Shoalhaven City Council
C/- Watkinson Apperley Pty Ltd

Hydrogeological Assessment:

Proposed Sub-division, Mundamia Release Area, Mundamia NSW.

P1002761JR01V02
June 2011

Copyright Statement

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All enquiries regarding this project are to be directed to the Project Manager.

Contents

1 Overview

1.1 Introduction and Scope

This report documents the findings of a Hydrogeological Assessment (HA) undertaken at Mundamia Release Area, Mundamia, NSW.

The HA documents hydrogeological characteristics, assesses likely impacts associated with proposed site development and identifies mitigation measures to address potential adverse impacts on the site's groundwater system.

The principal potential impact covered by the assessment is habitat modification to the Spring Tiny Greenhood Orchid and Nowra Heath Myrtle which may come about due to changes in groundwater regimes following site urban development.

This HA has put in place special protection and appropriate mitigation measures to address potential hydrogeological modification.

The site is on a ridge top position and the Spring Tiny Greenhood Orchid and Nowra Heath Myrtle rely on shallow groundwater located at the base of the soil profile. This HA therefore considers the characteristics and assessment of this shallow aquifer and not the deeper rock aquifer.

1.2 Assessment Coverage

Site development assessed by this report is restricted to the development of:

Lot 3 DP568613;

Lot 384 DP755952;

Lot 1 DP1021332; and

Part Lot 458 DP1063107.

Figure 1 identifies the above allotments. Within Areas H and G (Figure 1) (Aboriginal Land Council land) the HA scope is limited to groundwater monitoring only.

2 Site Description

2.1 Location

The site is located approximately 4 km south west of Nowra and is within the Shoalhaven City Council Local Government Area.

2.2 Field Investigations

Field investigations for the HA were primarily undertaken 18 – 20 October, 2010. Geotechnical data derived by Martens and Associates on 9 September, 2008 was used to supplement the former investigations. Investigations included the following:

- Walkover inspection of the site to assess existing site conditions, local topography, geology, soil conditions and vegetation;
- Completion of 8 boreholes with a truck mounted hydraulic auger on 18 – 20 October, 2010 with Groundwater Monitoring Bore (GMB) installation into 5 of the 8 boreholes;
- Completion of 13 boreholes with a 4WD mounted hydraulic auger on 9 September, 2008;
- Falling head tests to estimate hydraulic conductivity (k) at each GMB;
- Collection of 6 soil samples for Wilting Point and Field Capacity analysis by laboratory; and
- Installation of data loggers in accordance with the schedule provided in Table 1.

Table 1: Groundwater and rain gauge monitoring schedule.

Element	Monitoring Frequency (minutes)	Monitoring Period	Observations	Monitoring Method
GMB1, GMB2, GMB3, GMB4	10	19.10.2010 to 20.01.2011	GL, GT	Data logger
GMB5	10	19.10.2010 to 20.01.2011	BP, GL, GT, EC	Data logger
Rain Gauge	15	19.10.2010 to 20.01.2011	R	Rain gauge data logger

Key: BP = barometric pressure, GL = groundwater level, GT = groundwater temperature, EC = groundwater Electrical Conductivity, R = rain depth (mm).

2.3 Topography and Drainage

While site slopes vary from approximately 1 - 50% they are typically low at 3 - 6%. Indicative sub-catchments are shown in Figure 2.

2.4 Soil Profile

2.4.1 Overview

Borehole observations indicate that the site's soil profile typically comprises shallow (0 – 0.8 m deep) silty sand, silty gravel and gravels over extremely weathered sandstone. A deeper profile up to 2.8 m deep is also observed on the site and comprises silty sand over clayey sand and clays. The deeper profile is also underlain by extremely weathered sandstone. Borehole logs are provided in Attachment B with borehole locations provided in Figure 3.

2.4.2 Available Water Holding Capacity

6 soil samples were analysed by laboratory in order to better understand soil moisture conditions. Results are summarised in Table 2.

Table 2: Summary of available soil available water holding capacity results.

Sample ID. [1]	Field Capacity [2]	Wilting Point [3]	Soil Texture
2761/4/0.4	9.9	5.4	Silty gravel
2761/8/0.3	16.8	12.1	Clayey sand
2761/6/0.5	23.2	11.6	Clay fill
2761/2/1.0	15.1	8.0	Silty sand
2761/3/0.35	19.7	8.9	Organic silty sand
2761/5/0.1	19.1	9.9	Organic silty sand

Notes: [1.] #/#/# = project ID/borehole ID/sample depth. [2.] 0.3 bar %. [3.] 15 bar %.

2.5 Groundwater

2.5.1 Overview

Based on field and monitoring observations the shallow site groundwater system is generally characterised as follows:

- Unconfined.
- Moderate hydraulic conductivity (K).
- Base comprises extremely to moderately weathered sandstone with a low K value.
- Flow in areas of shallow soil is ephemeral (non-permanent) with the soil profile frequently becoming unsaturated.
- Flow in areas of deeper soil is less ephemeral.
- Flow vectors are expected to generally mimic the topography of the sandstone rock layer (which is expected to be similar to ground level topography but at a lower level).
- Groundwater availability is controlled by recharge, which is controlled by antecedent rainfall and evapotranspiration (ET).
- Groundwater discharges to the surface as seepage in areas where the sandstone rock layer forms the ground level. This occurs at the top of steep slopes on adjacent land.

2.5.2 Hydraulic Conductivity (K)

Site K testing to date is summarised in Table 3. Results indicate that site soils are of moderate permeability. Refer to Figure 3 for the location of GMBs.

Table 3: Summary of aquifer K testing results.

GMB	Test Medium	Estimated K (m/d)
1	Sand	5.46
1	Sandstone rock	0.01
2	Variable	0.42
3	Silty Sand	0.09
4	Silty sand and silty gravel	1.86
5	Silty sand	0.53
Geometric mean	Variable	0.36
Median		0.48
Mean		1.40

Notes: [1.] Results based on Martens and Associates testing completed on 19-20.10.2010. [2.] Test type = falling head. All data analysed using the Hvorslev (1981) method.

2.5.3 Manual Groundwater Level Measurements

Manual groundwater level measurements taken during this investigation are summarised in Table 4 together with GMB details.

Table 4: Manual groundwater level measurements.

GMB ID	GMB1	GMB2	GMB3	GMB4	GMB5
Surveyed GL (mAHD)	67.27	69.62	60.50	63.50	55.24
Invert (mAHD)	66.64	66.81	59.86	62.50	54.47
Depth into Ground (m)	0.64	2.81	0.64	1.00	0.77
MGA Easting	277612.00	277887.90	278361.30	278027.40	278501.90
MGA Northing	6137025.30	6137094.00	6137231.90	6137511.90	6137574.30
Top of pipe level (mAHD)	67.99	70.31	61.19	64.15	55.91
Pipe Height above GL (m)	0.72	0.69	0.69	0.65	0.67
Total Well Length (m)	1.36	3.50	1.33	1.65	1.44
Manual Dip Measurements (mAHD/mBGL)					
20/10/2010	66.88/0.39	67.25/2.37	dry	dry	dry
22/11/2010	66.80/0.47	67.69/1.93	60.01/0.49	dry	dry
20/01/2011	66.69/0.58	67.76/1.86	dry	dry	dry

2.5.4 Continuous Groundwater Level and Rain Measurements

A residual groundwater level plot for all GMBs with rainfall is provided in Figure 4. Individual groundwater level and rain plots are provided for

GMBs 1-5 in Figure 5, Figure 6, Figure 7, Figure 8 and Figure 9 respectively. Groundwater level response plots for GMB1, GMB3 and GMB5 are provided in Figure 10, Figure 11 and Figure 12 respectively. Groundwater level response plots for GMB2 and GMB4 are not provided due to a poor regression.

Analysis of continuous groundwater level and rain data indicates the following:

- GMB1 and GMB3 are saturated above the soil/rock interface for approximately 50% of the monitoring period.
- GMB2 is saturated above the soil/rock interface for the whole of the monitoring period.
- GMB4 remained dry above the soil/rock interface throughout the whole of the monitoring period. This is expected given that the silty gravel layer above the rock is considered to be highly permeable.
- GMB5 is saturated above the soil/rock interface for approximately 35% of the monitoring period.
- Based on the groundwater level response plot at GMB5 (Figure 12), which had the highest linear regression value, groundwater level response occurs once daily rain exceeds approximately 3 mm. Analysis of long-term climate data for Nowra indicates that on average a rain day of greater than 3 mm will occur 63 days per year.
- GMBs generally respond in a similar manner to stresses with the exception of GMB4. GMB4 was installed into soil considered to be more permeable than other GMBs.
- The mechanism responsible for groundwater level trends is principally influenced by recharge (a function of rainfall infiltration and ET). Soil type also influences groundwater level trends as less permeable soils retain groundwater for a longer period of time. Available Water Holding Capacity results (Table 2) support this conclusion.

2.5.5 Groundwater Electrical Conductivity (EC)

Groundwater EC was continuously monitored by a data logger at GMB 5. The maximum observed EC value of 510 µS/cm indicates groundwater is fresh.

2.5.6 *Vegetation*

The Spring Tiny Greenhood Orchid has been mapped (Figure 3) outside of the site whilst the Nowra Heath Myrtle has been mapped (Figure 3) both within and outside of the site. Advice from the project flora and fauna consultants is that both of these species may be adversely affected by potential changes to the surface water and groundwater regimes which may come about due to the proposed-development.

The habitat of the Spring Tiny Greenhood Orchid is associated with the moss gardens within some areas of Kunzea Shrubland. As no moss garden mapping is available, Kunzea Shrubland is taken as a mapping surrogate for potential Spring Tiny Greenhood Orchid (outside of mapped instances) habitat. This assessment therefore conservatively presumes that the Spring Tiny Greenhood Orchid could exist in areas of mapped Kunzea Shrubland.

Discharge of groundwater to the surface as seepage flow occurs in areas of sandstone outcropping and is the mechanism which provides groundwater to Spring Tiny Greenhood Orchid and Nowra Heath Myrtle. These species are considered to not be wholly reliant on groundwater as flow from surface water is also considered to sustain these species.

Seven areas of Kunzea Shrubland are mapped near the site (Areas A – G in Figure 3).

Of the seven areas depicted in Figure 3, Areas A, B, C and G have catchments that do not encroach onto areas of proposed site development. Areas D, E and F have catchments that do encroach upon areas of proposed site development and therefore are considered prone to potential impacts associated with site urban development.

Nowra Heath Myrtle is mapped downslope of areas proposed to be developed and therefore is considered prone to potential impacts associated with site urban development.

2.5.7 *Conceptual Hydrogeological Model*

The conceptual model is based on information detailed in Section 2 and is summarised as a schematic in Figure 13.

Inflow to the shallow groundwater system consists of infiltrated rainfall; outflows include ET and discharge as spring-flow (seepage).

3 Groundwater Impact Assessment

3.1 Potential Impacts

3.1.1 Altered Flow Regime

The proposed-development has the potential to alter groundwater flow to potential orchid habitat in Kunzea Shrubland Areas D, E and F (Figure 3) and to areas of Nowra Heath Myrtle whose hydrogeological catchment encroaches upon areas of proposed site development.

Urban development may alter flow regime as follows:

- Impervious areas shall increase resulting in reduced groundwater recharge.
- Reduced site vegetation shall result in reduced evapotranspiration.
- Reduced overall recharge shall reduce the total soil moisture content and therefore reduce the frequency of groundwater 'flow' events and the number of days per year when seepage to vegetated lands shall occur.

3.1.2 Changes to Flow Quality

Changes to groundwater quality may potentially impact the Spring Tiny Greenhood Orchid and Nowra Heath Myrtle areas identified above due to reductions in water quality. We note that this potential impact is considered less likely and can be managed more readily than impacts associated with altered flow regime.

3.2 CLASS-U3M-1D (Unsaturated Moisture Movement Model)

3.2.1 Overview

The CLASS soil moisture model developed by eWater Cooperative Research Centre is used to assess site groundwater recharge flow to the Spring Tiny Greenhood Orchid and Nowra Heath Myrtle. The model utilises site rainfall and evaporation data together with soil profile properties to assess the net recharge to groundwater.

In consultation with eWater Cooperative Research Centre it was confirmed the CLASS model was appropriate for this application as follows:

- Groundwater flow is ephemeral and therefore not suited to modelling with conventional groundwater models such as MODFLOW.

- The conceptual hydrogeological model is suited to CLASS as the soil/rock interface layer has a low slope and soil stratigraphy is not overly complex.

- Long-term climate data is considered important for the model simulation and CLASS is run using a long-term daily climate file.

- Catchment and soil science experts of the eWater Cooperative Research Centre indicated that the model was suitable for the intended application.

3.2.2 Inputs

Input parameters used in the model are summarised in Table 5 with 'screen dumps' of model inputs shown in Figure 14.

Table 5: CLASS input parameters.

Element	Input
Soil Layers	1
Soil Layer Depth (mBGL)	0 to 0.5
Soil Parameters	Loamy Sand (CLASS default soil catalogue parameters)
Soil K (m/d)	0.5
Ksub (m/d) [1]	0.5
Climate file	Daily 50 yr rain and evaporation file derived from NOWRA RAN BOM station

Notes: [1]. A Ksub value of 0.5 m/d was assigned so that flux out of the soil layer could be considered as seepage.

3.2.3 Results

Total seepage flux determined by the CLASS modelling system indicate an average of 473 mm/yr of water passes beyond root zones for undeveloped site conditions.

A 'first principles' analysis was used to verify CLASS results. Assuming mean annual rainfall of 1,256 mm; mean annual actual ET of 650 mm and a run-off coefficient of 0.15, seepage flux is estimated at 418 mm. This calculation validates the CLASS model results.

A sensitivity analysis was completed assuming vegetation was forest (compared to grass in primary analysis). This sensitivity analysis determined an average annual recharge of 436 mm/yr which

indicates that the CLASS model is relatively insensitive to vegetation type.

Seepage output results from the CLASS model are provided in Figure 15.

3.2.4 Impact Assessment

3.2.4.1 Overview

Advice from Allen, Price and Associates (project planner for Twynam Property Group) suggests that impervious area will be approximately 40% of total Malbec site area. Advice from Watkinson Apperley (Council's project planner) indicates that a similar impervious/pervious area balance is likely to result from the development proposed on Council lands.

This assessment is completed on the basis of recharge per ha of development to allow application to each site and future staging as required.

Average pre-development recharge is calculated to be 4.73 ML/ha/yr. Development resulting in an impervious area of 40% will decrease the average recharge to 2.84 ML/ha/yr (0.6 x 4.73 = 2.84). Consequently, 1.89 ML/ha/yr of supplementary recharge will be required to achieve a neutral impact.

As the final development design shall impact final impervious areas Table 6 has been prepared to provide recharge requirements for a range of final impervious area percentages.

All areas of the site require application of supplementary seepage (Figure 3).

Table 6: Supplementary recharge requirements.

Existing Annual Average Recharge (ML/ha/yr)	Impervious Area (%)	Required Supplementary Recharge to Achieve Neutral Impact (ML/ha/yr)
4.73	30	1.42
	35	1.66
	40	1.89
	45	2.13
	50	2.37
	55	2.60
	60	2.84

3.2.4.2 Conclusion

Analysis confirms that proposed urban development shall result in reduced groundwater recharge. This shall result in reduced seepage to downslope vegetation which is likely to have an adverse impact on vegetation health. Therefore, mitigation measures are required to ensure the protection of downslope vegetation in particular the Spring Tiny Greenhood Orchid and Nowra Heath Myrtle.

