING - light brown, sand filling with trace rock fragments		E	2.4 2.5		PID<1 ppm		
		SAND - brown, fine to medium grained sand with trace silt, damp (possible filling)		E	2.9 3.0		PID<1 ppm		
	3.0	SAND - grey, medium grained sand with trace silt and clay, moist to wet		A	3.4 3.5				
				A	3.9 4.0			▼	
	4.0	SAND - dark brown, fine to medium grained sand with some silt and clay, wet to saturated		A	4.4 4.5				
	4.6	SANDY CLAY - soft, dark brown, fine to medium grained sandy clay (probably with some peat), saturated		A	4.9 5.0				
				A	5.4 5.5				
				A	5.9 6.0				
	6.0	Bore discontinued at 6.0m - target depth reached							

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger

WATER OBSERVATIONS: Free groundwater observed at 4.3m whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Phase 2 Contamination Assessment
LOCATION: Stormwater Augmentation Works

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

BORE No: 2
PROJECT No: 71015.01
DATE: 27 Jul 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	BITUMINOUS CONCRETE							
	0.4	ROADBASE - trace tile fragments and gravel							
		FILLING - white, medium grained sand filling		A	0.4 0.5		PID<10ppm		
	0.8	FILLING - red brown, medium to fine grained, sand filling		A	0.8 1.0		PID<10ppm		
	1.3								
	1.4	SAND - yellow/dark yellow, medium grained sand with some clay		A	1.4 1.5		PID<10ppm		
	1.6	SANDY CLAY - mottled yellow/orange/grey, sandy clay (moist)							
		SANDY CLAY - red/orange, sandy clay (moist)							
	2.3	SAND - light grey, medium grained sand (moist to wet):		A	2.5 2.6		PID<10ppm		
	3.0	Bore discontinued at 3.0m - target depth reached							

RIG: Bobcat DRILLER: Salib LOGGED: ZS CASING: Uncased

TYPE OF BORING: Solid flight auger

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED	
Initials:	
Date:	

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Phase 2 Contamination Assessment
LOCATION: Stormwater Augmentation Works

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

BORE No: 3
PROJECT No: 71015.01
DATE: 29 Jul 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	BITUMINOUS CONCRETE							
	0.2	ROADBASE GRAVEL							
	0.3	RIPPED SANDSTONE		A	0.3 0.5		PID<10ppm		
	0.7	FILLING - dark brown, silty clay filling with some gravel							
	1.1	FILLING - dark brown, sandy clay with some gravel and trace wood fragments		A	0.8 1.0		PID<10ppm		
		FILLING - light brown, sandy clay filling with some gravel		A	1.3 1.5		PID<10ppm		
	1.7	Bore discontinued at 1.7m - refusal on sandstone boulder							

RIG: DT 100 DRILLER: G Cooper LOGGED: ZS CASING: Uncased

TYPE OF BORING: Solid flight auger

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED	
Initials:	
Date:	

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Phase 2 Contamination Assessment
LOCATION: Stormwater Augmentation Works

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

BORE No: 4
PROJECT No: 71015.01
DATE: 28 Jul 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.1	FILLING - dark brown, silty sand filling with trace rootlets (topsoil)							
	0.6	FILLING - dark brown, silty clay filling with some sand and concrete fragments		A	0.3 0.5		PID<10ppm		
	1.1	CLAY - light brown, silty clay with some sand, small band of dark brown silty sand/clay		A	0.7 1.0		PID<10ppm		
	1.5	SILTY CLAY - red brown, silty clay		A	1.2 1.5		PID<10ppm		
	1.6	SILTY CLAY - mottled grey and red brown, silty clay with some sand		A	1.6 2.0		PID<10ppm		
	2.1	SILTY CLAY - very stiff, light grey, silty clay							
		SAND - light grey, medium grained sand, wet to moist		A	2.3 2.6		PID<10ppm		
	3.0	- slight odour, wet Bore discontinued at 3.0m - target depth reached		A	2.8 3.0		PID<10ppm		

RIG: DT 100 DRILLER: G Cooper LOGGED: ZS CASING: Uncased

TYPE OF BORING: Solid flight auger

WATER OBSERVATIONS:

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED	
Initials:	
Date:	

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Phase 2 Contamination Assessment
LOCATION: Stormwater Augmentation Works

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

BORE No: 6
PROJECT No: 71015.01
DATE: 28 Jul 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	BITUMINOUS CONCRETE							
	0.2	ROADBASE		A	0.2 - 0.4		PID<10ppm		
	0.4	RIPPED SANDSTONE							
		FILLING - yellow brown, sandy clay filling		A	0.8 - 1.0		PID<10ppm		
	1.2	SANDY CLAY - yellow brown, sandy clay		A	1.2 - 1.5		PID<10ppm		
	1.6	SANDY CLAY - grey sandy clay		A	1.8 - 2.0		PID<10ppm		
	2.2	SANDY CLAY - grey, sandy clay with some fine rock fragments (low strength sandstone)		A	2.3 - 2.5		PID<10ppm		
	3.0	Bore discontinued at 3.0m - target depth reached							

RIG: DT 100 DRILLER: G Cooper LOGGED: ZS CASING: Uncased

TYPE OF BORING: Solid flight auger

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED	
Initials:	
Date:	

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Phase 2 Contamination Assessment
LOCATION: Stormwater Augmentation Works

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

BORE No: 7
PROJECT No: 71015.01
DATE: 28 Jul 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	BITUMINOUS CONCRETE							Gatic lid cap
	0.2	ROADBASE - gravel with silty sand							Gravel backfill
	0.5	FILLING - dark brown, sandy clay filling with some gravel and concrete fragments		A	0.3				
					0.55				
		FILLING - dark sandy clay filling with gravel		A	0.8				Bentonite
	1.0				1.0				
		FILLING - black brown, sandy clay filling with gravel		A	1.3				
	2.1	SILTY SAND - dark grey, fine grained, silty sand, trace gravel (possibly filling)		A	2.3				Backfilled with gravel
	2.6	SANDY CLAY - dark grey/black, fine grained, sandy clay with some organic matter			2.5				Machine slotted PVC Screen
				A	3.0				
	3.6	SAND - yellow grey, medium grained sand, moist (alluvial)			3.5				
				A	3.7				
					4.0				
	4.3	Bore discontinued at 4.3m - refusal on white/grey sandstone							End cap

RIG: DT 100 DRILLER: G Cooper LOGGED: ZS CASING: Uncased

TYPE OF BORING: Solid flight auger

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED	
Initials:	
Date:	

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall - First Stage Retail Expansion
LOCATION: Myer and Myer Carpark, Warringah Mall, Brookvale

SURFACE LEVEL: 10.33
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 303
PROJECT No: 71015.03
DATE: 12 Oct 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	BITUMINOUS CONCRETE							Gatic cover
	0.25	ROADBASE							
	0.35	FILLING - sandstone boulder		A	0.3		PID<10ppm		
	0.5	ROADBASE - dark brown, gravelly sand			0.5				Gravel
	1	SAND - yellow, medium grained sand, moist		A	0.8		PID<10ppm		
	1.2	SAND - dark grey, medium grained sand, moist			1.0				
				A	1.3		PID<10ppm		
					1.5				Bentonite
		- becoming very moist to wet		A	1.8		PID<10ppm		
	2.0	CLAY - dark grey, stiff clay (slightly silty), moist, with some sand			2.0				
				A	2.3		PID<10ppm		
	2.6	SAND - light grey, alluvial, medium grained sand			2.5			21-10-09	
				A	2.8		PID<10ppm		
					3.0				
	4.5	SILTY CLAY - dark grey black, firm, silty clay with organic odour, wet, (organic clay - peaty - black)							Gravel
									Machine slotted PVC screen
				A	5.8		PID<10ppm		
	6.0	Bore discontinued at 6.0m - target depth reached			6.0				End cap

RIG: Bobcat **DRILLER:** SS (Ground Test) **LOGGED:** ZS **CASING:** Uncased

TYPE OF BORING: Solid flight auger

WATER OBSERVATIONS: Wet at 2.6m. Water level at 2.6m on 21/1009

REMARKS:

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

CHECKED	
Initials:	
Date:	

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall - First Stage Retail Expansion
LOCATION: Myer and Myer Carpark, Warringah Mall, Brookvale

SURFACE LEVEL: 10.56
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 304
PROJECT No: 71015.03
DATE: 13 Oct 09
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	BITUMINOUS CONCRETE - asphalt							Gatic cover
	0.1	ROADBASE							
	0.6	FILLING - red brown, clayey sand filling with some gravel		A	0.3 0.5		PID<10ppm		Gravel
	1.0	FILLING - dark brown, clayey sand filling with some gravel and boulders (ripped sandstone?)		A	0.8 1.0		PID<10ppm		
		FILLING - dark brown, medium grained sand filling with some clay and trace gravel		A	1.2 1.5		PID<10ppm		
	1.7	CLAY - stiff, red brown, silty clay		A	2.0 2.1		PID<10ppm		Bentonite
	2.5	SAND - grey, medium grained sand, wet		A*	2.9 3.0		PID<10ppm	21-10-09	
	5.6	ORGANIC CLAY - black, organic clay with strong organic odour							Gravel
	6.0	Bore discontinued at 6.0m - target depth reached							Machine slotted PVC screen End cap

RIG: Bobcat **DRILLER:** SS (Ground Test) **LOGGED:** ZS **CASING:** Uncased

TYPE OF BORING: Solid flight auger

WATER OBSERVATIONS: Wet at 3.0m during drilling. Water level at 2.8m on 21/10/09

REMARKS: *Denotes field replicate samples BD4 and BD4R taken

SAMPLING & IN SITU TESTING LEGEND

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

CHECKED	
Initials:	
Date:	

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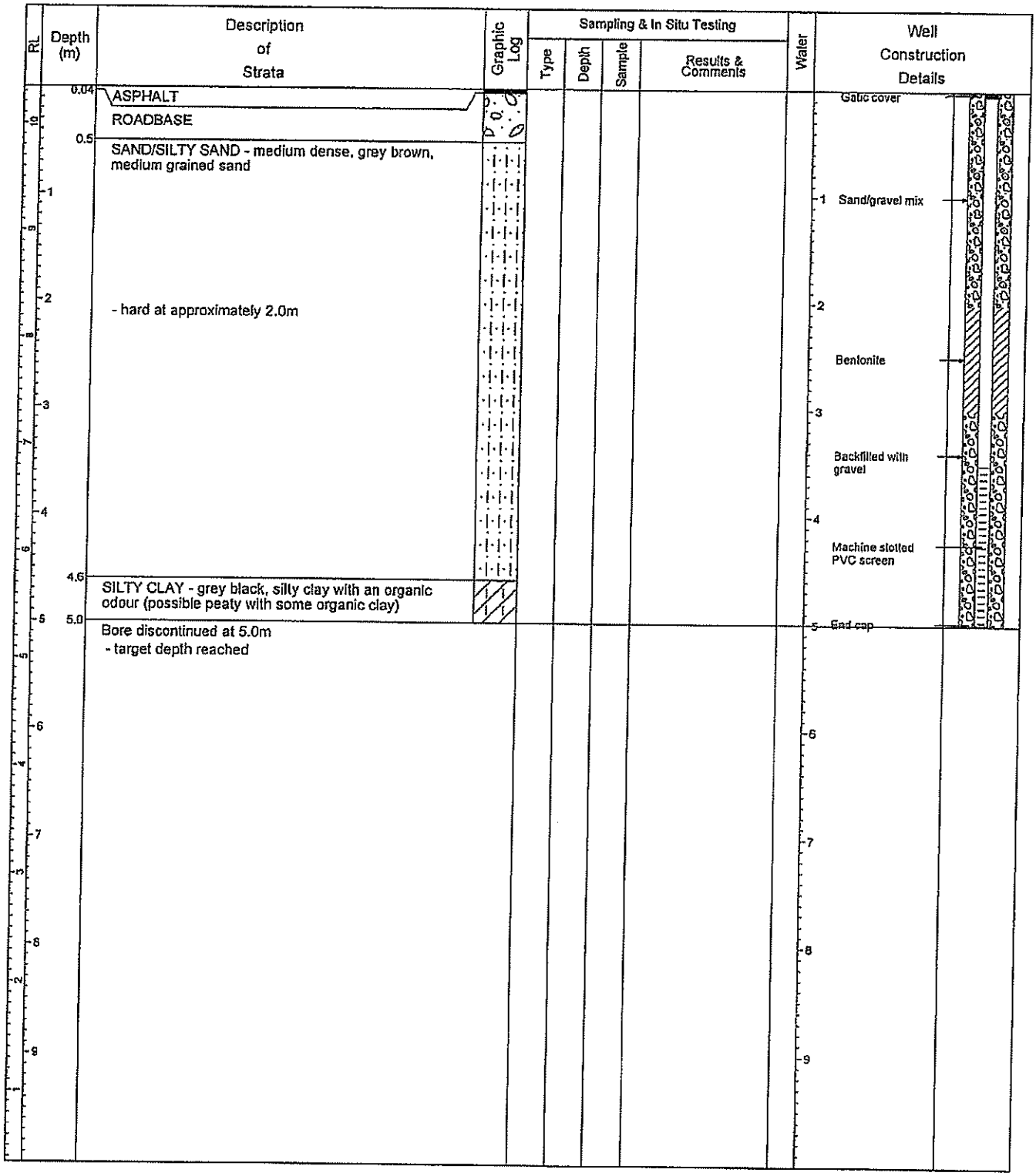
BOREHOLE LOG

CLIENT: AMP Capital Investors Pty Ltd
PROJECT: Supplementary Contamination Assessment
LOCATION: Warringah Mall

SURFACE LEVEL: 10.35 AHD
EASTING: 339302.36
NORTHING: 6262347.22
DIP/AZIMUTH: 90°/--

BORE No: 506
PROJECT No: 71015.06
DATE: 30/8/2010
SHEET 1 OF 1



RIG: Cross Country **DRILLER:** SP **LOGGED:** ZM **CASING:** HC to 5.0m **SURVEY DATUM:**

TYPE OF BORING: Solid flight auger to 1.0m; Rotary drilling with mud (Guar gum) to 5.0m

WATER OBSERVATIONS: No free groundwater observed during augering

REMARKS: 100% drilling fluid loss from approximately 2.0m

SAMPLING & IN SITU TESTING LEGEND

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

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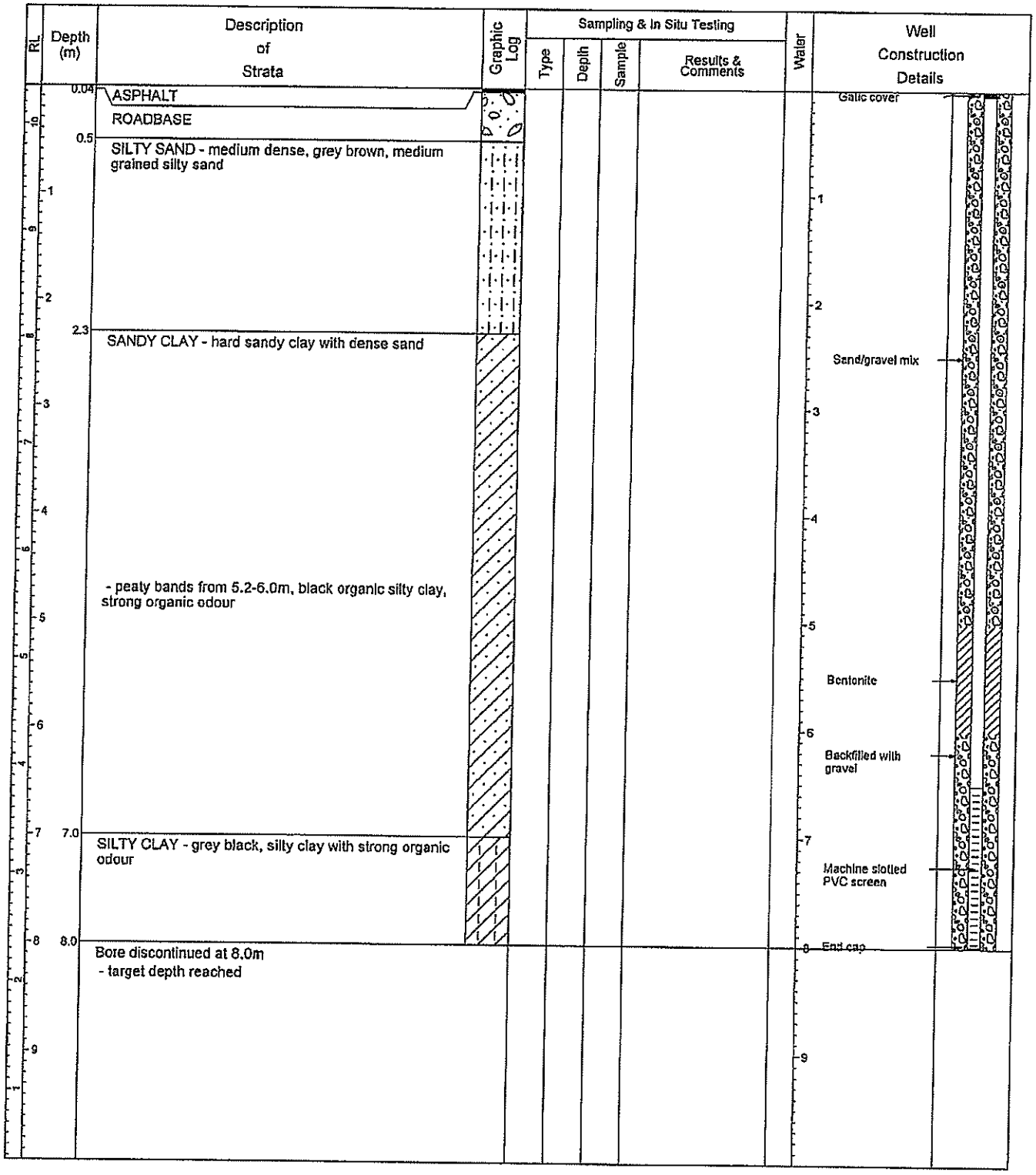
BOREHOLE LOG

CLIENT: AMP Capital Investors Pty Ltd
PROJECT: Supplementary Contamination Assessment
LOCATION: Warringah Mall

SURFACE LEVEL: 10.36 AHD
EASTING: 339305.6
NORTHING: 626234647
DIP/AZIMUTH: 90°/--

BORE No: 506A
PROJECT No: 71015.06
DATE: 1/9/2010
SHEET 1 OF 1



RIG: Cross Country **DRILLER:** SP **LOGGED:** ZM **CASING:** HC to 8.0m **SURVEY DATUM:**

TYPE OF BORING: Solid flight auger to 1.0m; Rotary with mud (Guar gum) 8.0m

WATER OBSERVATIONS: No free groundwater observed during augering

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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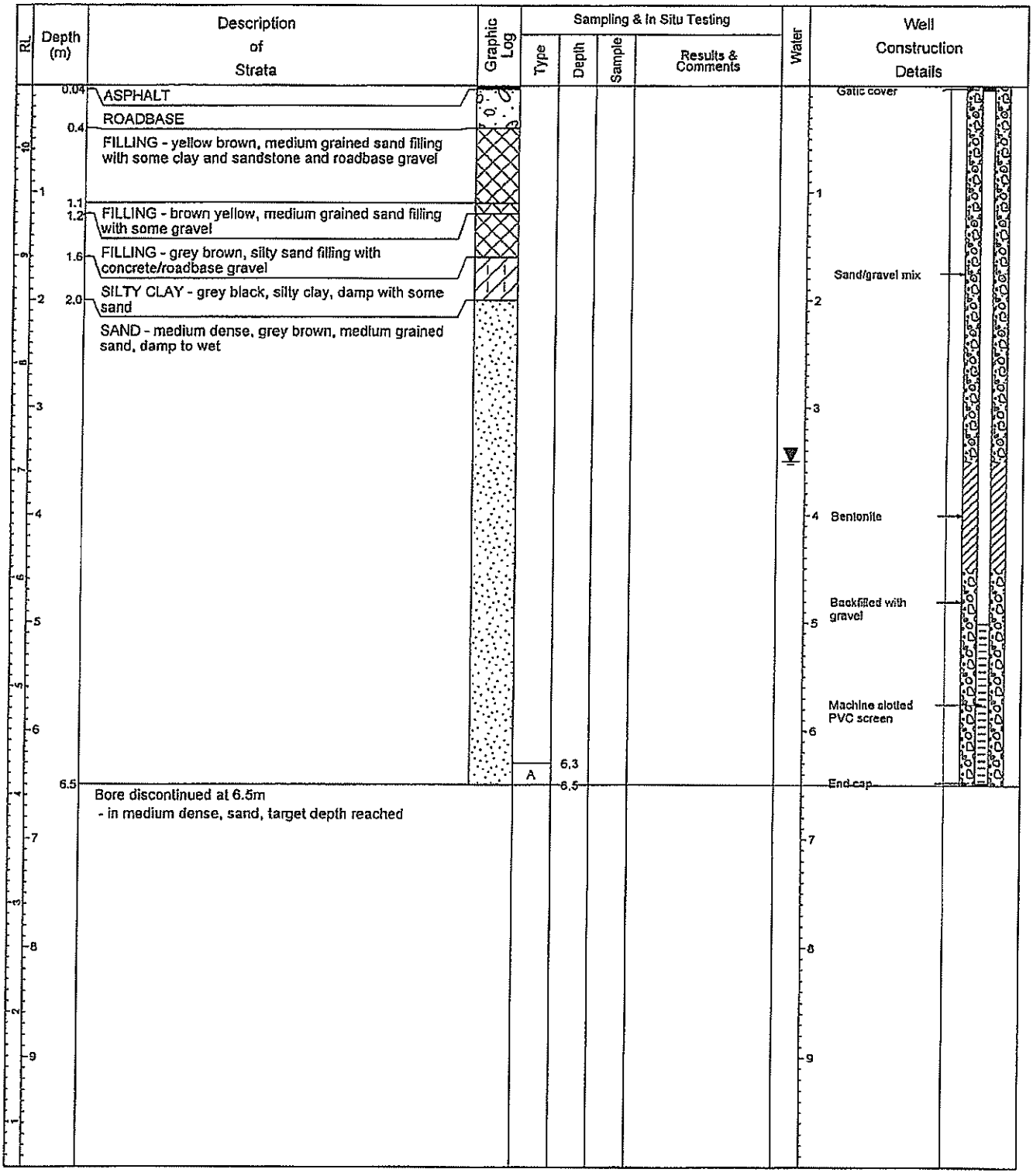
BOREHOLE LOG