Due to the hydrogeological catchments of the site and location of potential Spring Tiny Greenhood Orchid habitat and Nowra Heath Myrtle, mitigation works are required across all areas of the site as shown in Figure 3.

Importantly, with mitigation works outlined in Section 4 of this report, the post-development flow to the potential Spring Tiny Greenhood Orchid habitat and Nowra Heath Myrtle shall be equivalent to the pre-development flow thus ensuring no adverse hydrogeological effects on this valuable ecological resource.

4 Mitigation Strategy

4.1 Mitigation Objective

The objective of the mitigation strategy is to develop site design recommendations to ensure that the development does not significantly alter the volume of groundwater available to the Spring Tiny Greenhood Orchid and Nowra Heath Myrtle.

4.2 Mitigation Strategy

4.2.1 Overview

Existing site recharge conditions result in maximum duration seepage flow after rainfall recharge occurs throughout the catchment. To best mimic this process it is recommended that supplementary recharge be applied throughout the catchment and not concentrated at the end of the stormwater system low in the hydrogeological catchment of the potential Spring Tiny Greenhood Orchid habitat and Nowra Heath Myrtle. To achieve this, recharge systems should be applied at regular lateral and longitudinal spacing.

4.2.2 Supplementary Recharge System (SRS)

A stormwater recharge infiltration system is proposed to be designed to augment natural recharge. The system is to supply supplementary recharge at rates detailed in Table 6. Final required supplementary recharge volume will depend on the development's impervious area percentage.

Structures suited to facilitating supplementary recharge include:

- Road side swales
- Bio-retention swales
- Bio-retention basins
- Rain gardens

4.3 Location and Design of SRS

4.3.1 Location

Recharge structures are to be sized to replace lost recharge and located to ensure recharge is distributed throughout the catchment. The distribution of the SRS at a range of distances from the potential

Spring Tiny Greenhood Orchid habitat and Nowra Heath Myrtle shall assist in ensuring temporal seepage patterns remain unaltered.

SRS are required across the entire site (Figure 3).

4.3.2 Typical Design of SRS

SRS sizing is based on the following assumptions:

- 189 mm/ha/yr of supplementary recharge is required to replace lost recharge.
- The SRS is designed to recharge water for events of 3 mm/d rainfall or greater based on observed groundwater response to this size of rainfall event. Review of climate information indicates rainfall of 3mm or more occurs on average 63 days per year based on local climate record analysis.
- Site soils are generally silty sands and clayey sands and therefore the minimum expected K value is 240 mm/d (i.e 10 mm/hr).
- To achieve 189 mm/ha/yr of recharge over 63 days with a daily recharge rate of 240 mm/d a recharge basin area of 125 m^2/ha is required (1890000/(63 x 240). This area rate does not take into account SRS side batters and therefore a nominal footprint of 250 m^2/ha is considered appropriate.
- SRS are to store 240 mm of water from any given rainfall event to ensure adequate daily infiltration. This may be provided as standing water depth 240 mm deep or aggregate filled storage beds of approximately 720 mm depth or a combination of the two.
- It is noted that the distributed recharge areas shall need to be hydraulically connected to the potential Spring Tiny Greenhood Orchid habitat and Nowra Heath Myrtle areas. Groundwater flow obstructions such as roads along contours with pavements to/or near rock shall need to ensure that water can flow unobstructed to the site boundaries. This is to be addressed at detailed design stage but is expected to be feasible by adopting some or all the following:
  - Under road culverts at specific locations;
  - Permeable aggregate drains upslope, beneath and downslope of roads;
  - Permeable road sub-base.

4.3.3 Monitoring and Performance Criteria of SRS

The SRS should be inspected regularly for debris build up and sediment accumulation.

If SRS infiltration becomes reduced then the SRS base may require stripping of fines to ensure ongoing effective infiltration from the system.

4.4 Water Quality Measures

4.4.1 Groundwater

Review of typical pollutant generation rates for agricultural and residential land uses indicate Event Mean Concentrations (EMCs) for the proposed residential land use are typically lower than for agricultural land use (predominant current land use). Therefore, as pollutant concentrations shall be reduced the quality of water seeping through to the aquifer should be the same or better.

4.4.2 Surface Water

Stormwater quality will need to be addressed. This is outside the scope of this investigation.

5 Conclusion

This Hydrogeological Assessment confirmed that the site has a shallow ephemeral (non-permanent) groundwater system within the soil mantle over shallow sandstone rock. This groundwater discharges as seepage at areas of rock outcropping and maintains water supply to potential Spring Tiny Greenhood Orchid habitat within Kunzea Shrubland and Nowra Heath Myrtle vegetation.

Groundwater flow directions at the site are considered to approximate natural ground level vectors. Sensitive vegetation's hydrogeological catchments cover the entire proposed site development.

Mitigation measures have been outlined to ensure the protection of the vegetation associations, these include a system of stormwater infiltration areas to supplement groundwater recharge.

The recommended stormwater infiltration areas are to be located throughout the development area. Recharge systems are required at a rate of 125 m^2/ha (nominal footprint of 250 m^2/ha with side batters) and are to include 240 mm of runoff storage.

Design of road and other structures/infrastructure with the potential to intercept, disrupt or redirect groundwater flows is to be undertaken with due consideration to maintain the existing downslope groundwater regime.

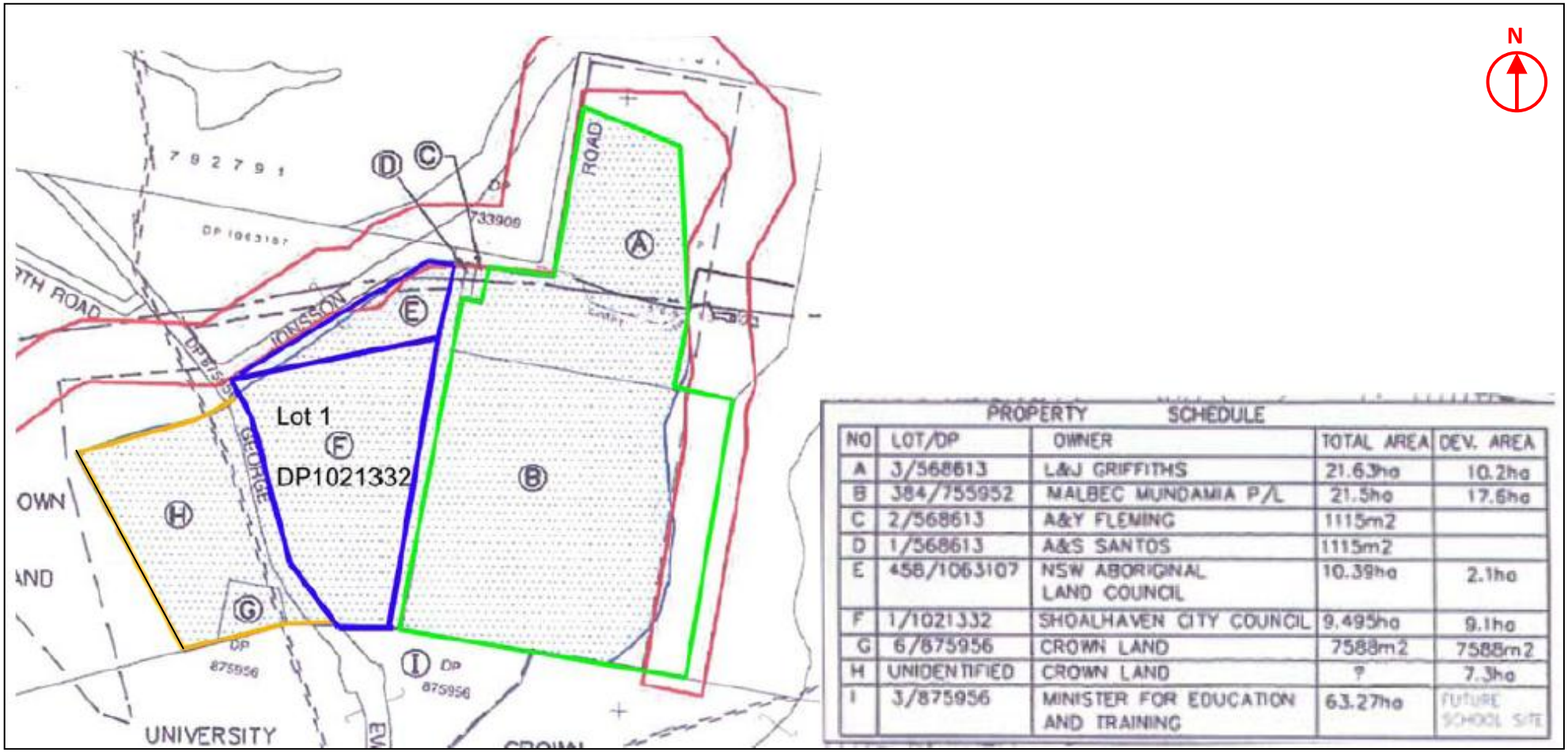
Assessment findings indicate that site development is able to proceed with a neutral impact provided the recommendations in this report are adhered to.

6 Limitations Statement

Groundwater conditions during proposed works may be found to be different from those detailed in this report due to investigation limitations and/or climate conditions. Should, during site works, soil or water conditions be found to be significantly different to those detailed in this report, works shall cease immediately and the new conditions should be assessed by Martens & Associates to determine implications before recommencement.

Martens & Associates Pty Ltd has undertaken this assessment for the purposes of the current development proposal. No reliance on this report should be made for any other investigation or proposal. Martens & Associates accepts no responsibility, and provides no guarantee regarding the characteristics of areas of the site not specifically studied in this investigation.

7 Attachment A – Figures



PROPERTY SCHEDULE

NO	LOT/DP	OWNER	TOTAL AREA	DEV. AREA
A	3/568613	L&J GRIFFITHS	21.63ha	10.2ha
B	384/755952	MALBEC MUNDAMIA P/L	21.5ha	17.6ha
C	2/568613	A&Y FLEMING	1115m2	
D	1/568613	A&S SANTOS	1115m2	
E	458/1063107	NSW ABORIGINAL LAND COUNCIL	10.39ha	2.1ha
F	1/1021332	SHOALHAVEN CITY COUNCIL	9.495ha	9.1ha
G	6/875956	CROWN LAND	7588m2	7588m2
H	UNIDENTIFIED	CROWN LAND	?	7.3ha
I	3/875956	MINISTER FOR EDUCATION AND TRAINING	63.27ha	FUTURE SCHOOL SITE

Notes:

1. Areas covered by Groundwater Assessment = A, B, E, F, G and H.

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	WATKINSON APPERLEY	**AREAS COVERED BY GROUNDWATER ASSESSMENT**	Drawing No: **FIGURE 1**
Approved:	AN		
Date:	30.06.2010		
Scale:	APPROX 1: 16,550		Job No: P1002761

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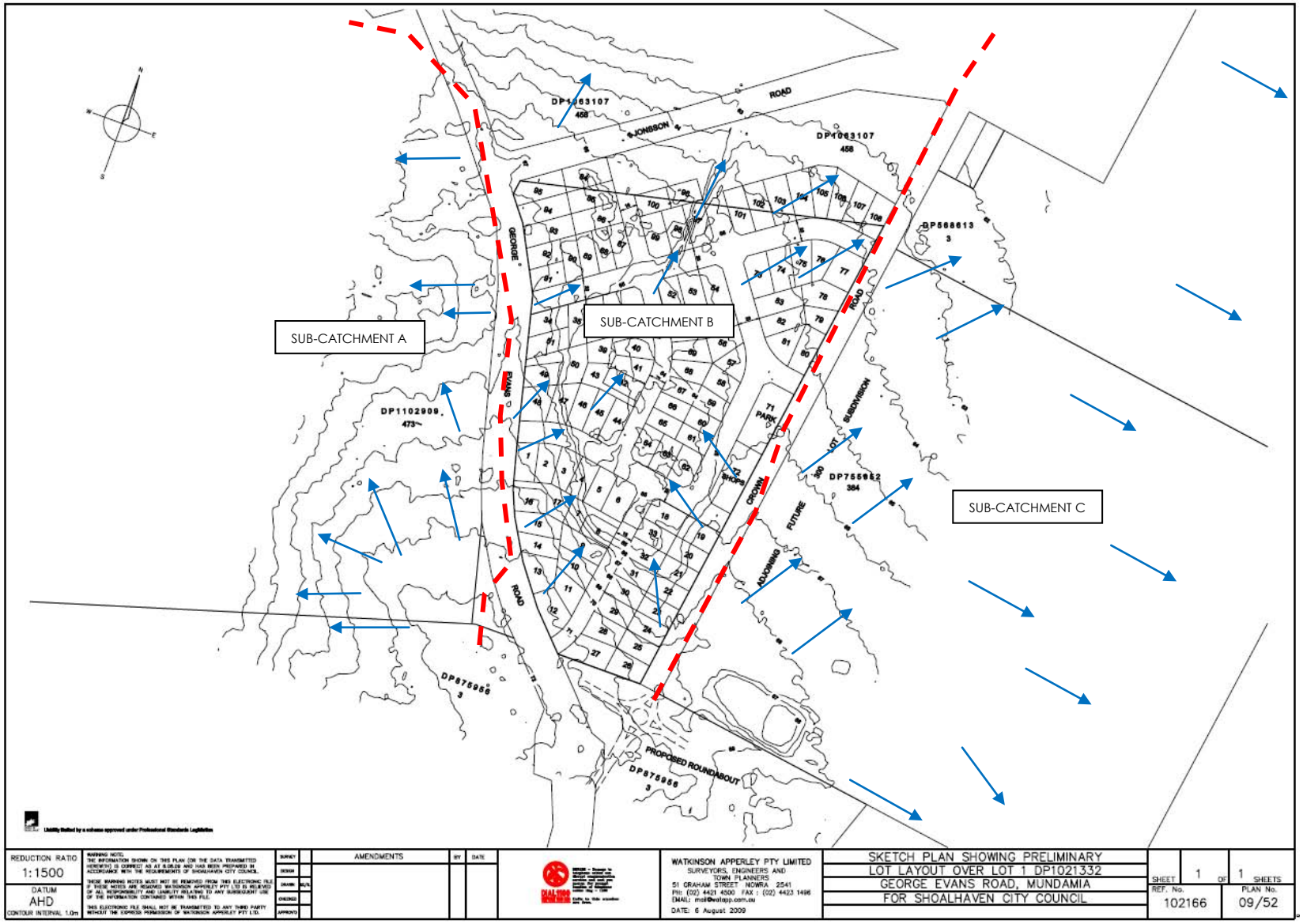