CLIENT: AMP Capital Investors Pty Ltd
PROJECT: Supplementary Contamination Assessment
LOCATION: Warringah Mall

SURFACE LEVEL: 10.59 AHD
EASTING: 339292.83
NORTHING: 6262319.28
DIP/AZIMUTH: 90°/--

BORE No: 507
PROJECT No: 71015.06
DATE: 30/8/2010
SHEET 1 OF 1



RIG: Cross Country **DRILLER:** SP **LOGGED:** ZM **CASING:** HC to 6.5m

TYPE OF BORING: Solid flight auger to 6.5m

WATER OBSERVATIONS: Free groundwater observed at approximately 3.5m

REMARKS: *Casing and advancer lost down hole. Unable to retrieve, possibly jammed by bentonite seal

SAMPLING & IN SITU TESTING LEGEND

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

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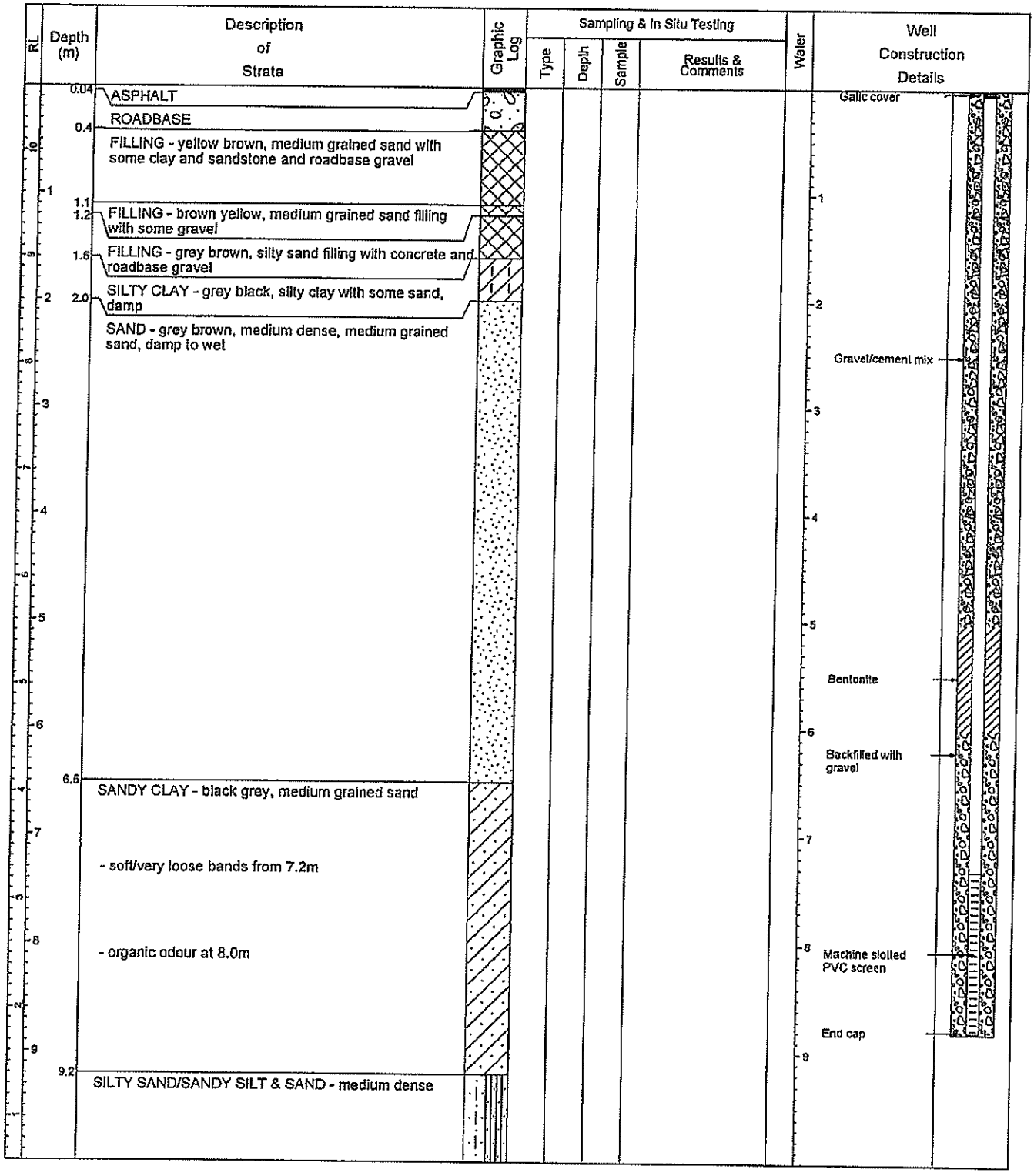
BOREHOLE LOG

CLIENT: AMP Capital Investors Pty Ltd
PROJECT: Supplementary Contamination Assessment
LOCATION: Warringah Mall

SURFACE LEVEL: 10.60 AHD
EASTING: 339296.21
NORTHING: 6262319.66
DIP/AZIMUTH: 90°/--

BORE No: 507A
PROJECT No: 71015.06
DATE: 1/9/2010
SHEET 1 OF 3



RIG: Cross Country **DRILLER:** SP **LOGGED:** ZM **CASING:** HC to 9.2m

TYPE OF BORING: Solid flight auger to 1.0m; Rotary with mud (Guar gum and supertrol) to 9.2m

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Hole collapse to 8.8m due to high water pressure & very loose sandy conditions. Grease from casing on outside of well pipe

SURVEY DATUM:

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: AMP Capital Investors Pty Ltd
PROJECT: Supplementary Contamination Assessment
LOCATION: Warringah Mall

SURFACE LEVEL: 10.60 AHD
EASTING: 339296.21
NORTHING: 6262319.66
DIP/AZIMUTH: 90°/--

BORE No: 507A
PROJECT No: 71015.06
DATE: 1/9/2010
SHEET 2 OF 3

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		SILTY SAND/SANDY SILT & SAND - medium dense *(continued)*							
	13.2	SILTY CLAY/CLAYEY SILT							

RIG: Cross Country **DRILLER:** SP **LOGGED:** ZM **CASING:** HC to 9.2m
TYPE OF BORING: Solid flight auger to 1.0m; Rotary with mud (Guar gum and supertrol) to 9.2m
WATER OBSERVATIONS: No free groundwater observed
REMARKS: Hole collapse to 8.8m due to high water pressure & very loose sandy conditions. Grease from casing on outside of well pipe
SURVEY DATUM:

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: AMP Capital Investors Pty Ltd
PROJECT: Supplementary Contamination Assessment
LOCATION: Warringah Mall

SURFACE LEVEL: 10.60 AHD
EASTING: 339296.21
NORTHING: 6262319.66
DIP/AZIMUTH: 90°/--

BORE No: 507A
PROJECT No: 71015.06
DATE: 1/9/2010
SHEET 3 OF 3

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
-10	21	SILTY CLAY/CLAYEY SILT *(continued)*							21
-11	21.7	WEATHERED ROCK							
-11	21.9	Bore discontinued at 21.9m - target depth reached							
-12	22								22
-12	23								23
-13	24								24
-14	25								25
-15	25								26
-16	27								27
-17	28								28
-18	29								29
-19									

RIG: Cross Country **DRILLER:** SP **LOGGED:** ZM **CASING:** HC to 9.2m
TYPE OF BORING: Solid flight auger to 1.0m; Rotary with mud (Guar gum and supertrol) to 9.2m
WATER OBSERVATIONS: No free groundwater observed
REMARKS: Hole collapse to 8.8m due to high water pressure & very loose sandy conditions. Grease from casing on outside of well pipe
SURVEY DATUM:

SAMPLING & IN SITU TESTING LEGEND

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

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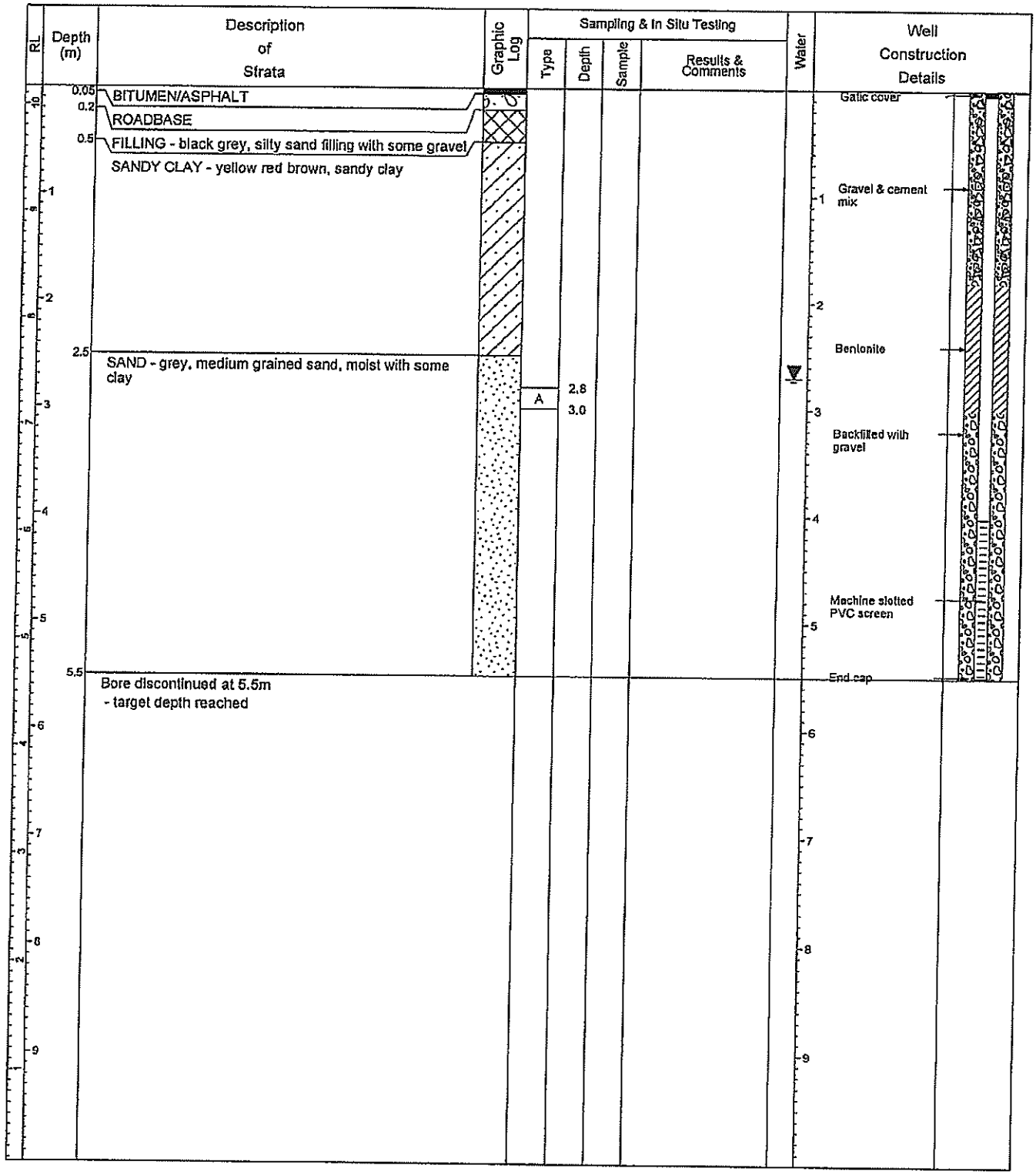
BOREHOLE LOG

CLIENT: AMP Capital Investors Pty Ltd
PROJECT: Supplementary Contamination Assessment
LOCATION: Warringah Mall

SURFACE LEVEL: 10.17 AHD
EASTING: 339432.04
NORTHING: 6262394.84
DIP/AZIMUTH: 90°/--

BORE No: 509
PROJECT No: 71015.06
DATE: 18/8/2010
SHEET 1 OF 1



RIG: Scout 2 **DRILLER:** JS **LOGGED:** ZM **CASING:** Uncased **SURVEY DATUM:**

TYPE OF BORING: Solid flight auger to 5.5m

WATER OBSERVATIONS: Free groundwater observed at 2.7m

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Brookvale Creek, Old Pittwater Road, Brookvale

SURFACE LEVEL: 8.6 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: H101
PROJECT No: 71015.18
DATE: 9/9/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
8	0.0	FILLING - brown silty sand filling with some clay, trace plastic and roots		A	0.0 - 0.1		PID<1 ppm	▼	
	0.5	SILTY SAND - light grey, silty fine to medium sand with trace clay and rootlets, saturated		A	0.5		PID<1 ppm		
	0.7	CLAY - stiff, light grey clay with some sand, saturated		A	0.7 - 0.8		PID<1 ppm		
	0.9	Bore discontinued at 0.9m - Test bore collapse							
7	1								1
6	2								2
5	3								3
4	4								4

RIG: Hand Auger **DRILLER:** JE **LOGGED:** DW **CASING:** Uncased
TYPE OF BORING: Hand auger
WATER OBSERVATIONS: Free groundwater observed at 0.5m whilst drilling
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Brookvale Creek, Old Pittwater Road, Brookvale

SURFACE LEVEL: 8.7 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: H102
PROJECT No: 71015.18
DATE: 9/9/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
8	0.0	FILLING - brown-grey sand filling with some silt and trace clay		A	0.0 - 0.1		PID<1ppm		
	0.4			A	0.4 - 0.5		PID<1ppm	▼	
		- piece of tinsel at 0.5m							
		- possibly natural from 0.8m		A	0.9 - 1.0		PID<1ppm		
1	1.1	Bore discontinued at 1.1m - Borehole collapse							1
7	2								2
6	3								3
5	4								4
4									

RIG: Hand Auger **DRILLER:** JE **LOGGED:** DW **CASING:** Uncased
TYPE OF BORING: Hand auger
WATER OBSERVATIONS: Free groundwater observed at 0.5m whilst drilling
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Brookvale Creek, Old Pittwater Road, Brookvale

SURFACE LEVEL: 8.9 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: H103
PROJECT No: 71015.18
DATE: 9/9/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
8	0	FILLING - silty sand filling with some rootlets		A	0.0		PID<1ppm		
					0.1				
		- some clay at 0.4 - 1.5m		A	0.4		PID<1ppm		
					0.5			▼	
		- saturated from 0.6m							
	1			A	0.9		PID<1ppm		1
		- possibly natural from 1.0m			1.0				
	1.5			A	1.4		PID<1ppm		
		Bore discontinued at 1.5m			1.5				
		- target depth reached							
7	2								2
6	3								3
5	4								4
4									

RIG: Hand Auger **DRILLER:** JE **LOGGED:** DW **CASING:** Uncased
TYPE OF BORING: Hand auger
WATER OBSERVATIONS: Free groundwater observed at 0.6m whilst drilling
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Brookvale Creek, Old Pittwater Road, Brookvale

SURFACE LEVEL: 8.5 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: H104
PROJECT No: 71015.18
DATE: 10/9/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		FILLING - brown sand filling with trace silt, and rootlets - trace sand at 0-0.1m - saturated and possibly natural from 0.2m		*A	0.0 0.1		PID<1ppm	▼	
				A	0.4		PID<1ppm		
	0.5	Bore discontinued at 0.5m - Borehole collapse			0.5				

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

TYPE OF BORING: Hand auger

WATER OBSERVATIONS: Free groundwater observed at 0.2m whilst drilling

REMARKS: *BD1-100913 is blind replicate of 0-0.1m

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Brookvale Creek, Old Pittwater Road, Brookvale

SURFACE LEVEL: 8.8 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: H105
PROJECT No: 71015.18
DATE: 10/9/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.1	FILLING - brown clayey sand filling with trace rootlets		*A	0.0 - 0.1		PID<1ppm		
		SAND - light grey mottled brown, fine to medium sand with trace clay and roots, moist to wet		A	0.4 - 0.5		PID<1ppm		
	0.7	CLAY - stiff, brown mottled grey clay with some silt and fine sand, moist		A	0.7 - 0.8		PID<1ppm		
	0.85	Bore discontinued at 0.85m - target depth reached							

RIG: Hand Auger **DRILLER:** DW **LOGGED:** DW **CASING:** Uncased
TYPE OF BORING: Hand auger
WATER OBSERVATIONS: No free groundwater observed whilst drilling
REMARKS: *BD2-100913 in blind replicate of 0-0.1m

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Brookvale Creek, Old Pittwater Road, Brookvale

SURFACE LEVEL: 8.6 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: H106
PROJECT No: 71015.18
DATE: 10/9/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		FILLING - dark brown sand filling with trace silt rootlets and organic matter		A	0.0 0.1		PID<1ppm		
				A	0.4 0.5		PID<1ppm		
	0.5	SAND - light grey, fine to medium sand with some clay, saturated		A	0.6 0.7		PID<1ppm		
	0.75	Bore discontinued at 0.75m - Borehole collapse							

RIG: Hand Auger **DRILLER:** DW **LOGGED:** DW **CASING:** Uncased
TYPE OF BORING: Hand auger
WATER OBSERVATIONS: Free groundwater observed at 0.3m whilst drilling
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 10.4*
EASTING: 339398
NORTHING: 6262466
DIP/AZIMUTH: 90°/--

BORE No: 620
PROJECT No: 71015.17
DATE: 18/4/2013
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	0.1	ASPHALTIC CONCRETE							A			
	0.3	ROADBASE - grey angular to subangular roadbase gravel							A			
	0.75	FILLING - red brown, medium to coarse grained sand filling with some crushed sandstone fragments							A			
1	1.1	SAND - loose, dark grey, fine to medium grained sand, moist (possible filling)							S			4,4,2 N = 6
	1.7	SAND - loose, light grey brown, fine to medium grained sand, moist				18-04-13						
2		CLAYEY SAND - very loose, dark grey to grey, fine grained, clayey sand, wet							S			3,3,0 N = 3
3	3.2	SAND - medium dense, light grey, fine to medium grained sand with some silt and clay, wet							S			5,11,12 N = 23
4												
5	5.0	SANDY CLAY - stiff, grey, fine grained sandy clay, wet							S			3,5,7 N = 12
6												
7	6.9	SAND - medium dense, dark grey, fine to medium grained sand with some clay, wet							S			4,12,11 N = 23
8	7.9	SANDY CLAY - very soft, dark grey, slightly peaty, fine grained sandy clay, wet							S			1,0,0 N = 0
9								Unless otherwise stated rock is fractured along rough planar bedding dipping at 0°-10°				
	9.7	SANDSTONE - (See next page)										

RIG: DT100 **DRILLER:** SS **LOGGED:** SI **CASING:** HW to 2.5m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary drilling to 10.1m; NMLC-Coring to 16.0m

WATER OBSERVATIONS: Free groundwater observed at 1.9m whilst augering

REMARKS: *Surface level m AHD

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 10.4*
EASTING: 339398
NORTHING: 6262466
DIP/AZIMUTH: 90°/--