KEY:
INDICATIVE SURFACE WATER AND GROUNDWATER FLOW DIRECTIONS

INDICATIVE SUB-CATCHMENT BOUNDARY

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	NA – SEE PLAN	**INDICATIVE SUB-CATCHMENTS**	Drawing No: **FIGURE 2**
Approved:	NA – SEE PLAN		
Date:	NA – SEE PLAN		
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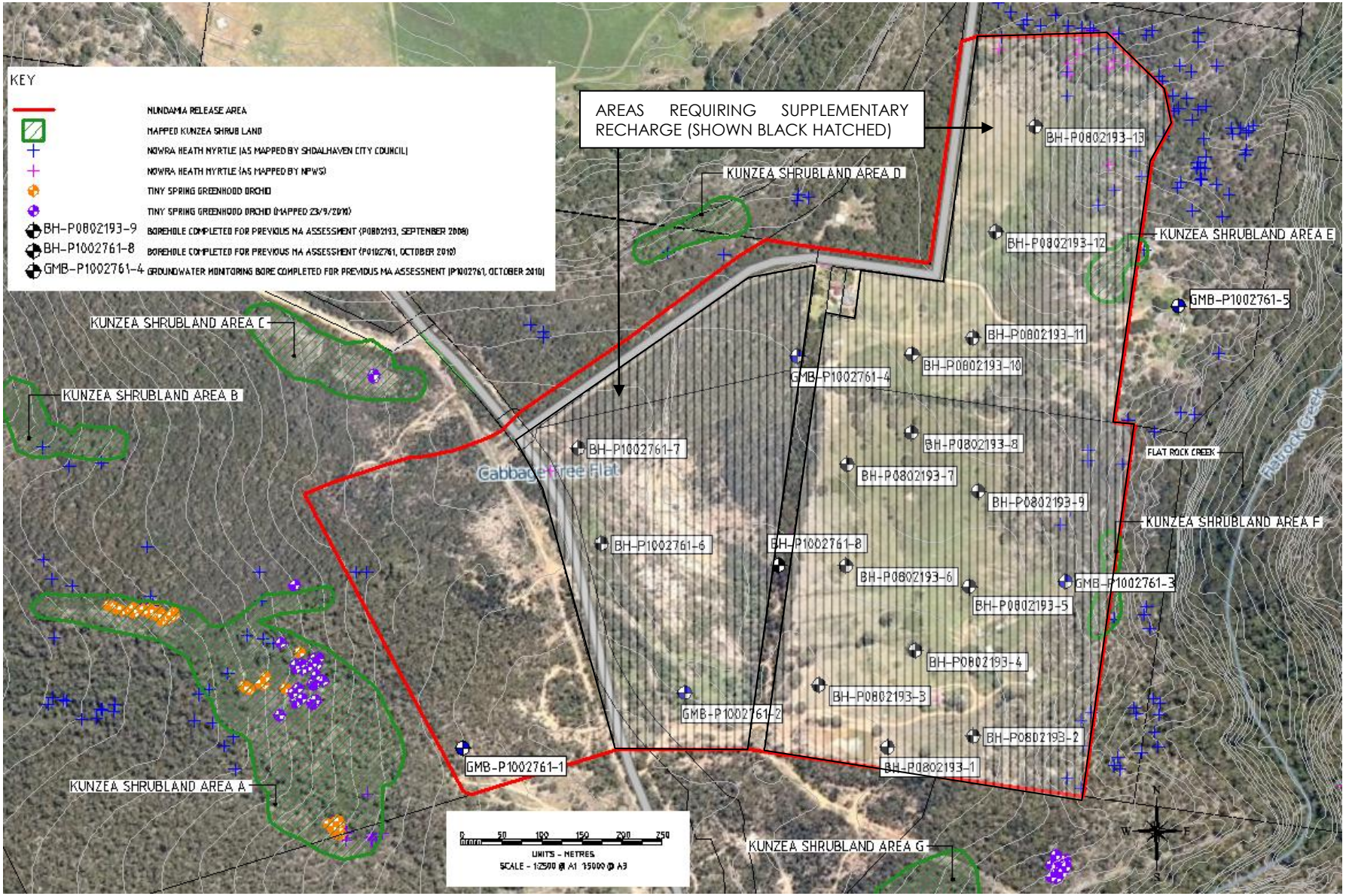

Notes:

1. Borehole locations indicative only.
2. GMB locations surveyed.

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**BOREHOLE AND GMB LOCATIONS**	Drawing No: **FIGURE 3**
Approved:	AN		
Date:	15.02.2011		
Scale:	APPROX 1: 7,080		Job No: P1002761

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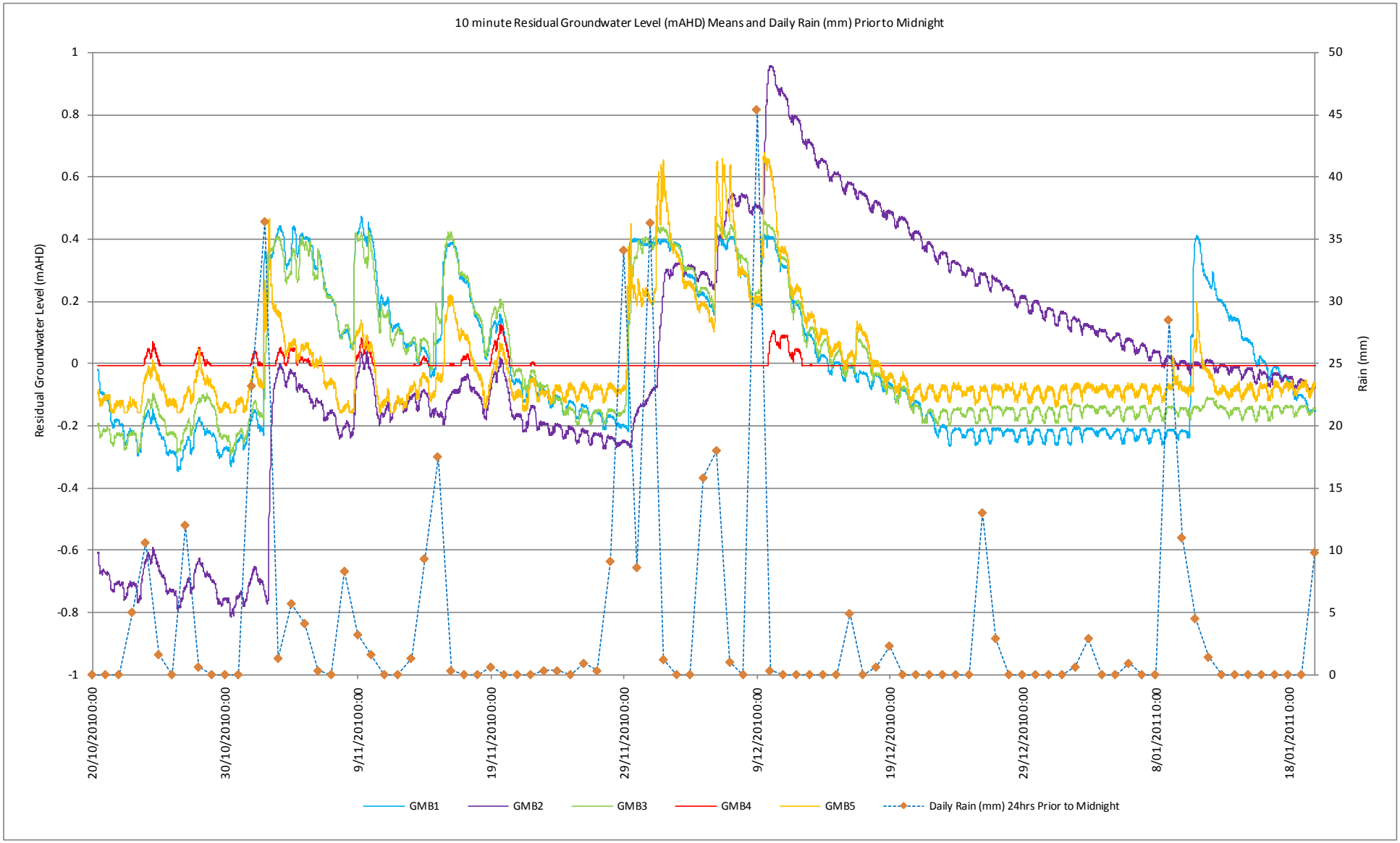

Notes:

1. Residual mean = observed level – mean GMB level over monitoring period. This was done to normalise data.

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**RESIDUAL MEAN GROUNDWATER LEVELS AND SITE RAIN**	Drawing No: **FIGURE 4**
Approved:	AN		
Date:	15.02.2011		
Scale:	NA		Job No: P1002761

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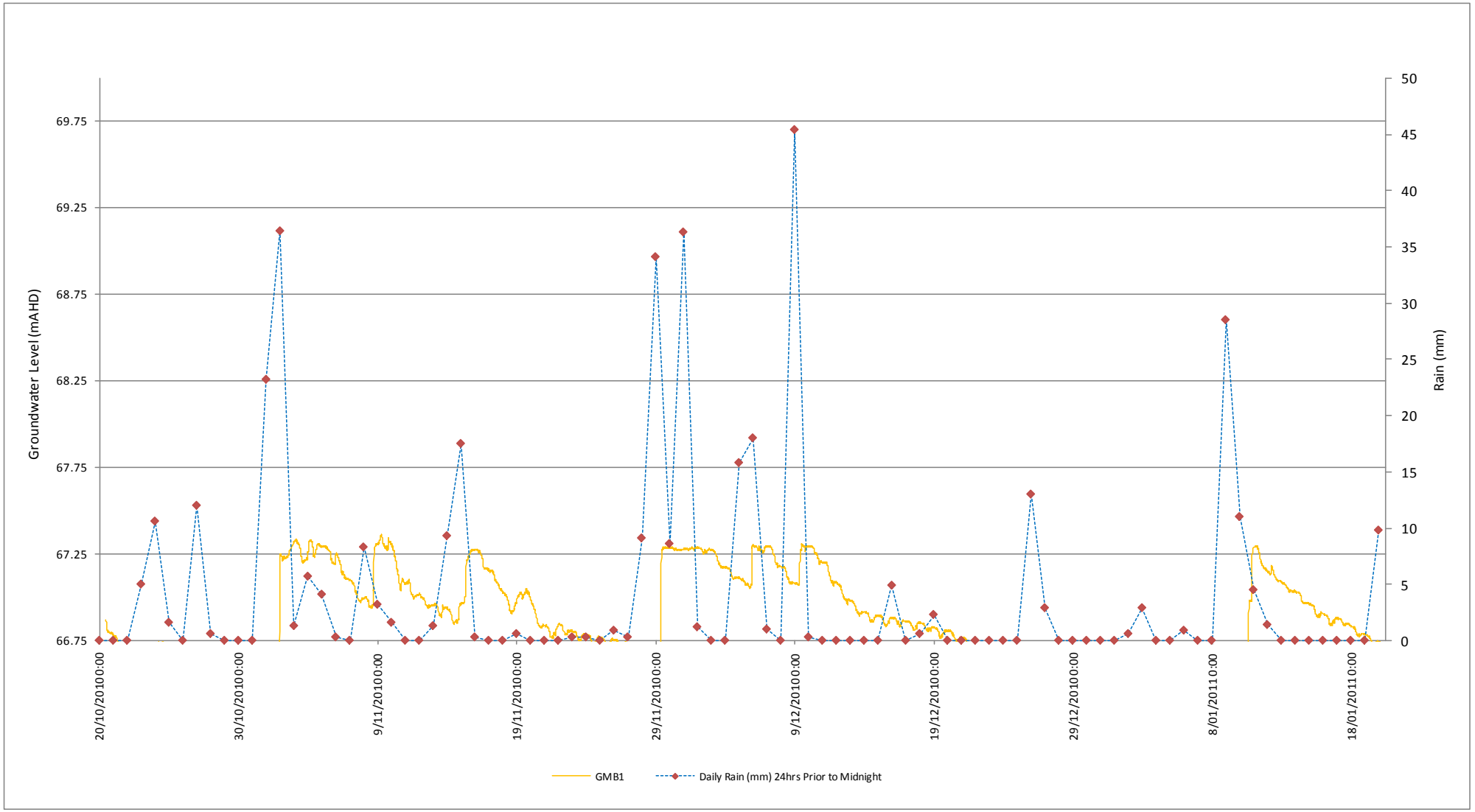

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Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
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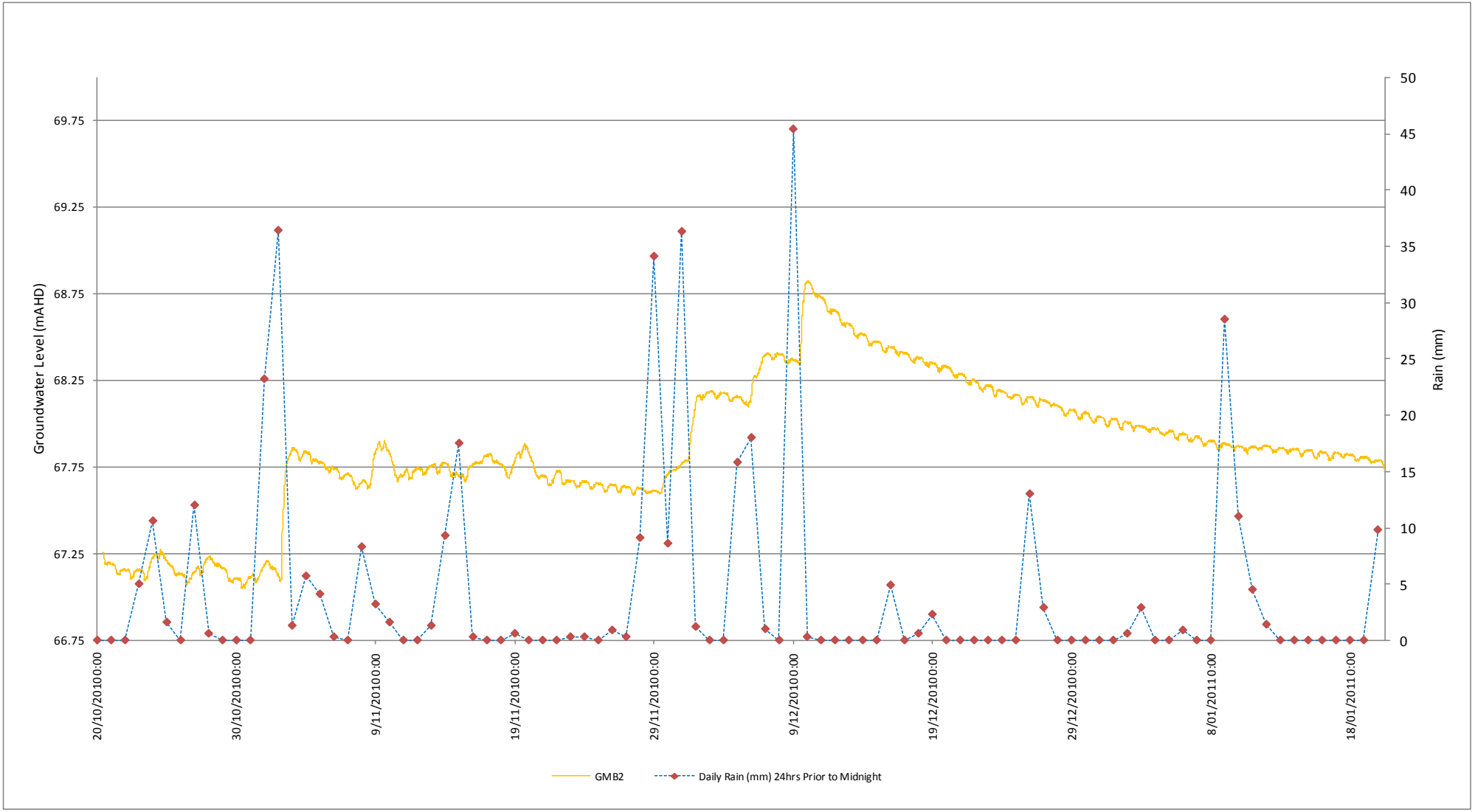
Approved:	AN		
Date:	15.02.2011		
Scale:	NA		Job No: P1002761