BORE No: 620
PROJECT No: 71015.17
DATE: 18/4/2013
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	10.1	SANDSTONE - extremely low strength, light grey brown, fine to medium grained sandstone *(continued)*							S			10/10mm refusal
	11	SANDSTONE - medium then low to medium strength, fresh, then moderately to slightly weathered, slightly fractured and unbroken, light grey, medium to coarse grained sandstone						11.15m: B5°, cly vn 11.4m: B15°, cly vn	C	100	100	PL(A) = 0.4
	11.73							11.51m: CORE LOSS: 220mm				
	12							12.1m to 12.4m: J85°, pl, ro, fe 12.25m: J25°, pl, ro, fe 12.42 & 12.52m: B15°, fe, cly vn 12.65m: B0°, Ds 90mm	C	89	80	PL(A) = 0.9
	13 13.0	SANDSTONE - high strength, moderately to slightly weathered then fresh, fractured and slightly fractured, light grey and purple brown, medium to coarse grained sandstone						12.97m: J40°, pl, ro, cly 13.2m: J45°, pl, ro, cly				PL(A) = 0.9
	14							13.97m: J45°, cu, ro, fe 14.09m to 14.19m: B(x3), 0°-10°, fe, cly 14.36m: J30°, un, ro, fe 14.44m: B5°, cly 5mm 14.62m: B5°, cly 10mm	C	100	93	PL(A) = 1.2 PL(A) = 1.9
	15	-from 15.75m medium strength						14.86m: B5°, fe 15.16m to 15.77m: B(x3) 5°-10°, cly co 1-3mm				PL(A) = 1.2 PL(A) = 0.6
	16 16.0	Bore discontinued at 16.0m										
	17											
	18											
	19											

RIG: DT100 **DRILLER:** SS **LOGGED:** SI **CASING:** HW to 2.5m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary drilling to 10.1m; NMLC-Coring to 16.0m

WATER OBSERVATIONS: Free groundwater observed at 1.9m whilst augering

REMARKS: *Surface level m AHD

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 9.6*
EASTING: 339486
NORTHING: 6262465
DIP/AZIMUTH: 90°/--

BORE No: 621
PROJECT No: 71015.17
DATE: 15/4/2013
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	0.05	ASPHALTIC CONCRETE										
	0.35	ROADBASE										
		FILLING - yellow brown, fine to medium grained, sandy clay filling with a trace of charcoal, fragments of ironstone and sandstone gravel, moist							S			2,0,1 N = 1
	1.35	SILTY CLAY - very soft, dark grey, silty clay and organic fragments, wet				15-04-13						
		1.5m: saturated							S			0,0,0 N = 0
		2.8m: yellow sandy clay bands										
									S			0,0,0 N = 0
	4.5	CLAY - very soft grey clay, saturated, possibly interbedded with silty sand										
									S			0,0,1 N = 1
	6.5	ORGANIC SANDY CLAY - very soft, dark grey, fine to medium grained, organic sandy clay with some silty clay bands and sulphur odour, saturated							S			1,0,0 N = 0
	8.0	CLAYEY SAND - medium dense, grey, fine to medium grained clayey sand with some quartz gravel, saturated							S			3,6,7 N = 13
		9.2 to 9.6m: black charcoal and decomposed organic matter										
	9.6	SAND - (see next page)										

RIG: DT100 **DRILLER:** SS **LOGGED:** SI **CASING:** HW to 3.0m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary drilling to 13.2m; NMLC-Coring to 16.2m

WATER OBSERVATIONS: Free groundwater observed at 1.5m whilst augering

REMARKS: *Surface level m AHD

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 9.6*
EASTING: 339486
NORTHING: 6262465
DIP/AZIMUTH: 90°/--

BORE No: 621
PROJECT No: 71015.17
DATE: 15/4/2013
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
		SAND - medium dense, light brown and dark grey, fine to medium grained sand, slightly silty, saturated *(continued)*							S			9,8,5 N = 13
	11 11.0	SAND - loose, light grey, fine to medium grained sand with some clay and quartz gravel, saturated							S			3,3,3 N = 6
	12											
	13 13.0	SANDSTONE - extremely low strength, light grey brown, fine to medium grained sandstone						Unless otherwise stated rock is fractured along rough planar bedding dipping at 0°-10°	S			25/30mm refusal
	13.25	SANDSTONE - medium strength, slightly weathered and fresh, slightly fractured, light grey and brown, medium grained sandstone. Some extremely low strength bands						13.4m: B0°, cly 15mm 13.74m: B5°, cly 10mm 14.32m & 14.6m: B5°, cly vn 14.6m: B5°, cly 25mm	C	100	92	PL(A) = 0.4 PL(A) = 0.6
	14											
	15	14.95 to 15.15m: highly and moderately weathered, purple brown						15.13m: J30°, cu, ro, fe 15.3m: B0°, cly 25mm				PL(A) = 0.7
	16							15.8m: J40°, pl, sm, cly 20mm 15.95m: B10°, cly 5mm 16.1m: B5°, cly 10mm				
	16.2	Bore discontinued at 16.2m										
	17											
	18											
	19											

RIG: DT100 **DRILLER:** SS **LOGGED:** SI **CASING:** HW to 3.0m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary drilling to 13.2m; NMLC-Coring to 16.2m

WATER OBSERVATIONS: Free groundwater observed at 1.5m whilst augering

REMARKS: *Surface level m AHD

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 9.4*
EASTING: 339481
NORTHING: 6262418
DIP/AZIMUTH: 90°/--

BORE No: 622
PROJECT No: 71015.17
DATE: 18/4/2013
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering	Graphic Log	Rock Strength	Water	Fracture Spacing (m)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	0.05	ASPHALTIC CONCRETE							A			
	0.35	ROADBASE GRAVEL							A			
		FILLING - poorly compacted, dark grey, sandy clay filling with some roadbase gravel, moist							A			
1	1.2	SANDY CLAY - soft then stiff, light grey, fine to medium grained sandy clay, wet				18-04-13			S			1,2,2 N = 4
2		2.0m: stiff							S			10,12,9 N = 21
3	3.5	SAND: medium dense, light brown, fine to medium grained sand with some silt and clay, wet							S			6,8,5 N = 13
4												
5	5.0	PEATY CLAY - very soft, dark grey, peaty clay with trace of fine grained sand, wet							S			0,0,0 N = 0
6	6.6	SAND - medium dense, grey, fine to medium grained sand wet							S			5,9,10 N = 19
7	7.7	SANDY CLAY - very stiff, grey brown, fine to medium grained, sandy clay with some ironstone gravel, moist										
8	8.5	SANDSTONE - very low strength, brown, fine to medium grained sandstone						Unless otherwise stated rock is fractured along rough planar bedding dipping at 0°-10°	S			25/50mm refusal
9	9.4	SANDSTONE - low strength, fresh, slightly fractured, light grey, medium grained sandstone						9.58m: B10°, cly 10mm 9.85m: B5°, cly 20mm	C	100	95	PL(A) = 0.2

RIG: DT100 **DRILLER:** SS **LOGGED:** SI **CASING:** HW to 2.5m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary drilling to 9.4m; NMLC-Coring to 12.4m

WATER OBSERVATIONS: Free groundwater observed at 1.2m whilst augering

REMARKS: *Surface level m AHD

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 9.4*
EASTING: 339481
NORTHING: 6262418
DIP/AZIMUTH: 90°/--

BORE No: 622
PROJECT No: 71015.17
DATE: 18/4/2013
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	10.05	SANDSTONE - medium then high strength, fresh and moderately weathered, slightly fractured, light grey yellow brown and red brown, medium grained sandstone						10.58m to 10.66m: B(x3) 10°-15°, fe, cly 2-5mm 10.96m: J75°, pl, ro, cln 11.36m: B5°, fe, cly 11.64m & 11.7m: J20°-25°, pl, ro, fe	C	100	95	PL(A) = 0.6 PL(A) = 0.9 PL(A) = 1.2
	12.4	Bore discontinued at 12.4m										

RIG: DT100 **DRILLER:** SS **LOGGED:** SI **CASING:** HW to 2.5m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary drilling to 9.4m; NMLC-Coring to 12.4m

WATER OBSERVATIONS: Free groundwater observed at 1.2m whilst augering

REMARKS: *Surface level m AHD

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 9.6*
EASTING: 339458
NORTHING: 6262391
DIP/AZIMUTH: 90°/--

BORE No: 623
PROJECT No: 71015.17
DATE: 17/4/2013
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
	0.1	ASPHALTIC CONCRETE							A			
		ROADBASE GRAVEL							A			
	0.6	FILLING - poorly compacted, dark grey, sandy clay filling with some crushed rock fragments and roadbase gravel, moist							A			
	1	0.9m: hydrocarbon odour							S			5,4,5 N = 9
	2	2.0 INTERBEDDED PEATY CLAYEY SAND AND SAND - very soft dark grey and black peaty clayey sand and very loose dark black sand with some clay, wet				17-04-13			S			0,0,1 N = 1
	3	3.1m: light grey clay band										
	4								S			0,0,0 N = 0
	5								S			1,0,0 N = 0
	6	5.9m: charcoal sandy clay band										
	7	7.0 CLAYEY SAND - loose, light grey to grey, fine grained clayey sand, wet						Unless otherwise stated rock is fractured along rough planar bedding dipping at 0°-10°	S			0,2,2 N = 4
	8	8.2 SANDSTONE - extremely low strength, fine to medium grained sandstone										
	9							8.5m: CORE LOSS: 1500mm	C	33	28	

RIG: DT100 **DRILLER:** SS **LOGGED:** SI **CASING:** HW to 3.0m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary drilling to 8.5m; NMLC-Coring to 14.3m

WATER OBSERVATIONS: Free groundwater observed at 2.1m whilst augering

REMARKS: *Surface level m AHD

SAMPLING & IN SITU TESTING LEGEND

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

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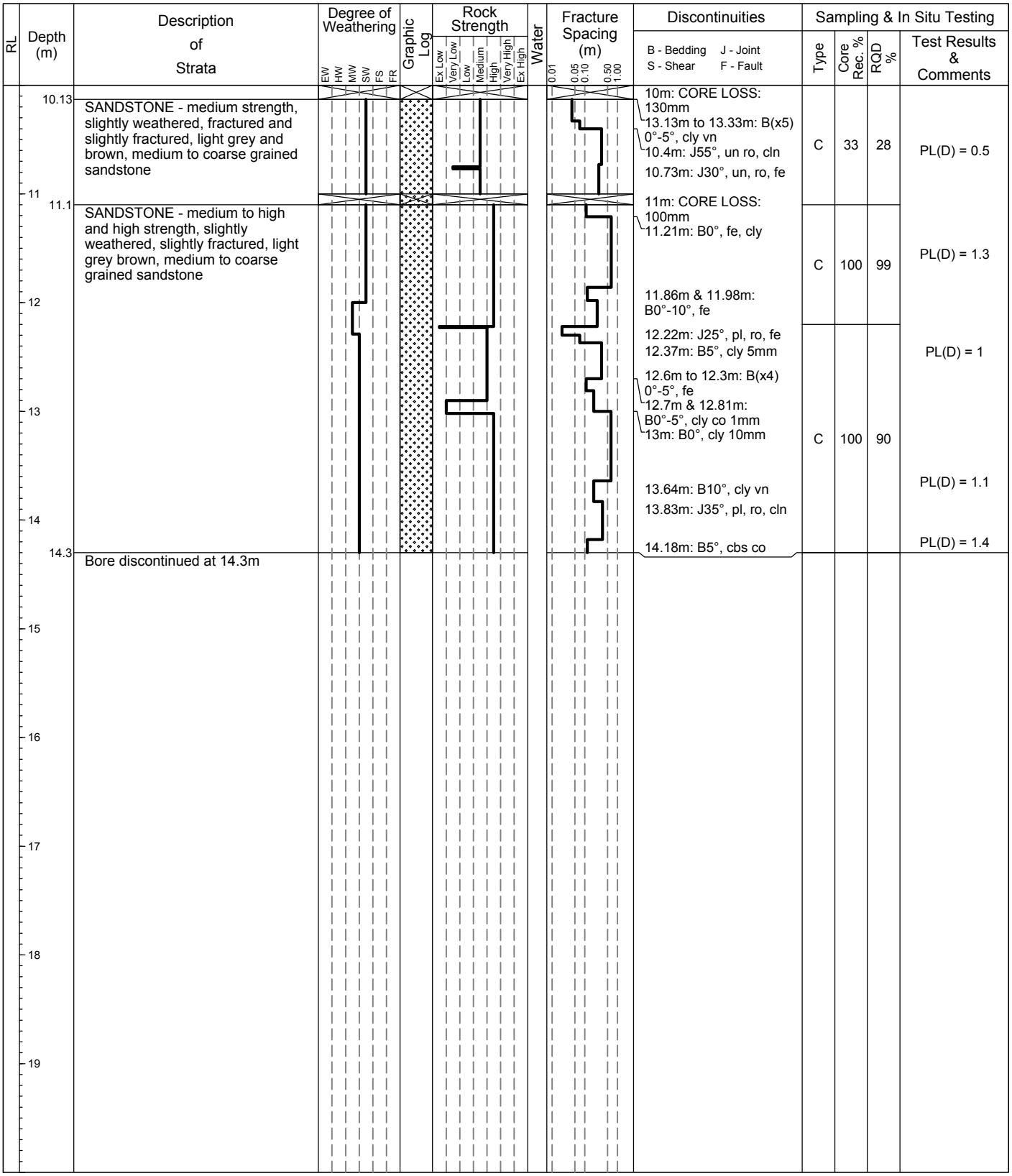
BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 9.6*
EASTING: 339458
NORTHING: 6262391
DIP/AZIMUTH: 90°/--

BORE No: 623
PROJECT No: 71015.17
DATE: 17/4/2013
SHEET 2 OF 2



RIG: DT100 **DRILLER:** SS **LOGGED:** SI **CASING:** HW to 3.0m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary drilling to 8.5m; NMLC-Coring to 14.3m

WATER OBSERVATIONS: Free groundwater observed at 2.1m whilst augering

REMARKS: *Surface level m AHD

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 9.1*
EASTING: 339534
NORTHING: 6262343
DIP/AZIMUTH: 90°/--

BORE No: 624
PROJECT No: 71015.17
DATE: 19/4/2013
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low / Very Low / Low / Medium / High / Very High / Ex High)	Water	Fracture Spacing (m) (0.01 / 0.05 / 0.10 / 0.50 / 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	0.05	ASPHALTIC CONCRETE							A			
	0.35	ROADBASE GRAVEL							A			
	0.7	FILLING - red brown silty clay filling with trace of fine grained sand and ironstone gravel, moist							A			
1	1.0	FILLING - crushed sandstone and sandy clay filling, moist to wet							S			12,8,5 N = 13
		CLAYEY SAND - medium dense, grey, fine grained clayey sand, moist (possible filing) -from 1.4m: wet				19-04-13						
2	2.1	SANDY CLAY - stiff, light grey brown, fine to medium grained sandy clay, wet							S			2,3,5 N = 8
3												
4									S			3,5,9 N = 14
5	5.0	SANDY CLAY - firm, light grey, fine to medium grained sandy clay, wet										
6									S			2,2,4 N = 6
	6.5	SANDSTONE - extremely low strength, light grey brown, fine to medium grained sandstone						Unless otherwise stated rock is fractured along rough planar bedding dipping at 0°-10°				
7	7.0	SANDSTONE - low and very low strength, highly and slightly weathered, slightly fractured, light grey, medium to coarse grained sandstone						7.22m: CORE LOSS: 270mm	C	49	49	PL(A) = 0.2
8								8m: CORE LOSS: 2290mm				
9									C	0	0	

RIG: DT100 **DRILLER:** SS **LOGGED:** SI **CASING:** HW to 2.5m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary drilling to 7.0m; NMLC-Coring to 14.5m

WATER OBSERVATIONS: Free groundwater observed at 1.4m whilst augering

REMARKS: *Surface level m AHD

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 9.1*
EASTING: 339534
NORTHING: 6262343
DIP/AZIMUTH: 90°/--

BORE No: 624
PROJECT No: 71015.17
DATE: 19/4/2013
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
	10.29	SANDSTONE - low and very low strength, highly and slightly weathered, slightly fractured, light grey, medium to coarse grained sandstone(continued)							C	55	5	
	10.76							10.7m: CORE LOSS: 60mm				
11	11.1	SANDSTONE - medium then medium to high strength, slightly weathered, slightly fractured and unbroken, light grey brown, medium to coarse grained sandstone						11.04m: J30°. un, ro cz 10mm	C	99	85	
								11.53m: B0°, cly 11.64m: B0°. cly vn	C	100	77	PL(A) = 0.4
12								11.87m: B10°, cly 12.06m: B0°, cly 10mm				PL(A) = 0.7
13									C	100	99	PL(A) = 0.6
14								14.2m: B0°. fe				PL(A) = 1
	14.5	Bore discontinued at 14.5m										
15												
16												
17												
18												
19												

RIG: DT100 **DRILLER:** SS **LOGGED:** SI **CASING:** HW to 2.5m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary drilling to 7.0m; NMLC-Coring to 14.5m

WATER OBSERVATIONS: Free groundwater observed at 1.4m whilst augering

REMARKS: *Surface level m AHD

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 10.1*
EASTING: 339651
NORTHING: 6262340
DIP/AZIMUTH: 90°/--

BORE No: 625
PROJECT No: 71015.17
DATE: 23/4/2013
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low / Very Low / Low / Medium / High / Very High / Ex High)	Water	Fracture Spacing (m) (0.01 / 0.05 / 0.10 / 0.50 / 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	0.05	ASPHALTIC CONCRETE							A			
	0.3	ROADBASE GRAVEL							A			
		FILLING - variably compacted, red brown, crushed sandstone filling with some clay							A			
	1								S			6,5,9 N = 14
	2.1	CLAY - firm to stiff, light grey clay, moist										
	2								S			1,3,5 N = 8
	3											
	3.5	SANDY CLAY - very stiff, light grey brown, fine to medium grained sandy clay, moist										
	4								S			3,8,12 N = 20
	5.0	CLAY - stiff, light grey clay, moist										
	5								S			3,5,5 N = 10
	6											
	7.0	SAND - dense, light grey, fine to medium grained sand with some silt and clay							S			14,16,16 N = 32
	7											
	7.9	PEATY CLAY - very soft, dark grey, peaty clay with trace of fine grained sand, wet										
	8								S			0,0,0 N = 0
	9											
	10.0											

RIG: DT100 **DRILLER:** SS **LOGGED:** SI **CASING:** HW to 2.5m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary drilling to 13.0m; NMLC-Coring to 19.0m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: *Surface level m AHD

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 10.1*
EASTING: 339651
NORTHING: 6262340
DIP/AZIMUTH: 90°/--

BORE No: 625
PROJECT No: 71015.17
DATE: 23/4/2013
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low / Very Low / Low / Medium / High / Very High / Ex High)	Water	Fracture Spacing (m) (0.01 / 0.05 / 0.10 / 0.50 / 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
		CLAYEY SAND - medium dense, dark grey, fine to medium grained clayey sand, wet							S			1,4,13 N = 17
	11											
	11.8	SANDY CLAY - stiff, light grey, fine grained sandy clay, moist (possibly extremely low strength sandstone)						Unless otherwise stated rock is fractured along rough planar bedding dipping at 0°-10°	S			4,5,8 N = 13
	12											
	13											
	13.0 13.08	SANDSTONE - very low strength, highly weathered, slightly fractured, red purple brown then light grey brown, medium to coarse grained sandstone						13m: CORE LOSS: 80mm 13.22m: J10°-15°, un, ro, fe, cly	C	80	55	PL(A) = 1.5
	14							13.58m: J5-10°, un, ro, fe, cly 14.52m: B0°, cly	C	100	18	
	15							15.32m: J35°, cu, ro, cln	C	88	40	PL(A) = 0.5 PL(A) = 0.6
	15.1	SANDSTONE - medium strength, slightly weathered then fresh, slightly fractured, light grey brown, medium to coarse grained sandstone -15.7 to 16.15m: very low strength						15.82m: CORE LOSS: 180mm				
	16							16.16m: B0°, cly 5mm 16.48m: B10°, cly 5mm				PL(A) = 1.3
	16.0											
	17							16.92m: J45°, pl, sm, cly co 1mm				
	17.2	SANDSTONE - high strength, fresh, slightly fractured and unbroken, light grey, medium to coarse grained sandstone							C	100	95	PL(A) = 1.9
	18							18.11 to 18.38m: B10°, cly co, J85°, un, ro, cln 18.62m: B5°,cly 2mm				PL(A) = 0.5
	18.9 19	Bore discontinued at 18.9m										

RIG: DT100 **DRILLER:** SS **LOGGED:** SI **CASING:** HW to 2.5m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary drilling to 13.0m; NMLC-Coring to 19.0m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: *Surface level m AHD

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 9.5*
EASTING: 339630
NORTHING: 6262300
DIP/AZIMUTH: 90°/--

BORE No: 626
PROJECT No: 71015.17
DATE: 24/4/2013
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	0.05	ASPHALTIC CONCRETE							A			
	0.35	ROADBASE GRAVEL							A			
	0.9	FILLING - light grey brown, fine to medium grained sand filling with some concrete gravel, humid							A			
1		FILLING - moderately compacted, light grey brown, crushed shale fragment filling, humid							S			10,12,5 N = 17
	1.6	SANDY CLAY - very stiff, light grey, fine to medium grained sandy clay, moist										
2									S			2,6,10 N = 16
3												
4	4.0	SANDSTONE - very low strength, light grey brown, fine to medium, grained sandstone						Unless otherwise stated rock is fractured along rough planar bedding dipping at 0°-10°	S			4,6,25/100mm refusal
	4.5	SANDSTONE - very low strength, highly weathered, slightly fractured, light brown, red brown and yellow brown, medium grained sandstone							C	100	0	
5								5.0m to 5.4m: J70°-85°, un, ro, fe				
									C	100	0	
6								6.3m: J50°, pl, ro, fe				
7								7.16m: J85°-90°, pl, ro ,fe	C	92	0	
8								8.05m: CORE LOSS: 170mm				
	8.22	SANDSTONE - low to medium then medium strength, moderately to slightly weathered, slightly fractured, light grey and brown, medium grained sandstone										PL(A) = 0.6
9								8.92m: J70°, pl, sm, cly	C	99	90	
								9.41m: B0°, fe, cly 9.6m: B5°, fe 9.68m: B5°, cly vn 9.88m: B5°, cly co 1mm				PL(A) = 0.8