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**GMB2 CONTINUOUS GROUNDWATER LEVEL AND RAIN**	Drawing No: **FIGURE 6**
Approved:	AN		
Date:	15.02.2011		
Scale:	NA		Job No: P1002761

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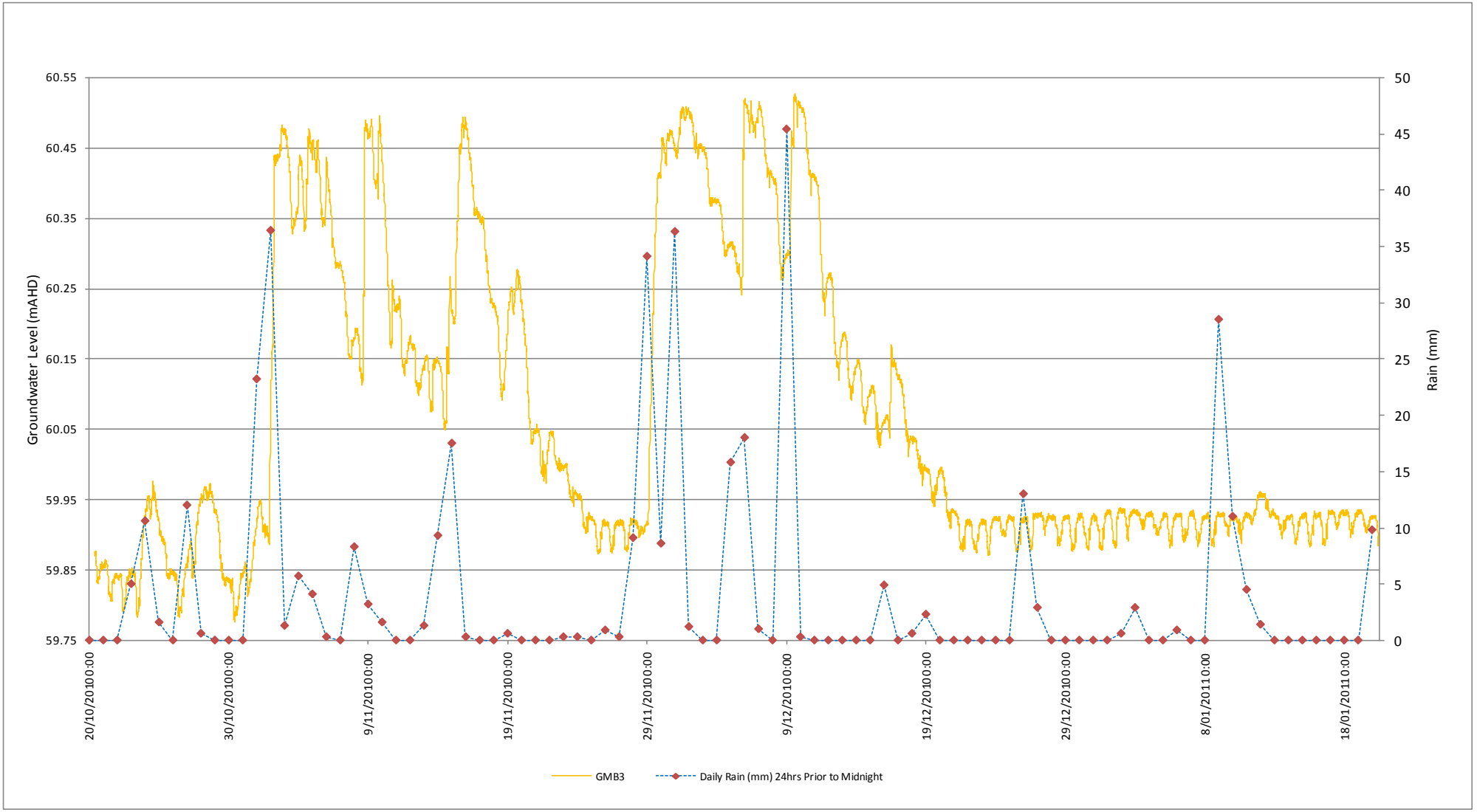
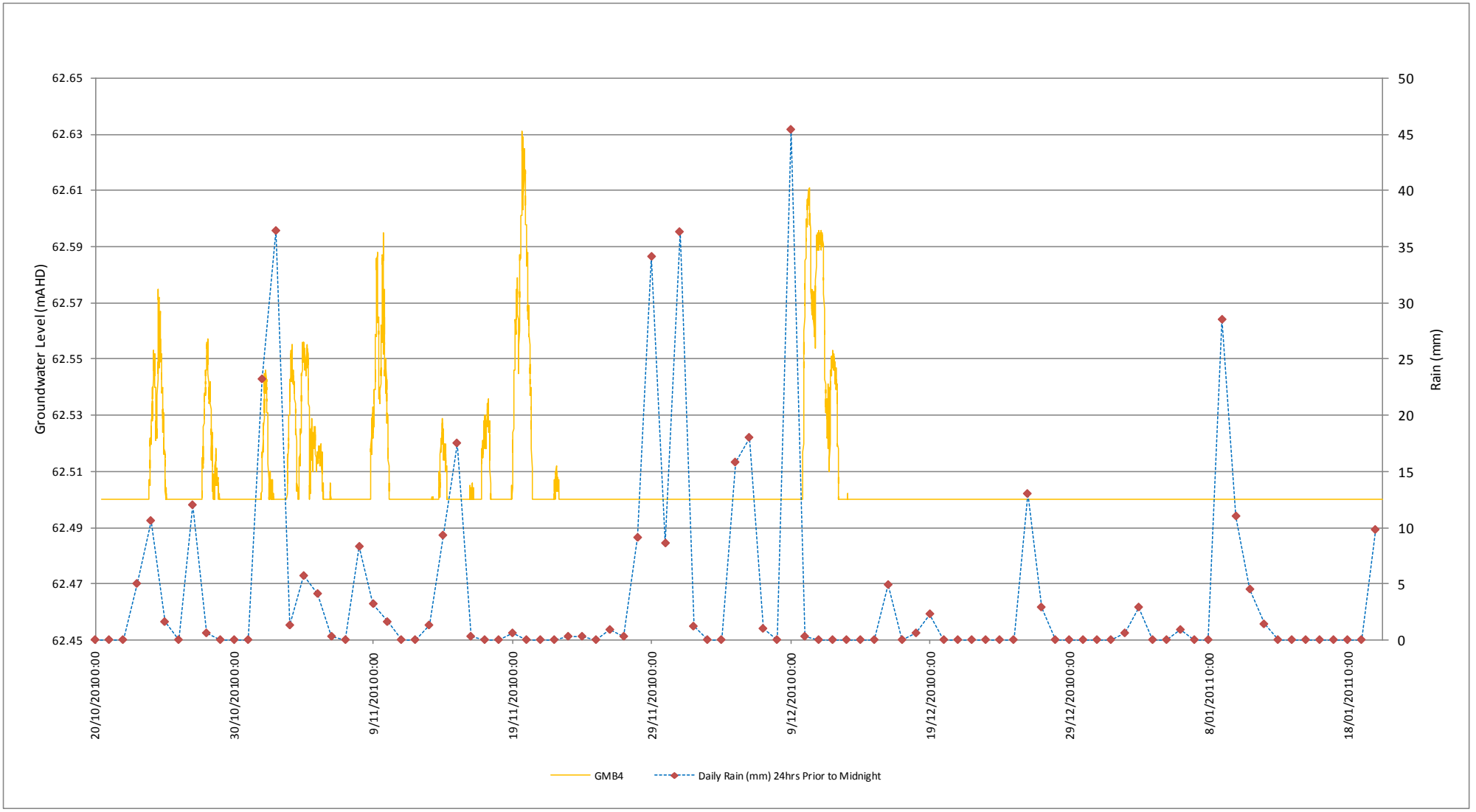
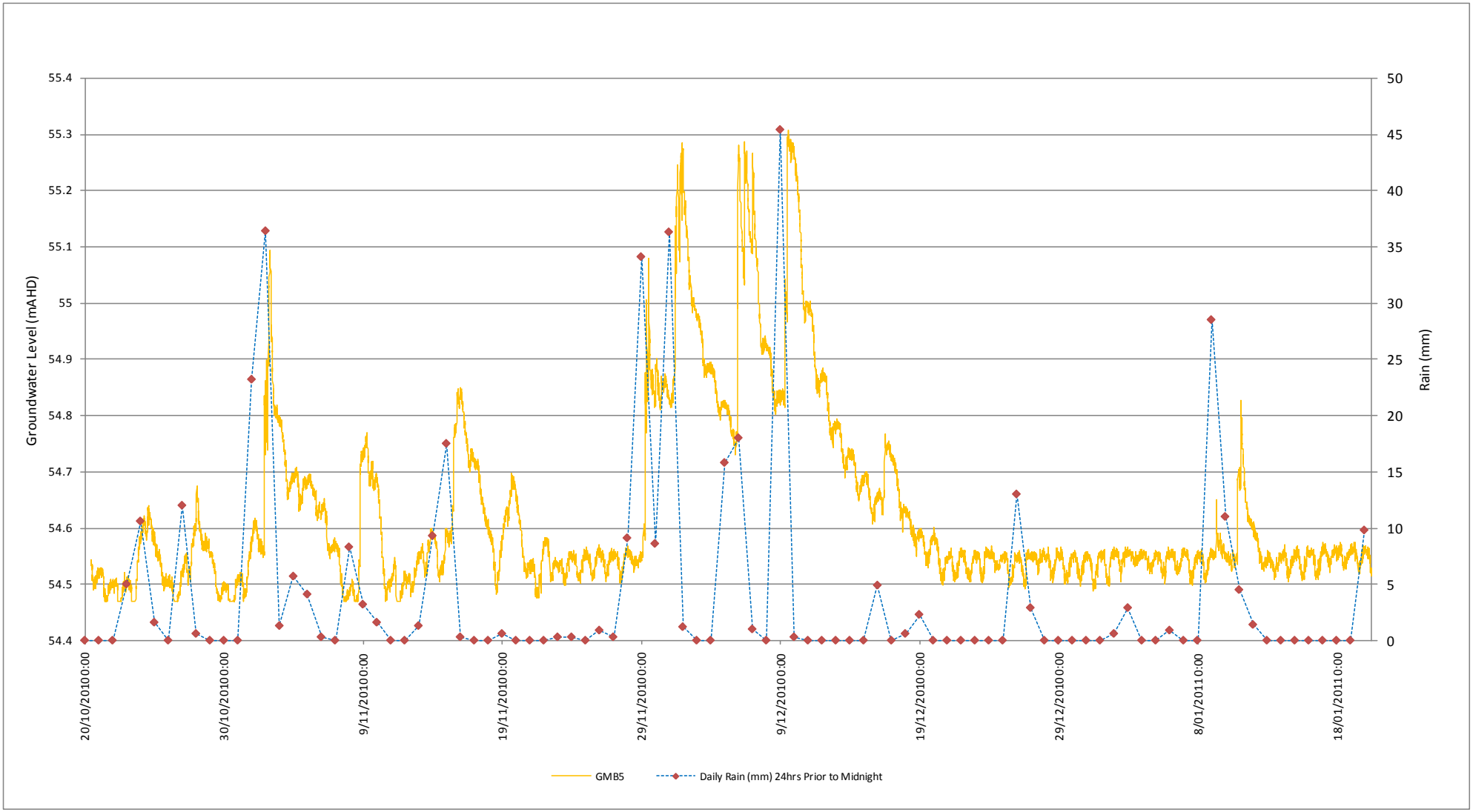


Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**GMB3 CONTINUOUS GROUNDWATER LEVEL AND RAIN**	Drawing No: **FIGURE 7**
Approved:	AN		
Date:	15.02.2011		
Scale:	NA		Job No: P1002761



martens

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**GMB4 CONTINUOUS GROUNDWATER LEVEL AND RAIN**	Drawing No: **FIGURE 8**
Approved:	AN		
Date:	15.02.2011		
Scale:	NA		Job No: P1002761



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**GMB5 CONTINUOUS GROUNDWATER LEVEL AND RAIN**	Drawing No: **FIGURE 9**
Approved:	AN		
Date:	15.02.2011		
Scale:	NA		Job No: P1002761

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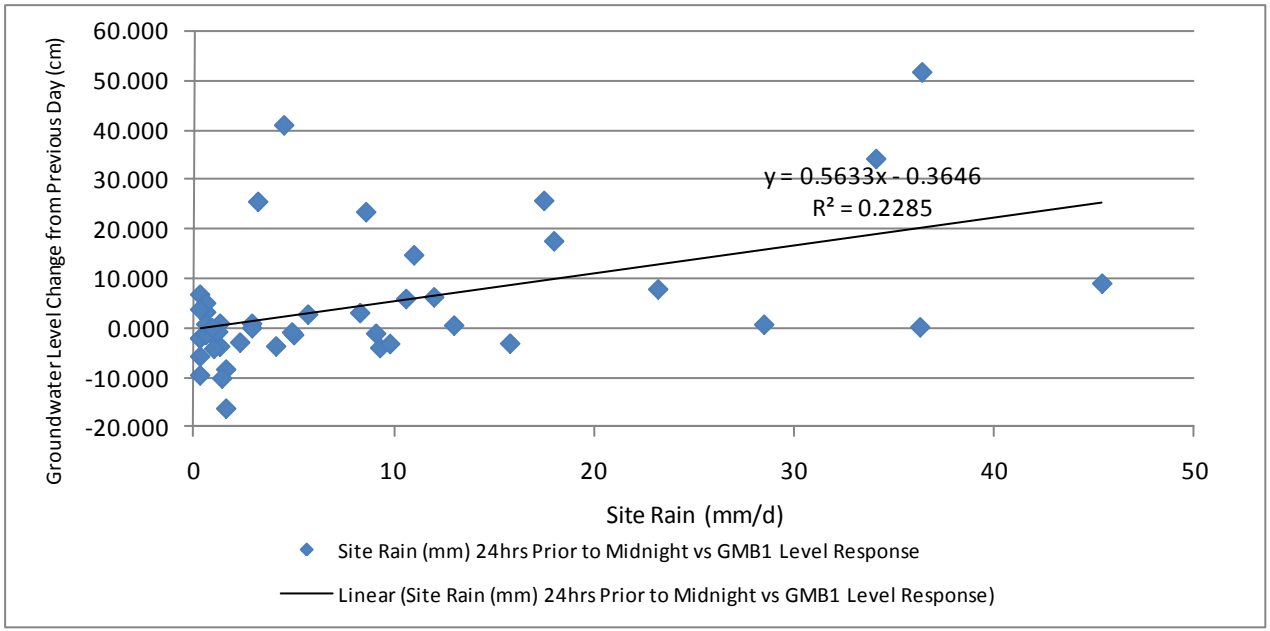
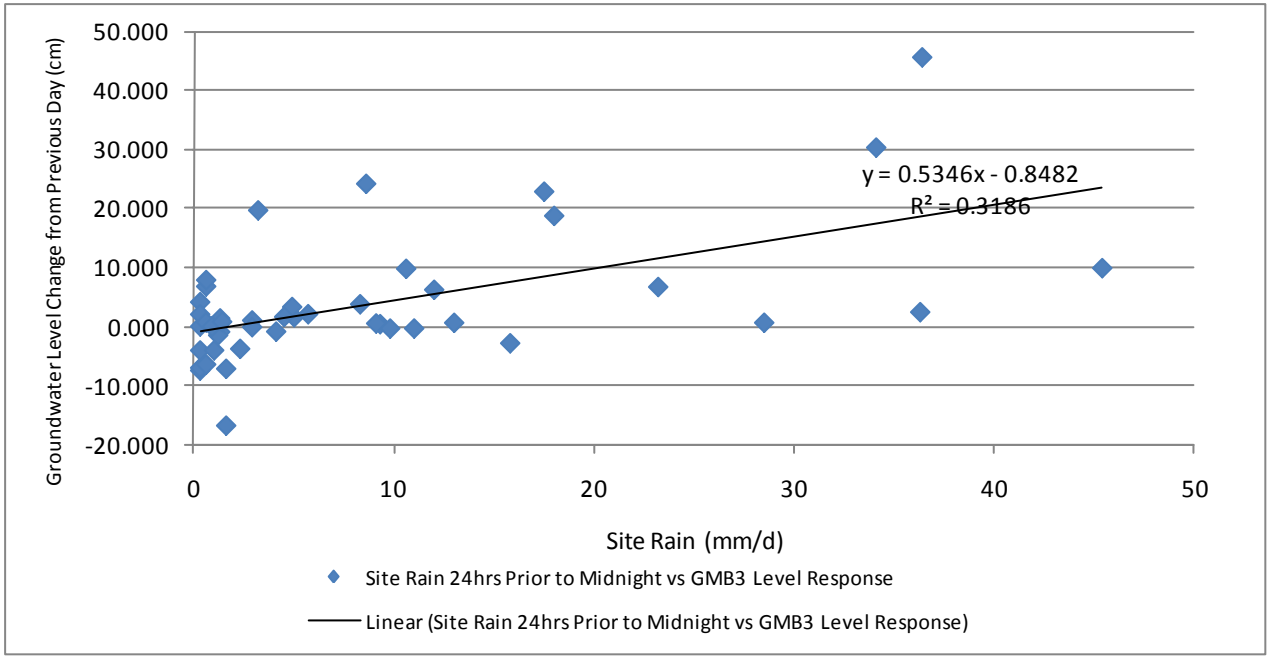


Notes:

1. Line formula indicates that a groundwater response occurs once daily rainfall exceeds 0.65 mm.

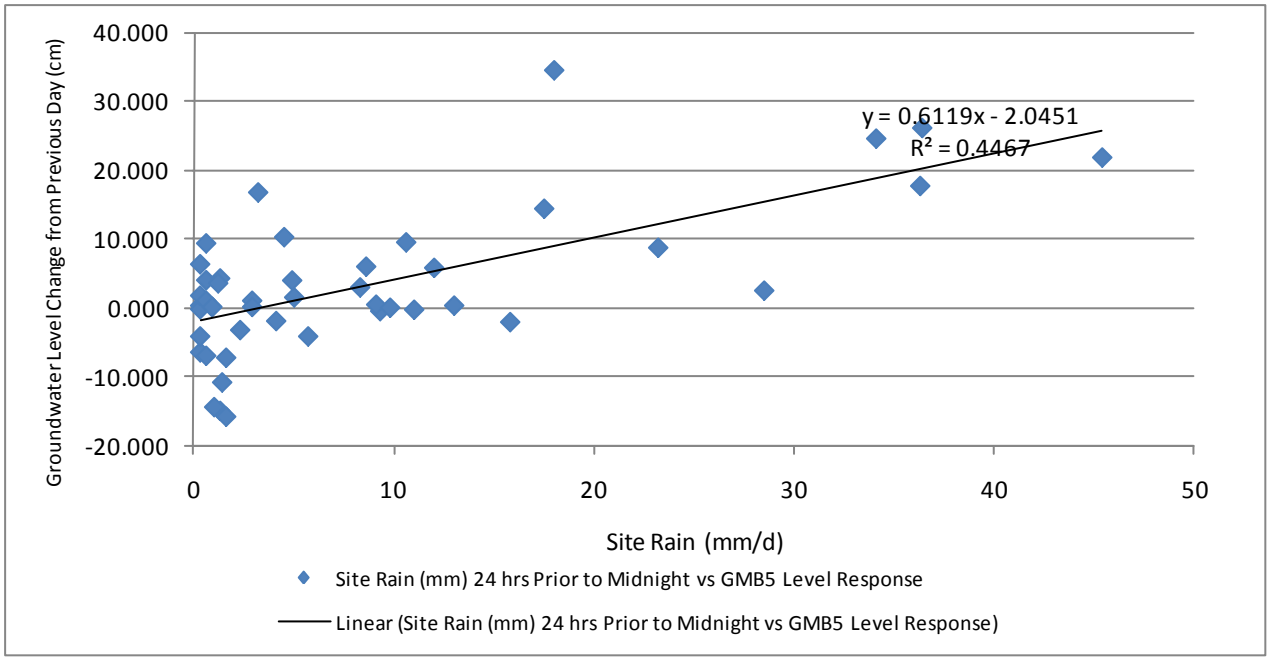
Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**GMB1 GROUNDWATER LEVEL RESPONSE VS DAILY RAINFALL**	Drawing No: **FIGURE 10**
Approved:	AN		
Date:	15.02.2011		
Scale:	NA		Job No: P1002761



Notes:

1. Line formula indicates that a groundwater response occurs once daily rainfall exceeds 1.59 mm.

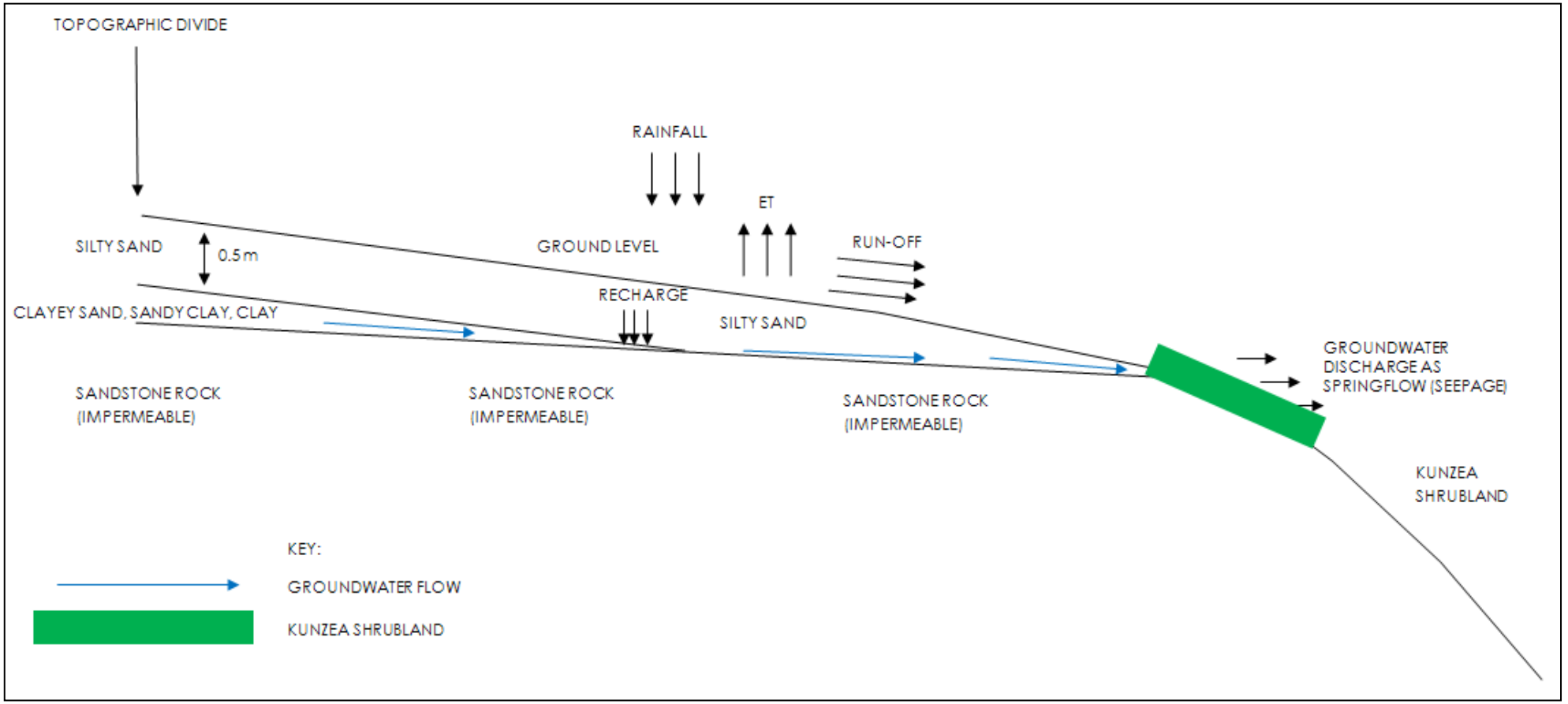
Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**GMB3 GROUNDWATER LEVEL RESPONSE VS DAILY RAINFALL**	Drawing No: **FIGURE 11**
Approved:	AN		
Date:	15.02.2011		
Scale:	NA		Job No: P1002761



Notes:

1. Line formula indicates that a groundwater response occurs once daily rainfall exceeds 3.34 mm.

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**GMB5 GROUNDWATER LEVEL RESPONSE VS DAILY RAINFALL**	Drawing No: **FIGURE 12**
Approved:	AN		
Date:	15.02.2011		
Scale:	NA		Job No: P1002761



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**CONCEPTUAL HYDROGEOLOGICAL MODEL**	Drawing No: **FIGURE 13**
Approved:	AN		
Date:	15.02.2011		
Scale:	NA		Job No: P1002761

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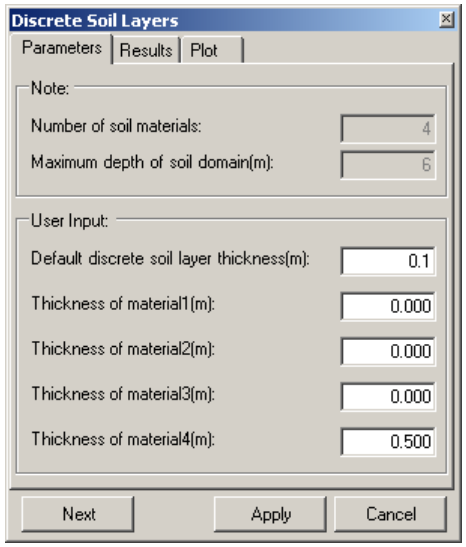

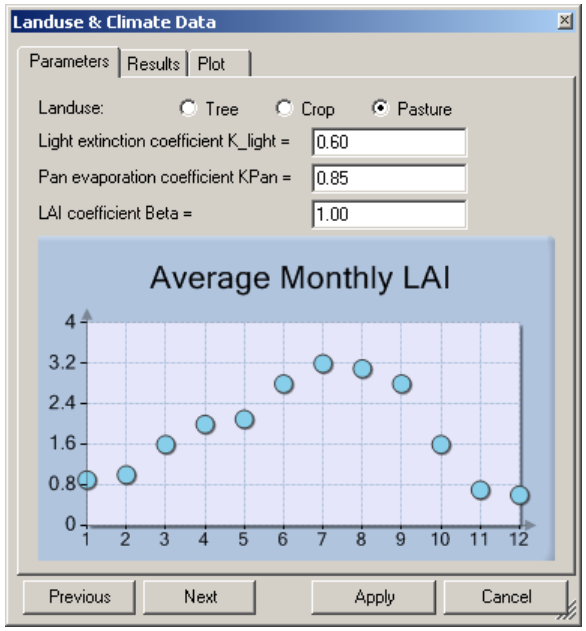

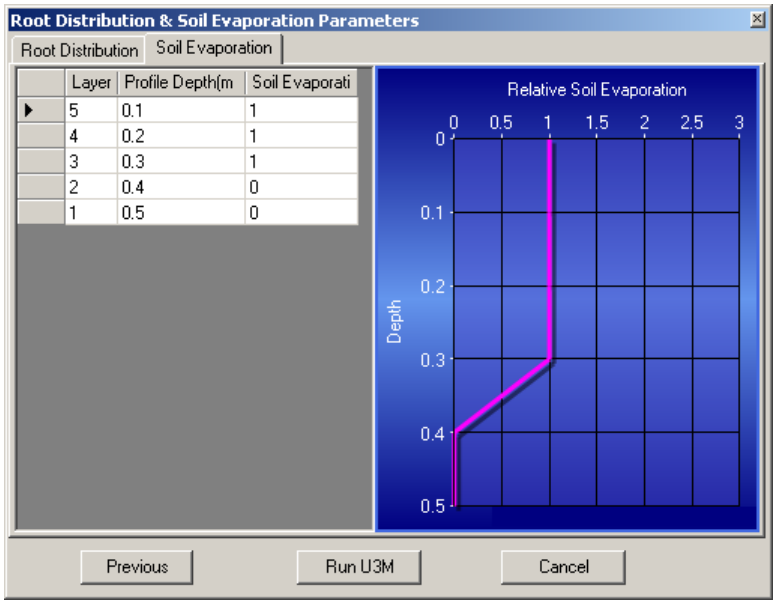

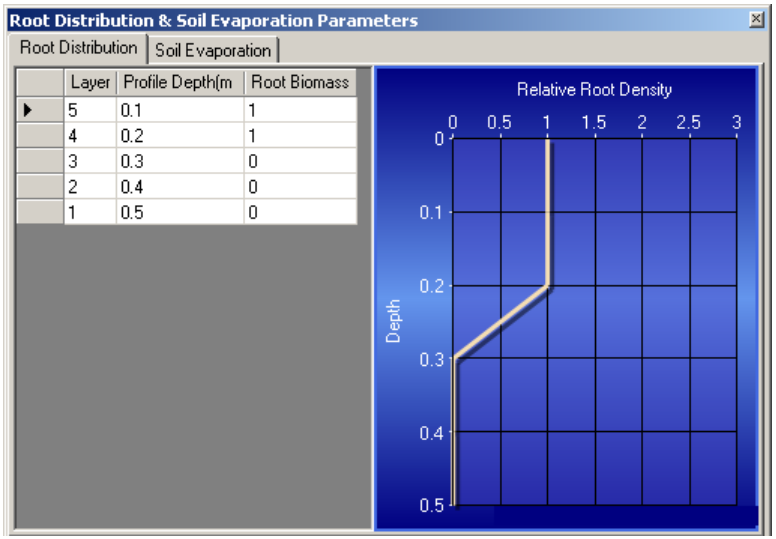

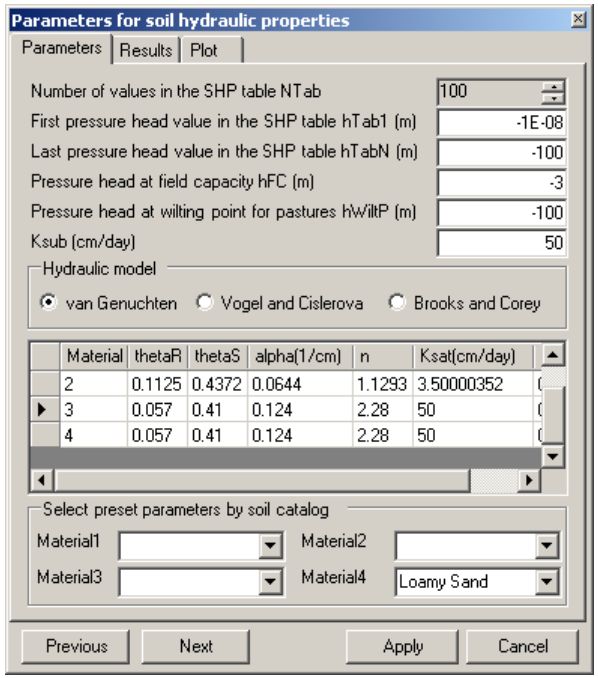

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**CLASS MODEL INPUTS**	Drawing No: **FIGURE 14**
Approved:	AN		
Date:	18.02.2011		
Scale:	NA		Job No: P1002761