RIG: DT100 **DRILLER:** SS **LOGGED:** SI **CASING:** HW to 2.5m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary drilling to 4.5m; NMLC-Coring to 13.0m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: *Surface level m AHD

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 9.5*
EASTING: 339630
NORTHING: 6262300
DIP/AZIMUTH: 90°/--

BORE No: 626
PROJECT No: 71015.17
DATE: 24/4/2013
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
		SANDSTONE - low to medium then medium strength, moderately to slightly weathered, slightly fractured, light grey and brown, medium grained sandstone *(continued)*						10.1m: B0°, cly 10mm 10.3m: B0°, cly 10mm 10.8m: B5°, cly 10mm	C	99	90	PL(A) = 0.4
11	11.0	SANDSTONE - medium strength, moderately to slightly weathered, slightly fractured, light grey brown, medium to coarse grained sandstone. Some very low strength bands										
												PL(A) = 0.8
12								11.86m: B15°, cly vn	C	91	77	
												PL(A) = 0.7
								12.4m: J30°, pl, ro, fe 12.45m: J30°, pl, ro, fe 12.65m: J45°, un, ro, fe 12.73m: B5°, cly 12.84m: CORE LOSS: 80mm				
13	12.92 13.0	Bore discontinued at 13.0m										
14												
15												
16												
17												
18												
19												

RIG: DT100 **DRILLER:** SS **LOGGED:** SI **CASING:** HW to 2.5m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary drilling to 4.5m; NMLC-Coring to 13.0m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: *Surface level m AHD

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 9.4*
EASTING: 339603
NORTHING: 6262270
DIP/AZIMUTH: 90°/--

BORE No: 627
PROJECT No: 71015.17
DATE: 29/4/2013
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	0.05	ASPHALTIC CONCRETE							A			
	0.15	ROADBASE GRAVEL							A			
	0.5	FILLING - crushed sandstone filling with some clay							A			
		CLAY - very stiff, red brown clay, moist							S			2,8,10 N = 18
	1.7	SANDSTONE - extremely low strength, extremely weathered, light grey, fine to medium grained sandstone (stiff clay properties)							S			6,7,7 N = 14
		4.0m: very low strength						Unless otherwise stated rock is fractured along rough planar bedding dipping at 0°-10°	S			25/120mm refusal
	4.45	SANDSTONE - very low then low strength, highly and moderately weathered, slightly fractured, light grey and orange brown, medium to coarse grained sandstone							C	100	94	PL(D) = 1 PL(D) = 0.1
	5.41	SANDSTONE - medium to high strength, moderately weathered, slightly fractured and unbroken, light grey and red brown, medium to coarse grained sandstone						5.45m: B0°, cly	C	100	90	PL(D) = 0.1 PL(D) = 1.1
	7.55	7.3 to 7.55m: extremely low strength, extremely weathered yellow brown sandstone						7.35m: fg, 150mm				
		SANDSTONE - medium strength, fresh, slightly fractured and unbroken, light grey and orange brown, medium to coarse grained sandstone. Some extremely low strength bands						8.65m: B0°-5°, cly 15mm	C	100	90	PL(D) = 1 PL(D) = 0.8
	9.75	SANDSTONE (see next page)						>>				

RIG: DT100 **DRILLER:** SS **LOGGED:** PGH **CASING:** HW to 2.5m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary drilling to 4.45m; NMLC-Coring to 14.15m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: *Surface level m AHD

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 9.4*
EASTING: 339603
NORTHING: 6262270
DIP/AZIMUTH: 90°/--

BORE No: 627
PROJECT No: 71015.17
DATE: 29/4/2013
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
		SANDSTONE - high strength, slightly weathered and fresh, slightly fractured and unbroken, light grey and orange brown, medium to coarse grained sandstone *(continued)*							C	100	90	PL(D) = 1.4
	11											
	11.41							11.41m: CORE LOSS: 290mm				PL(D) = 1.1
	11.7											
	12							12.25m: B0°, cly 5mm 12.4m: B0°-5°, cly 3mm	C	91	88	PL(D) = 1.1
	13							12.73m: B0°, cly 5-8mm				
	14											
	14.15	Bore discontinued at 14.15m										
	15											
	16											
	17											
	18											
	19											

RIG: DT100 **DRILLER:** SS **LOGGED:** PGH **CASING:** HW to 2.5m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary drilling to 4.45m; NMLC-Coring to 14.15m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: *Surface level m AHD

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 9.5*
EASTING: 339555
NORTHING: 6262169
DIP/AZIMUTH: 90°/--

BORE No: 628
PROJECT No: 71015.17
DATE: 30/4/2013
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low / Very Low / Low / Medium / High / Very High / Ex High)	Water	Fracture Spacing (m) (0.01 / 0.05 / 0.10 / 0.50 / 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	0.05	ASPHALTIC CONCRETE										
	0.15	FILLING - slightly brown sandy, gravel filling, humid							A			
		FILLING - brown silty sand filling with subrounded and angular gravel, dry							A			
	0.85	FILLING - dark grey sand with some clay and charcoal, humid							S			6,10,15 N = 25
	3.1	SILTY SAND - very loose, dark grey to black, fine to medium grained silty sand with a trace of clay, humid				30-04-13			S			2,4,4 N = 8
	4.7	PEATY CLAY - very soft, black peaty clay							S			0,1,1 N = 2
	6.4	SAND - very loose, black, medium to coarse grained sand							S			0,0,0 N = 0
	8.0	SAND - very loose, grey, coarse grained sand							S			2,1,2 N = 3
	9.3	SANDSTONE - extremely low strength, light grey brown, fine to medium grained sandstone						Unless otherwise stated rock is fractured along rough planar bedding dipping at 0°-10°	S			2,1,2 N = 3
	9.7	SANDSTONE - (see next page)							C	100	95	PL(A) = 0.5

RIG: DT100 **DRILLER:** SS **LOGGED:** PGH **CASING:** HW to 4.0m

TYPE OF BORING: Solid flight auger to 4.0m; Rotary drilling to 9.2m; NMLC-Coring to 14.5m

WATER OBSERVATIONS: Free groundwater observed at 3.75 whilst augering

REMARKS: *Surface level m AHD

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 9.5*
EASTING: 339555
NORTHING: 6262169
DIP/AZIMUTH: 90°/--

BORE No: 628
PROJECT No: 71015.17
DATE: 30/4/2013
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
		SANDSTONE - medium and high strength, slightly weathered and fresh, slightly fractured then unbroken, light grey, medium to coarse grained sandstone *(continued)*						10.15m: B0°, cly 5mm 10.66m: B0°-5°, cly 5mm 11.1m: B0°, cly 5mm 12.32m: J75°, pl, ro, cln 12.45m: J75°, pl, ro, cln 12.6m: J45°, pl, ro, cln 12.7m: B0°. cly 2mm	C	100	95	PL(A) = 0.7 PL(A) = 0.8 PL(A) = 2.1
									C	100	94	PL(A) = 0.8 PL(A) = 1.6
	14.5	Bore discontinued at 14.5m										

RIG: DT100 **DRILLER:** SS **LOGGED:** PGH **CASING:** HW to 4.0m

TYPE OF BORING: Solid flight auger to 4.0m; Rotary drilling to 9.2m; NMLC-Coring to 14.5m

WATER OBSERVATIONS: Free groundwater observed at 3.75 whilst augering

REMARKS: *Surface level m AHD

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 10.3*
EASTING: 339317
NORTHING: 6262338
DIP/AZIMUTH: 90°/--

BORE No: 629
PROJECT No: 71015.17
DATE: 22/4/2013
SHEET 1 OF 4

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	0.05	ASPHALTIC CONCRETE							A			
	0.25	ROADBASE GRAVEL							A			
	0.7	FILLING - light grey to grey, fine to medium grained sand filling with some clay and crushed sandstone gravel										
1	1.4	SANDY CLAY - very stiff, light brown, fine to medium grained sandy clay, moist										
		CLAYEY SAND - loose, light grey, fine to medium grained clayey sand, moist				17-04-13			S			4,11,9 N = 20
2												
									S			2,2,3 N = 5
3												
	3.5	SAND - loose, light grey to grey, medium grained sand with a trace of silt, wet										
4									S			1,1,3 N = 4
5												
	5.3	PEATY CLAY - very soft, dark grey to black, peaty clay, wet							S			2,1,2 N = 3
6												
7									S			0,0,0 N = 0
8												
	8.7	CLAYEY SAND - medium dense, grey, fine to medium grained clayey sand, wet							S			2,7,12 N = 19
9												
	10.0											

RIG: Bobcat **DRILLER:** SY **LOGGED:** SI **CASING:** HW to 6.8m, HQ to 26.1m

TYPE OF BORING: Solid flight auger to 5.5m; Rotary drilling to 26.1m; NMLC-Coring to 36.3m

WATER OBSERVATIONS: Free groundwater observed at 2.0 whilst augering

REMARKS: *Surface level m AHD; Hole grouted to surface upon completion

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 10.3*
EASTING: 339317
NORTHING: 6262338
DIP/AZIMUTH: 90°/--

BORE No: 629
PROJECT No: 71015.17
DATE: 22/4/2013
SHEET 2 OF 4

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low / Very Low / Low / Medium / High / Very High / Ex High)	Water	Fracture Spacing (m) (0.01 / 0.05 / 0.10 / 0.50 / 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
		SAND - medium dense, light grey to grey, medium grained sand with trace of clay, wet							S			12,13,13 N = 26
	11											
	12 12.0	CLAYEY SAND - medium dense, grey, fine to medium grained clayey sand, wet										
	13 13.0	PEATY CLAY - very soft, dark grey to black, peaty clay with some fine grained sand, wet							S			2,0,0 N = 0
	14											
	15											
	16								S			1,0,0 N = 0
	17 17.0	CLAYEY SAND - medium dense to dense, brown, medium to coarse grained clayey sand, moist										
	18											
	19								S			17,17,12 N = 29

RIG: Bobcat **DRILLER:** SY **LOGGED:** SI **CASING:** HW to 6.8m, HQ to 26.1m

TYPE OF BORING: Solid flight auger to 5.5m; Rotary drilling to 26.1m; NMLC-Coring to 36.3m

WATER OBSERVATIONS: Free groundwater observed at 2.0 whilst augering

REMARKS: *Surface level m AHD; Hole grouted to surface upon completion

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 10.3*
EASTING: 339317
NORTHING: 6262338
DIP/AZIMUTH: 90°/--

BORE No: 629
PROJECT No: 71015.17
DATE: 22/4/2013
SHEET 3 OF 4

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
		CLAYEY SAND - medium dense to dense, brown, medium to coarse grained clayey sand, moist *(continued)*										
	21	20.5m: orange brown, medium to coarse grained clayey sand with quartz gravel										
	22								S			18,25/110mm refusal
	22.2	CLAYEY SAND - very dense, light grey brown, medium grained clayey sand, moist (possibly extremely low strength sandstone)										
	23											
	24											
	25											
	25.0	SANDSTONE - extremely low to very low strength, light grey brown, medium grained sandstone						Unless otherwise stated rock is fractured along rough planar bedding dipping at 0°-10°				
	26											
	26.3							26.1m: CORE LOSS: 200mm	C	87	73	PL(A) = 0.4
	26.6	SANDSTONE - medium then low strength, highly to moderately weathered, fractured and slightly fractured, orange brown to brown, medium grained sandstone.						27.47m: B0°, cly 10mm				
	27											
	28								C	90	84	PL(A) = 0.2 PL(A) = 0.2
	29											
	29.2	SANDSTONE - extremely low and medium strength, slightly weathered, fractured, orange brown to brown, medium grained sandstone.						29.2m: B0°, cly 15mm 29.29m: CORE LOSS: 220mm				PL(A) = 0.4
	29.51											
	29.85							29.8m: B0°, cly 10mm				

RIG: Bobcat **DRILLER:** SY **LOGGED:** SI **CASING:** HW to 6.8m, HQ to 26.1m

TYPE OF BORING: Solid flight auger to 5.5m; Rotary drilling to 26.1m; NMLC-Coring to 36.3m

WATER OBSERVATIONS: Free groundwater observed at 2.0 whilst augering

REMARKS: *Surface level m AHD; Hole grouted to surface upon completion

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 10.3*
EASTING: 339317
NORTHING: 6262338
DIP/AZIMUTH: 90°/--

BORE No: 629
PROJECT No: 71015.17
DATE: 22/4/2013
SHEET 4 OF 4

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
		SANDSTONE - medium strength, slightly weathered, fractured and slightly fractured, orange brown to brown, medium grained sandstone *(continued)*						29.83m: B0°. cly 20mm 30.15m: B15°, fe 30.33m: B15°, fe 30.56m: B0°, cly 10mm 31.38m: J45°, pl, ro, fe	C	90	84	
	31											PL(A) = 0.6
	32								C	85	71	PL(A) = 0.5
	32.21	SANDSTONE - extremely low to very low and medium strength, slightly weathered, fractured to slightly fractured, orange brown to brown, medium to coarse grained sandstone						32.14m: J70°, pl ro, fe, cly				
	32.41							32.21m: CORE LOSS: 200mm				PL(A) = 0.4
	32.92							32.67m: CORE LOSS: 250mm				
	33							33.13m: J45°, pl, ro, cln				
	33.72							33.52m: CORE LOSS: 200mm				
	34											
	34.05	SANDSTONE - medium strength, slightly weathered, slightly fractured, orange brown to brown, medium grained sandstone										PL(A) = 1.6
	35								C	87	71	
								35.42 to 35.5m: J45°, pl, ro, cln				PL(A) = 0.6
	36											
	36.3	Bore discontinued at 36.3m						36m: CORE LOSS: 300mm				
	37											
	38											
	39											

RIG: Bobcat **DRILLER:** SY **LOGGED:** SI **CASING:** HW to 6.8m, HQ to 26.1m

TYPE OF BORING: Solid flight auger to 5.5m; Rotary drilling to 26.1m; NMLC-Coring to 36.3m

WATER OBSERVATIONS: Free groundwater observed at 2.0 whilst augering

REMARKS: *Surface level m AHD; Hole grouted to surface upon completion

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 10.5*
EASTING: 339300
NORTHING: 6262329
DIP/AZIMUTH: 90°/--

BORE No: 630
PROJECT No: 71015.17
DATE: 29/4/2013
SHEET 1 OF 4

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	0.05	ASPHALTIC CONCRETE							A			
	0.25	ROADBASE GRAVEL							A			
		FILLING - light grey to grey brown, gravelly sand filling, moist							A			
	0.8	SAND - medium dense, light grey to grey, fine to medium grained sand with trace of clay, moist							S			5,5,6 N = 11
	1.3	SILTY SAND - loose, light grey to grey, fine grained silty sand, moist										
		2.0m: wet				29-04-13			S			2,2,2 N = 4
	3.0	SANDY CLAY - soft then very soft, dark grey, fine to medium grained, sandy clay, wet							S			2,1,2 N = 3
	5.2	PEATY CLAY - very soft, dark grey to black, peaty clay with some fine grained sand, saturated							S			0,0,0 N = 0
	7.3	CLAYEY SAND - medium dense, dark grey, fine to medium grained clayey sand, saturated							S			0,0,6 N = 6
									S			4,8,10 N = 18

RIG: Bobcat **DRILLER:** SY **LOGGED:** SI **CASING:** HW to 7.0m & HQ to 19.2m

TYPE OF BORING: Solid flight auger to 5.5m; Rotary drilling to 26.5m; NMLC-Coring to 31.0m

WATER OBSERVATIONS: Free groundwater observed at 2.0 whilst augering

REMARKS: *Surface level m AHD; Hole grouted to surface upon completion

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 10.5*
EASTING: 339300
NORTHING: 6262329
DIP/AZIMUTH: 90°/--

BORE No: 630
PROJECT No: 71015.17
DATE: 29/4/2013
SHEET 2 OF 4

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low / Very Low / Low / Medium / High / Very High / Ex High)	Water	Fracture Spacing (m) (0.01 / 0.05 / 0.10 / 0.50 / 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
11	11.0	CLAYEY SAND - medium dense, dark grey, fine to medium grained clayey sand, saturated *(continued)*							S			7,6,6 N = 12
		PEATY CLAY - soft, dark brown, peaty clay, wet										
12	12.5	CLAYEY SAND - loose, dark grey to black, fine to medium grained clayey sand, wet							S			6,4,5 N = 9
14	14.5	SAND - loose to medium dense, grey, medium to coarse grained sand with some clay and a trace of quartz gravel							S			8,5,5 N = 10
18	18.0	SANDY CLAY - hard, light grey brown, fine to medium grained sandy clay with a trace of ironstone gravel, wet (possibly weathered sandstone)							S			9,20,25/100 refusal

RIG: Bobcat **DRILLER:** SY **LOGGED:** SI **CASING:** HW to 7.0m & HQ to 19.2m

TYPE OF BORING: Solid flight auger to 5.5m; Rotary drilling to 26.5m; NMLC-Coring to 31.0m

WATER OBSERVATIONS: Free groundwater observed at 2.0 whilst augering

REMARKS: *Surface level m AHD; Hole grouted to surface upon completion

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 10.5*
EASTING: 339300
NORTHING: 6262329
DIP/AZIMUTH: 90°/--

BORE No: 630
PROJECT No: 71015.17
DATE: 29/4/2013
SHEET 3 OF 4

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	21	SANDY CLAY - hard, light grey brown, fine to medium grained sandy clay with a trace of ironstone gravel, wet (possibly weathered sandstone) *(continued)*										
	22								S			9,20,22 N = 42
	23											
	24											
	25											
	26 26.0	SANDSTONE - extremely low strength, extremely weathered, light grey brown, fine to medium grained sandstone						Unless otherwise stated rock is fractured along rough planar bedding dipping at 0°-10°				
	26.68	SANDSTONE - very low to low strength, highly weathered, light grey brown, medium grained sandstone						26.5m: CORE LOSS: 180mm 27.2m: J65°, un, ro, cly 27.6 & 27.7m: J35°, he	C	97	0	PL(A) = 0.2
	27											
	28 28.0	SANDSTONE - medium strength, moderately weathered, fractured, light grey brown, medium grained sandstone						28.16m: J45°, pl, ro, fe 28.51m: B0°, cly 10mm 28.61m: J30°, pl, ro ,cln 28.8m: J45°, pl, sm, cly				PL(A) = 0.4
	29 29.0	SANDSTONE - very low strength, highly weathered, light grey brown, medium grained sandstone						28.86m: J75°, un, ro, fe 29m: CORE LOSS: 1000mm	C	40	25	
	30.0											

RIG: Bobcat **DRILLER:** SY **LOGGED:** SI **CASING:** HW to 7.0m & HQ to 19.2m

TYPE OF BORING: Solid flight auger to 5.5m; Rotary drilling to 26.5m; NMLC-Coring to 31.0m

WATER OBSERVATIONS: Free groundwater observed at 2.0 whilst augering

REMARKS: *Surface level m AHD; Hole grouted to surface upon completion

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Westfield Design & Construction Pty Ltd
PROJECT: Warringah Mall Redevelopment
LOCATION: Condamine Street, Brookvale

SURFACE LEVEL: RL 10.5*
EASTING: 339300
NORTHING: 6262329
DIP/AZIMUTH: 90°/--

BORE No: 630
PROJECT No: 71015.17
DATE: 29/4/2013
SHEET 4 OF 4

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
		SANDSTONE - very low strength, highly weathered, light grey brown, medium grained sandstone (continued)						30m: CORE LOSS: 800mm	C	40	25	
	30.8											
	31 31.0	Bore discontinued at 31.0m										
	32											
	33											
	34											
	35											
	36											
	37											
	38											
	39											

RIG: Bobcat **DRILLER:** SY **LOGGED:** SI **CASING:** HW to 7.0m & HQ to 19.2m

TYPE OF BORING: Solid flight auger to 5.5m; Rotary drilling to 26.5m; NMLC-Coring to 31.0m

WATER OBSERVATIONS: Free groundwater observed at 2.0 whilst augering

REMARKS: *Surface level m AHD; Hole grouted to surface upon completion

SAMPLING & IN SITU TESTING LEGEND

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

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About this Report

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Introduction

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

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

Copyright

Borehole and Test Pit Logs

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

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

Groundwater

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

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

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

Reports

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

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

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

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

About this Report

Site Anomalies

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

Information for Contractual Purposes

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

Site Inspection

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