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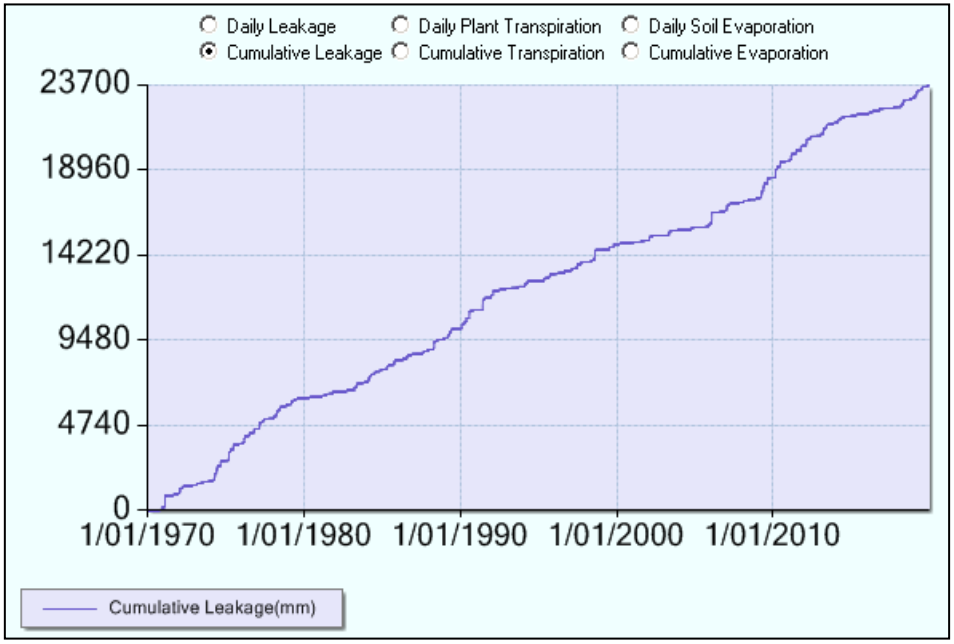

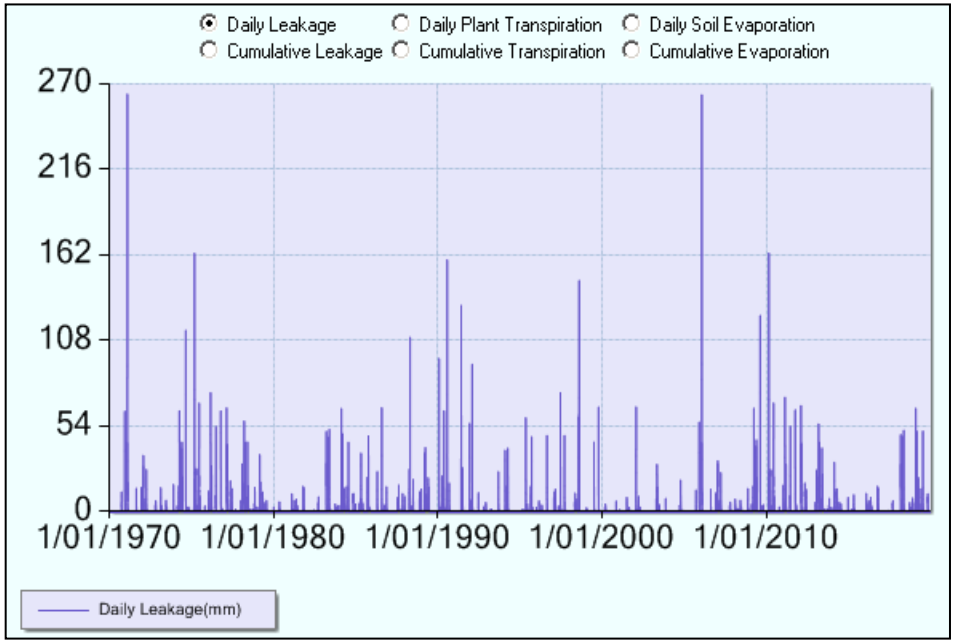

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	BR	**CLASS MODEL OUTPUT PLOTS**	Drawing No: **FIGURE 15**
Approved:	AN		
Date:	18.02.2011		
Scale:	NA		Job No: P1002761

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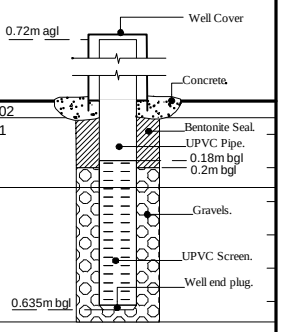
8 Attachment B – Borehole logs

CLIENT	**Shoalhaven City Council**	**COMMENCED**	18.10.10	**COMPLETED**	18.10.10	**REF**	**BH1**
PROJECT	**Hydrogeological Investigation**	**LOGGED**	BR	**CHECKED**	AN	**Sheet**	**1 of 1**
SITE	**Aboriginal Land Council (Mundamia)**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1002761
EQUIPMENT	Auger	**EASTING**	-	**RL SURFACE**	67.27m AHD		
EXCAVATION DIMENSIONS	Ø90mm X 0.66m depth	**NORTHING**	-	**ASPECT**	West	**SLOPE**	4%

EXCAVATION DATA / MATERIAL DATA / SAMPLING & TESTING

METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA (Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.)	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	WATER WELL DETAILS
A	Nil	N	M	0.05			SM	SILTY SAND - Brown, shallow veneer Immediately underneath moss.			A	0.02	2761/1/0.02
A	Nil	N	M	0.28			SW	SAND - Light brown tending to light grey to white with depth, coarse grained, sandstone quartz gravels (2-4mm, 5%).			A	0.1	2761/1/ 0.1
A	Nil	N	M	0.66			SW	SLIGHTLY WEATHERED SANDSTONE.					
								Borehole terminated at 0.66m on slightly weathered sandstone.					



1.0 / 2.0 / 3.0 / 4.0 / 4.5

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Hornsby, NSW 2077 Australia
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mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

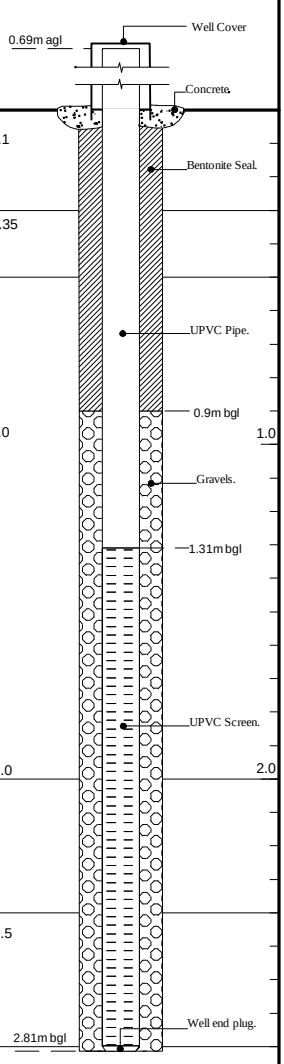
Quality Sheet No. 4

CLIENT	**Shoalhaven City Council**	**COMMENCED**	18.10.10	**COMPLETED**	18.10.10	**REF**	**BH2**
PROJECT	**Hydrogeological Investigation**	**LOGGED**	BR	**CHECKED**	AN	**Sheet**	**1 of 1**
SITE	**Shoalhaven City Council (Mundamia)**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1002761
EQUIPMENT	Auger	**EASTING**	-	**RL SURFACE**	69.62m AHD		
EXCAVATION DIMENSIONS	Ø90mm X 2.8m depth	**NORTHING**	-	**ASPECT**	North East	**SLOPE**	5-10%

EXCAVATION DATA / MATERIAL DATA / SAMPLING & TESTING

METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	
A	Nil	N	D	0.3			OL	ORGANIC SILT - Dark brown, possibly fill?			A	0.1	2761/2/0.1
A	Nil	N	D	0.5			CL	SILTY CLAY - Dark brown, ironstone gravels (10-20mm, 2%), possibly fill?			A	0.35	2761/2/0.35
A	Nil	N	D	1.0			SM	SILTY SAND - Dark brown, very fine grained, gravels (10-15mm, 30%), wood pieces (tree root?), possibly fill?			A	1.0	2761/2/1.0
				2.0							A	2.0	2761/2/2.0
A	Nil	N	M	2.4			OH	ORGANIC SILT - Dark brown, plastic, wood content, high organic content, very moist, possibly fill?					
A	Nil	N	M	2.8			CL	CLAY - Light grey to white, very high sand content, coarse grained, very moist, possibly extremely weathered sandstone.			A	2.5	2761/2/2.5
				3.0				Borehole terminated at 2.8m on extremely weathered sandstone.					
				4.0									
				4.5									

WATER WELL DETAILS



EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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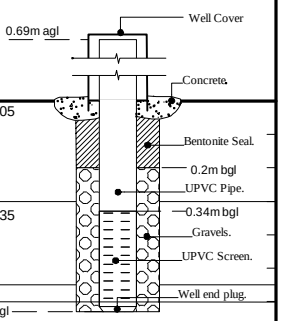
mail@martens.com.au WEB: http://www.martens.com.au

Engineering Log - Borehole

CLIENT	**Malbec**	**COMMENCED**	18.10.10	**COMPLETED**	18.10.10	**REF**	**BH3**
PROJECT	**Hydrogeological Investigation**	**LOGGED**	BR	**CHECKED**	AN	**Sheet**	**1 of 1**
SITE	**Mundamia (Lot 384, DP755952)**	**GEOLOGY**	Sandstone	**VEGETATION**	Moss/grass	**PROJECT NO.**	P1002761
EQUIPMENT	Auger	**EASTING**	-	**RL SURFACE**	60.50m AHD		
EXCAVATION DIMENSIONS	Ø90mm X 0.6m depth	**NORTHING**	-	**ASPECT**	East	**SLOPE**	Approx 10%

EXCAVATION DATA / MATERIAL DATA / SAMPLING & TESTING

METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA (Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.)	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	WATER WELL DETAILS
A	Nil	N	M	0.3			SM	ORGANIC SILTY SAND - Dark brown.			A	0.05	2761/3/0.05
A	Nil	N	M	0.55			SM	ORGANIC SILTY SAND - Light brown, moisture increasing with depth.			A	0.35	2761/3/0.35
A	Nil	N	M	0.6			EW	EXTREMELY WEATHERED SANDSTONE - Quartz gravels (2-5mm, 5%), very easy to drill through.					
				1.0				Borehole terminated at 0.6m on moderately weathered sandstone.					
				2.0									
				3.0									
				4.0									
				4.5									



EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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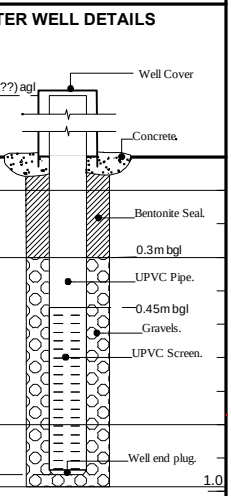
Engineering Log - Borehole

Quality Sheet No. 4

CLIENT	**Shoalhaven City Council**	**COMMENCED**	19.10.10	**COMPLETED**	19.10.10	**REF**	**BH4**
PROJECT	**Hydrogeological Investigation**	**LOGGED**	BR	**CHECKED**	AN	**Sheet**	**1 of 1**
SITE	**Shoalhaven City Council (Mundamia)**	**GEOLOGY**	Sandstone	**VEGETATION**	Shrubland	**PROJECT NO.**	P1002761
EQUIPMENT	Hand Auger	**EASTING**	-	**RL SURFACE**	63.50m AHD		
EXCAVATION DIMENSIONS	Ø90mm X 0.98m depth	**NORTHING**	-	**ASPECT**	North-North West	**SLOPE**	0-2%

EXCAVATION DATA						MATERIAL DATA				SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	WATER WELL DETAILS
HA	Nil	N	D	0.1			SM	SILTY SAND - Dark brown.			A	0.05	2761/4/0.05
HA	Nil	N	D	0.3			SM	SILTY SAND - Light brown to yellow.			A	0.2	2761/4/0.2
HA	Nil	N	D	0.8			GM	SILTY GRAVEL - Light brown to yellow silt, ironstone gravels (10-40mm, 85%).			A	0.4	2761/4/0.4
HA	Nil	N	D	0.98			EW	EXTREMELY WEATHERED SANDSTONE - White to grey.					
				2.0				Borehole terminated at 0.98m on extremely weathered sandstone.					
				3.0									
				4.0									
				4.5									



EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

Quality Sheet No. 4

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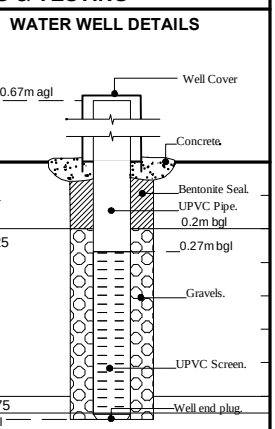
Engineering Log - Borehole

CLIENT	**Malbec**	**COMMENCED**	18.10.10	**COMPLETED**	18.10.10	**REF**	**BH5**
PROJECT	**Hydrogeological Investigation**	**LOGGED**	BR	**CHECKED**	AN	**Sheet**	**1 of 1**
SITE	**Mundamia (Lot 3, DP568613)**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1002761
EQUIPMENT	Auger	**EASTING**	-	**RL SURFACE**	55.24m AHD		
EXCAVATION DIMENSIONS	Ø90mm X 0.6m depth	**NORTHING**	-	**ASPECT**	North	**SLOPE**	5%

EXCAVATION DATA						MATERIAL DATA				SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	WATER WELL DETAILS
A	Nil	N	D	0.2			SM	ORGANIC SILTY SAND - Dark brown.			A	0.1	2761/5/0.1
A	Nil	N	M	0.7			SM	ORGANIC SILTY SAND - Light brown, gravels (10-30mm, 10%), slightly moist, moisture increasing with depth.			A	0.25	2761/5/0.25
A	Nil	N	M	0.75			EW	EXTREMELY WEATHERED SANDSTONE - Quartz gravels (2-4mm, 5%), slightly moist.			A	0.75	2761/5/0.75
				1.0				Borehole terminated at 0.75m on extremely weathered sandstone.					
				2.0									
				3.0									
				4.0									
				4.5									



EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

Quality Sheet No. 4

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Engineering Log - Borehole

CLIENT	**Shoalhaven City Council**	**COMMENCED**	19.10.10	**COMPLETED**	19.10.10	**REF**	**BH6**
PROJECT	**Hydrogeological Investigation**	**LOGGED**	BR	**CHECKED**	AN	**Sheet**	**1 of 1**
SITE	**Shoalhaven City Council (Mundamia)**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1002761
EQUIPMENT	Auger	**EASTING**	-	**RL SURFACE**	-		
EXCAVATION DIMENSIONS	Ø90mm X 1.65m depth	**NORTHING**	-	**ASPECT**	North West	**SLOPE**	2%

EXCAVATION DATA						MATERIAL DATA				SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
A	Nil	N	M	0.3			CL	CLAY (POSSIBLY FILL) - Light brown, gravels (4-30mm, 5%), soft.			A	0.1	2761/5/0.1 Sandstone fill observed within 10m of borehole, (bricks and large pieces of concrete 1m x 1m x 2m high, fill).
A	Nil	N	M	0.9			CL	CLAY (POSSIBLY FILL) - Dark brown, gravels (2-4mm, 10%), soft.			A	0.5	2761/5/0.5
A	Nil	N	M	1.0 1.3			CL	CLAY (POSSIBLY FILL) - Light brown, appreciable sand content, moisture increasing at 1.2m, soft, gravels (2-3mm, 5%).			A	1.0	2761/5/1.0 1.0
A	Nil	N	M	1.65			CL	CLAY (POSSIBLY FILL) - Dark brown, orange to yellow mottles, gravels (2-3mm, 5%), soft.					
				2.0 3.0 4.0 4.5				Borehole terminated at 1.65m on slightly weathered sandstone.					2.0 3.0 4.0 4.5

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

Quality Sheet No. 4

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Engineering Log - Borehole

CLIENT	**Shoalhaven City Council**	**COMMENCED**	19.10.10	**COMPLETED**	19.10.10	**REF**	**BH7**
PROJECT	**Hydrogeological Investigation**	**LOGGED**	BR	**CHECKED**	AN	**Sheet**	**1 of 1**
SITE	**Shoalhaven City Council (Mundamia)**	**GEOLOGY**	Sandstone	**VEGETATION**	NA	**PROJECT NO.**	P1002761
EQUIPMENT	Auger	**EASTING**	-	**RL SURFACE**	-		
EXCAVATION DIMENSIONS	Ø90mm X 0.05m depth	**NORTHING**	-	**ASPECT**	West	**SLOPE**	1-2%

EXCAVATION DATA						MATERIAL DATA				SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
A	Nil	N	D	0.02			GP	GRAVELS (5-50mm, 95%) - Remainder made up by coarse to fine sand.					Soil cover natural on large area of about 25-30m Ø as existent of natural tree growth.
A	Nil	N	D	0.05			EW	EXTREMELY WEATHERED SANDSTONE.					
								Borehole terminated at 0.05m on slightly weathered sandstone.					
				1.0								1.0	
				2.0								2.0	
				3.0								3.0	
				4.0								4.0	
				4.5								4.5	

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

martens

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Engineering Log - Borehole

CLIENT	**Shoalhaven City Council**	**COMMENCED**	19.10.10	**COMPLETED**	19.10.10	**REF**	**BH8**
PROJECT	**Hydrogeological Investigation**	**LOGGED**	BR	**CHECKED**	AN	**Sheet**	**1 of 1**
SITE	**Shoalhaven City Council (Mundamia)**	**GEOLOGY**	Sandstone	**VEGETATION**	NA - Casurina pine needles	**PROJECT NO.**	P1002761
EQUIPMENT	Auger	**EASTING**	-	**RL SURFACE**	-		
EXCAVATION DIMENSIONS	Ø90mm X 2.5m depth	**NORTHING**	-	**ASPECT**	North West	**SLOPE**	1-2%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS	
A	Nil	N	D	0.9			SC	CLAYEY SAND - Yellow to orange, low clay content, ironstone gravels (10-15mm, 25%).			A	0.3	2761/5/0.3	
A	Nil	N	D	1.0 1.2			SC	CLAYEY SAND - Reddish brown, low clay content, ironstone gravels (10-15mm, 35%).			A	1.0	2761/5/1.0	1.0
A	Nil	N	D	1.9			CL	CLAY - Reddish brown, gravels (5-10mm, 5%).			A	1.5	2761/5/1.5	
A	Nil	N	D	2.0 2.5			EW	EXTREMELY WEATHERED SANDSTONE – Grading to moderately weathered sandstone with depth (moderately weathered sandstone after about 2.2m).						2.0
				3.0 4.0 4.5				Borehole terminated at 2.5m on moderately weathered sandstone.						3.0 4.0 4.5

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

Quality Sheet No. 4

CLIENT	MALBEC PROPERTIES PTY LTD	**COMMENCED**	9/9/08	**COMPLETED**	9/9/08	**REF**	**BH1**
PROJECT	PRELIMINARY GEOTECHNICAL ASSESSMENT	**LOGGED**	JSF	**CHECKED**	ASN	**Sheet**	1 of 1
SITE	JONSSON ROAD, MUNDAMIA	**GEOLOGY**	SANDSTONE	**VEGETATION**	GRASS	**PROJECT NO.**	2193
EQUIPMENT	4WD MOUNTED PUSH TUBE	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø 50mm x 1400mm depth	**NORTHING**	NA	**ASPECT**	NE	**SLOPE**	< 2 °

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS	
PT	Nil	N	M	0.1			SM	ORGANIC SILTY SAND - Brown, moist, soft, rootlets.			PT	0.05	2193/1/0.05	
PT	Nil	N	M	0.5			SC	CLAYEY SAND - Light brown/ yellow, moist, loose, with clay content increasing with depth.			PT	0.4	2193/1/0.4	
PT	Nil	N	M	1.0			EW	EXTREMELY WEATHERED SANDSTONE Grey, clay with sandstone (ironstone) gravels (orange/ red), stiff, moist.			PT	0.8	2193/1/0.8	1.0
				1.4							PT	1.3	2193/1/1.3	
				2.0				Borehole terminated at 1.4m on extremely weathered sandstone.						2.0
				3.0										3.0
				4.0										4.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	MALBEC PROPERTIES PTY LTD	**COMMENCED**	9/9/08	**COMPLETED**	9/9/08	**REF**	**BH2**
PROJECT	PRELIMINARY GEOTECHNICAL ASSESSMENT	**LOGGED**	JSF	**CHECKED**	ASN	**Sheet**	1 of 1
SITE	JONSSON ROAD, MUNDAMIA	**GEOLOGY**	SANDSTONE	**VEGETATION**	GRASS	**PROJECT NO.**	2193
EQUIPMENT	4WD MOUNTED PUSH TUBE	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø 50mm x 700mm depth	**NORTHING**	NA	**ASPECT**	NE	**SLOPE**	< 2 °

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
PT	Nil	N	M	0.1			SM	ORGANIC SILTY SAND - Brown, moist, soft, rootlets.			PT	0.05	2193/21/0.05
PT	Nil	N	M	0.3			SC	CLAYEY SAND - Light brown/ yellow, moist, loose clay content increasing with depth.			PT	0.2	2193/2/0.2
PT	Nil	N	M	0.55			EW	EXTREMELY WEATHERED SANDSTONE - Wet with slightly weathered gravels.			PT	0.5	2193/2/0.5
PT	Nil	N	M	0.7			EW	EXTREMELY WEATHERED SANDSTONE					
				1.0				Borehole terminated at 0.7m on moderately weathered sandstone.					
				2.0									
				3.0									
				4.0									

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	MALBEC PROPERTIES PTY LTD	**COMMENCED**	9/9/08	**COMPLETED**	9/9/08	**REF**	**BH3**
PROJECT	PRELIMINARY GEOTECHNICAL ASSESSMENT	**LOGGED**	JSF	**CHECKED**	ASN	**Sheet**	1 of 1
SITE	JONSSON ROAD, MUNDAMIA	**GEOLOGY**	SANDSTONE	**VEGETATION**	GRASS	**PROJECT NO.**	2193
EQUIPMENT	4WD MOUNTED PUSH TUBE	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø 50mm x 1350mm depth	**NORTHING**	NA	**ASPECT**	NE	**SLOPE**	< 2 °

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS	
PT	Nil	N	M	0.15			SM	ORGANIC SILTY SAND - Brown, moist, soft, rootlets.			PT	0.1	2193/3/0.1	
PT	Nil	N	M	0.8			SC	CLAYEY SAND - Light brown/ yellow, moist, loose clay content increasing with depth.			PT PT	0.4 0.7	2193/3/0.4 2193/3/0.7	
PT	Nil	N	M	1.0 1.1			CL	SANDY CLAY - Light brown, with sandstone gravels moist, soft.			PT	1.0	2193/3/1.0	1.0
PT	Nil	N	M	1.35			EW	EXTREMELY WEATHERED SANDSTONE Grey, clay with sandstone gravels (orange/ red), stiff, moist.						
								Borehole terminated at 1.35m on extremely weathered sandstone.						
				2.0										2.0
				3.0										3.0
				4.0										4.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	MALBEC PROPERTIES PTY LTD	**COMMENCED**	9/9/08	**COMPLETED**	9/9/08	**REF**	**BH4**
PROJECT	PRELIMINARY GEOTECHNICAL ASSESSMENT	**LOGGED**	JSF	**CHECKED**	ASN	**Sheet**	1 of 1
SITE	JONSSON ROAD, MUNDAMIA	**GEOLOGY**	SANDSTONE	**VEGETATION**	GRASS	**PROJECT NO.**	2193
EQUIPMENT	4WD MOUNTED PUSH TUBE	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø 50mm x 1300mm depth	**NORTHING**	NA	**ASPECT**	NE	**SLOPE**	< 2 °

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS	
PT	Nil	N	M	0.15			SM	ORGANIC SILTY SAND - Brown, moist, soft, rootlets.			PT	0.1	2193/4/0.1	
PT	Nil	N	M	0.45			SC	CLAYEY SAND - Light brown/ yellow, moist, loose clay content increasing with depth.			PT	0.4	2193/4/0.4	
PT	Nil	0.6 ▽ Y	W	1.0			CL	SANDY CLAY - Grey, wet, soft, some sandstone gravels at 0.9 - 1.1m.			PT	0.9	Ground water at 0.6m. 2193/4/0.9	1.0
				1.3				Borehole terminated at 1.3m on sandy clay.						
				2.0										2.0
				3.0										3.0
				4.0										4.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
▽ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	MALBEC PROPERTIES PTY LTD	**COMMENCED**	9/9/08	**COMPLETED**	9/9/08	**REF**	**BH5**
PROJECT	PRELIMINARY GEOTECHNICAL ASSESSMENT	**LOGGED**	JSF	**CHECKED**	ASN	**Sheet**	1 of 1
SITE	JONSSON ROAD, MUNDAMIA	**GEOLOGY**	SANDSTONE	**VEGETATION**	GRASS	**PROJECT NO.**	2193
EQUIPMENT	4WD MOUNTED PUSH TUBE	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø 50mm x 1400mm depth	**NORTHING**	NA	**ASPECT**	NE	**SLOPE**	< 2 °

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS	
PT	Nil	N	M	0.15			SM	ORGANIC SILTY SAND - Brown, moist, soft, rootlets.			PT	0.1	2193/5/0.1	
PT	Nil	0.3 ▽ Y	M	0.55			SC	CLAYEY SAND - Orange, moist(wet at 0.3m), loose with minor sandstone gravels.			PT	0.4	Ground water at 0.3m. 2193/5/0.4	
PT	Nil	Y	W	0.8			HW	HIGHLY WEATHERED SANDSTONE						
PT	Nil	Y	W	1.0 1.4			SC	CLAYEY SAND - Grey,wet, loose, with minor sandstone gravels at 1.2m.			PT	1.2	2193/5/1.2	1.0
				2.0 3.0 4.0				Borehole terminated at 1.4m on clayey sand.						2.0 3.0 4.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
▽ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	MALBEC PROPERTIES PTY LTD	**COMMENCED**	9/9/08	**COMPLETED**	9/9/08	**REF**	**BH6**
PROJECT	PRELIMINARY GEOTECHNICAL ASSESSMENT	**LOGGED**	JSF	**CHECKED**	ASN	**Sheet**	1 of 1
SITE	JONSSON ROAD, MUNDAMIA	**GEOLOGY**	SANDSTONE	**VEGETATION**	GRASS	**PROJECT NO.**	2193
EQUIPMENT	4WD MOUNTED PUSH TUBE	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø 50mm x 1200mm depth	**NORTHING**	NA	**ASPECT**	NE	**SLOPE**	< 2 °

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
PT	Nil	N	M	0.1			SM	ORGANIC SILTY SAND - Brown, moist, soft, rootlets.			PT	0.05	2193/6/0.05
PT	Nil	N	M	0.7			CS	CLAYEY / SILTY SAND - Light brown, soft, moist.			PT	0.5	2193/6/0.5
PT	Nil	N	M	1.0 1.2			CL	SANDY CLAY - Grey, wet, soft, some sandstone gravels at 0.9 - 1.1m.					1.0
				2.0				Borehole terminated at 1.2m on sandy clay.					2.0
				3.0									3.0
				4.0									4.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	MALBEC PROPERTIES PTY LTD	**COMMENCED**	9/9/08	**COMPLETED**	9/9/08	**REF**	**BH7**
PROJECT	PRELIMINARY GEOTECHNICAL ASSESSMENT	**LOGGED**	JSF	**CHECKED**	ASN	**Sheet**	1 of 1
SITE	JONSSON ROAD, MUNDAMIA	**GEOLOGY**	SANDSTONE	**VEGETATION**	GRASS	**PROJECT NO.**	2193
EQUIPMENT	4WD MOUNTED PUSH TUBE	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø 50mm x 1200mm depth	**NORTHING**	NA	**ASPECT**	NE	**SLOPE**	< 2 °

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS	
PT	Nil	N	M	0.1			SM	ORGANIC SILTY SAND - Brown, moist, soft, rootlets.			PT	0.05	2193/7/0.05	
PT	Nil	N	M	0.6			SC	CLAYEY SAND - Light brown/ yellow, moist, loose clay content increasing with depth.			PT	0.4	2193/7/0.4	
PT	Nil	N	M	1.0 1.2			RS - EW	EXTREMELY WEATHERED SANDSTONE Grey, clay like properties with sandstone gravels (orange/ red), stiff, moist.			PT	1.0	2193/7/1.0	1.0
				2.0				Borehole terminated at 1.2m on extremely to moderately weathered sandstone.						2.0
				3.0										3.0
				4.0										4.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	MALBEC PROPERTIES PTY LTD	**COMMENCED**	9/9/08	**COMPLETED**	9/9/08	**REF**	**BH8**
PROJECT	PRELIMINARY GEOTECHNICAL ASSESSMENT	**LOGGED**	JSF	**CHECKED**	ASN	**Sheet**	1 of 1
SITE	JONSSON ROAD, MUNDAMIA	**GEOLOGY**	SANDSTONE	**VEGETATION**	GRASS	**PROJECT NO.**	2193
EQUIPMENT	4WD MOUNTED PUSH TUBE	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø 50mm x 1200mm depth	**NORTHING**	NA	**ASPECT**	NE	**SLOPE**	< 2 °

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS	
PT	Nil	N	M	0.15			SP	ORGANIC SILTY SAND - Brown, grey, moist, soft.			PT	0.1	2193/8/0.1	
PT	Nil	N	M	0.5			ML	CLAYEY SILT - Orange/ brown, moist, soft.			PT	0.3	2193/8/0.3	
PT	Nil	N	M	1.0			CL	CLAY - Grey, moist, firm, plastic.			PT	0.7	2193/8/0.7	1.0
				1.2							PT	1.1	2193/8/1.1	
								Borehole terminated at 1.2m on clay.						
				2.0										2.0
				3.0										3.0
				4.0										4.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	MALBEC PROPERTIES PTY LTD	**COMMENCED**	9/9/08	**COMPLETED**	9/9/08	**REF**	**BH9**
PROJECT	PRELIMINARY GEOTECHNICAL ASSESSMENT	**LOGGED**	JSF	**CHECKED**	ASN	**Sheet**	1 of 1
SITE	JONSSON ROAD, MUNDAMIA	**GEOLOGY**	SANDSTONE	**VEGETATION**	GRASS	**PROJECT NO.**	2193
EQUIPMENT	4WD MOUNTED PUSH TUBE	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø 50mm x 1100mm depth	**NORTHING**	NA	**ASPECT**	NE	**SLOPE**	< 2 °

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS	
PT	Nil	N	M	0.1			SM	ORGANIC SILTY SAND - Brown, moist, soft, rootlets.			PT	0.05	2193/9/0.05	
PT	Nil	0.3 ▽ Y	M	0.7			SC	CLAYEY SAND - Orange, moist(wet at 0.3m), loose with minor sandstone gravels.			PT	0.4	Ground water at 0.3m. 2193/9/0.4	
PT	Nil	Y	W	0.9			MW	MODERATELY WEATHERED SANDSTONE						
PT	Nil	Y	W	1.0 1.1			EW	EXTREMELY WEATHERED SANDSTONE - White coarse grained.			PT	1.0	2193/9/1.0	1.0
				2.0				Borehole terminated at 1.1m on moderately weathered sandstone .						2.0
				3.0										3.0
				4.0										4.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
▽ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	MALBEC PROPERTIES PTY LTD	**COMMENCED**	9/9/08	**COMPLETED**	9/9/08	**REF**	**BH10**
PROJECT	PRELIMINARY GEOTECHNICAL ASSESSMENT	**LOGGED**	JSF	**CHECKED**	ASN	**Sheet**	1 of 1
SITE	JONSSON ROAD, MUNDAMIA	**GEOLOGY**	SANDSTONE	**VEGETATION**	GRASS	**PROJECT NO.**	2193
EQUIPMENT	4WD MOUNTED AUGER	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø 95mm x 2800mm depth	**NORTHING**	NA	**ASPECT**	NE	**SLOPE**	< 3 °

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
A	Nil	N	M	0.3			SM	SILTY SAND - Brown, moist, soft.			A	0.1	2193/10/0.1
A	Nil	N	M	0.7			CS	CLAYEY SAND - Orange, moist.			A	0.4	2193/10/0.4
A	Nil	N	M	1.0			CL	SANDY/ SILTY CLAY - Orange,with red mottles, some sandstone floaters, firm, moist.			A	0.9	2193/10/0.9 1.0
A	Nil	1.7 ▽ Y	W	2.0			CL-EW	SANDY CLAY - With extremely weathered sandstone/ gravels, white and red mottled moist (wet below 1.7m).			A	1.5	2193/10/1.5 Ground water at 1.7m. 2.0
				2.8							A	2.5	2193/10/2.5
				3.0				Borehole terminated at 2.8m on extremely weathered sandstone.					3.0
				4.0									4.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
▽ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	MALBEC PROPERTIES PTY LTD	**COMMENCED**	9/9/08	**COMPLETED**	9/9/08	**REF**	**BH11**
PROJECT	PRELIMINARY GEOTECHNICAL ASSESSMENT	**LOGGED**	JSF	**CHECKED**	ASN	**Sheet**	1 of 1
SITE	JONSSON ROAD, MUNDAMIA	**GEOLOGY**	SANDSTONE	**VEGETATION**	GRASS	**PROJECT NO.**	2193
EQUIPMENT	4WD MOUNTED AUGER	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø 95mm x 1500mm depth	**NORTHING**	NA	**ASPECT**	NE	**SLOPE**	< 3 °

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS	
A	Nil	N	M	0.1			SP	ORGANIC SILTY SAND - Brown, grey, moist, soft.			A	0.1	2193/11/0.1	
A	Nil	N	M	0.6			CS	CLAYEY SAND - Orange, moist.			A	0.5	2193/11/0.5	
A	Nil	N	M	1.0 1.5			CL-EW	SANDY CLAY - With extremely weathered sandstone gravels, white and red mottled, moist.			A	1.2	2193/11/1.2	1.0
				2.0 3.0 4.0				Borehole terminated at 1.5m on sandy clay / extremely weathered sandstone.						2.0 3.0 4.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - Borehole

CLIENT	**MALBEC PROPERTIES PTY LTD**	**COMMENCED**	9/9/08	**COMPLETED**	9/9/08	**REF**	**BH12**
PROJECT	**PRELIMINARY GEOTECHNICAL ASSESSMENT**	**LOGGED**	JSF	**CHECKED**	ASN	**Sheet**	**1 of 1**
SITE	**JONSSON ROAD, MUNDAMIA**	**GEOLOGY**	SANDSTONE	**VEGETATION**	GRASS	**PROJECT NO.**	2193
EQUIPMENT	4WD MOUNTED AUGER	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø 95mm x 1500mm depth	**NORTHING**	NA	**ASPECT**	NE	**SLOPE**	< 3 °

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING			
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS	
A	Nil	N	M	0.15			SP	ORGANIC SILTY SAND - Brown, grey, moist, soft.			A	0.1	2193/12/0.1	
A	Nil	N	M	1.0			CL	SANDY/ SILTY CLAY - Orange,with red mottles, some sandstone floaters, firm, moist.			A A	0.3 0.8	2193/12/0.3 2193/12/0.8	1.0
A	Nil	N	M	1.5			CL-EW	SANDY CLAY - With extremely weathered sandstone / gravels, white and red mottled, moist.			A	1.4	2193/12/1.4	
				2.0				Borehole terminated at 1.5m on sandy clay / extremely weathered sandstone.						2.0
				3.0										3.0
				4.0										4.0

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

martens
MARTENS & ASSOCIATES PTY LTD
6/37 Leighton Place
Hornsby, NSW 2077 Australia
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Engineering Log - Borehole

CLIENT	MALBEC PROPERTIES PTY LTD	**COMMENCED**	9/9/08	**COMPLETED**	9/9/08	**REF**	**BH13**
PROJECT	PRELIMINARY GEOTECHNICAL ASSESSMENT	**LOGGED**	JSF	**CHECKED**	ASN	**Sheet**	1 of 1
SITE	JONSSON ROAD, MUNDAMIA	**GEOLOGY**	SANDSTONE	**VEGETATION**	GRASS	**PROJECT NO.**	2193
EQUIPMENT	4WD MOUNTED AUGER	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø 95mm x 1500mm depth	**NORTHING**	NA	**ASPECT**	NE	**SLOPE**	< 3 °

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE (L M H R)	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
A	Nil	N	M	0.3			SP	ORGANIC SILTY SAND - Brown, grey, moist, soft.			A	0.2	2193/13/0.2
A	Nil	N	M	1.0			CS	CLAYEY SAND - Orange, moist.			A	0.5	2193/13/0.5
A	Nil	N	M	1.5			CL	SANDY/ SILTY CLAY - Orange,with red mottles, some sandstone floaters, firm, moist.			A	1.4	2193/13/1.4
				2.0				Borehole terminated at 1.5m on sandy / silty clay.					
				3.0									
				4.0									

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
E Excavator
HA Hand auger
S Hand spade
PT Push tube
A Auger
CC Concrete Corer

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

PENETRATION
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
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F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
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D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
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D Disturbed sample
M Moisture content
Ux Tube sample (x mm)

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DCP Dynamic cone penetrometer
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CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
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Engineering Log - Borehole

9 Attachment C – Laboratory Report

Soil Conservation Service

SOIL TEST REPORT

Scone Research Centre

REPORT NO:	SCO10/324R1
REPORT TO:	Ben Rose Martens & Associates Pty Ltd 6 / 37 Leighton Place Hornsby NSW 2077
REPORT ON:	Six soil samples Ref: 2761
PRELIMINARY RESULTS ISSUED:	Not issued
REPORT STATUS:	Final
DATE REPORTED:	10 November 2010
METHODS:	Information on test procedures can be obtained from Scone Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED

SR Young
(Laboratory Manager)

SOIL AND WATER TESTING LABORATORY
Scone Research Centre

Report No: SCO10/324R1
Client Reference: Ben Rose
Martens & Associates Pty Ltd
6 / 37 Leighton Place
Hornsby NSW 2077

Lab No	Method	P18B/2 AWC	
	Sample Id	0.3bar (%)	15bar (%)
1	2761/4/0.4	9.9	5.4
2	2761/8/0.3	16.8	12.1
3	2761/6/0.5	23.2	11.6
4	2761/2/1.0	15.1	8.0
5	2761/3/0.35	19.7	8.9
6	2761/5/0.1	19.1	9.9

AWC = moisture content (%) by weight

SR Young

END OF TEST REPORT

10 Attachment D - Notes About This Report

Information

Important Information About Your Report

Subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Martens to help you interpret and understand the limitations of your report. Not all of course, are necessarily relevant to all reports, but are included as general reference.

Engineering Reports - Limitations

Geotechnical reports are based on information gained from limited sub-surface site testing and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely.

Engineering Reports – Project Specific Criteria

Engineering reports are prepared by qualified personnel and are based on the information obtained, on current engineering standards of interpretation and analysis, and on the basis of your unique project specific requirements as understood by Martens. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the Client.

Where the report has been prepared for a specific design proposal (eg. a three storey building), the information and interpretation may not be relative if the design proposal is changed (eg. to a twenty storey building). Your report should not be relied upon if there are changes to the project without first asking Martens to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Martens will not accept responsibility for problems that may occur due to design changes if they are not consulted.

Engineering Reports – Recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption often cannot be substantiated until project implementation has commenced and therefore your site investigation report recommendations should only be regarded as preliminary.

Only Martens, who prepared the report, are fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Martens cannot be held responsible for such misinterpretation.

Engineering Reports – Use For Tendering Purposes

Where information obtained from this investigation is provided for tendering purposes, Martens recommend 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. Attention is drawn to the document 'Guidelines for the Provision of Geotechnical Information in Tender Documents', published by the Institution of Engineers, Australia.

The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Engineering Reports – Data

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings *etc* are customarily included in a Martens report and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These data should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Engineering Reports – Other Projects

To avoid misuse of the information contained in your report it is recommended that you confer with Martens before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Subsurface Conditions - General

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

- Unexpected variations in ground conditions - the potential for will depend partly on test point (eg. excavation or borehole) spacing and sampling frequency which are often limited by project imposed budgetary constraints.

- Changes in guidelines, standards and policy or interpretation of guidelines, standards and

policy by statutory authorities.

- The actions of contractors responding to commercial pressures.

- Actual conditions differing somewhat from those inferred to exist, because no professional, no matter how qualified, can reveal precisely what is hidden by earth, rock and time.

  The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions

If these conditions occur, the Company will be pleased to assist with investigation or advice to resolve the matter.

Subsurface Conditions - Changes

Natural processes and the activity of man create subsurface conditions. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Reports are based on conditions which existed at the time of the subsurface exploration.

Decisions should not be based on a report whose adequacy may have been affected by time. If an extended period of time has elapsed since the report was prepared, consult Martens to be advised how time may have impacted on the project.

Subsurface Conditions - Site Anomalies

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

Report Use By Other Design Professionals

To avoid potentially costly misinterpretations when other design professionals develop their plans based on a report, retain Martens to work with other project professionals who are affected by the report. This may involve Martens explaining the report design implications and then reviewing plans and specifications produced to see how they have incorporated the report findings.

Subsurface Conditions - Geoenvironmental Issues

Your report generally does not relate to any findings, conclusions, or recommendations about the potential for hazardous or contaminated materials existing at the site unless specifically required to do so as part of the Company's proposal for works.

Specific sampling guidelines and specialist equipment, techniques and personnel are typically used to perform geoenvironmental or site contamination assessments. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Martens for information relating to such matters.

Responsibility

Geotechnical reporting relies on interpretation of factual information based on professional judgment and opinion and has an inherent level of uncertainty attached to it and is typically far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded.

To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Martens to other parties but are included to identify where Martens' responsibilities begin and end. Their use is intended to help all parties involved to recognize their individual responsibilities. Read all documents from Martens closely and do not hesitate to ask any questions you may have.

Site Inspections

Martens will always be pleased to provide engineering inspection services for 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. Martens is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction.

Soil Data

Explanation of Terms (1 of 3)

Definitions

In engineering terms, soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material does not exhibit any visible rock properties and can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726 and the S.A.A Site Investigation Code. In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

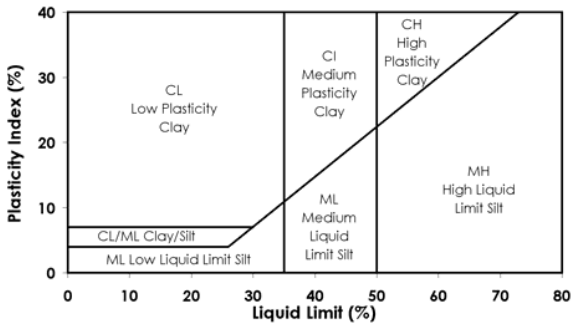
Particle Size

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. sandy clay). Unless otherwise stated, particle size is described in accordance with the following table.

Division	Subdivision	Size
BOULDERS		>200 mm
COBBLES		60 to 200 mm
GRAVEL	Coarse	20 to 60 mm
	Medium	6 to 20 mm
	Fine	2 to 6 mm
SAND	Coarse	0.6 to 2.0 mm
	Medium	0.2 to 0.6 mm
	Fine	0.075 to 0.2 mm
SILT		0.002 to 0.075 mm
CLAY		< 0.002 mm

Plasticity Properties

Plasticity properties can be assessed either in the field by tactile properties, or by laboratory procedures.



Moisture Condition

Dry — Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.

Moist — Soil feels cool and damp and is darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.

Wet — As for moist but with free water forming on hands when handled.

Consistency of Cohesive Soils

Cohesive soils refer to predominantly clay materials.

Term	C_u (kPa)	Approx SPT "N"	Field Guide
Very Soft	<12	2	A finger can be pushed well into the soil with little effort.
Soft	12 - 25	2 to 4	A finger can be pushed into the soil to about 25mm depth.
Firm	25 - 50	4 – 8	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 - 100	8 – 15	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 - 200	15 – 30	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	> 200	> 30	The surface of the soil can be marked only with the thumbnail.
Friable	-		Crumbles or powders when scraped by thumbnail

Density of Granular Soils

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration test (SPT) or Dutch cone penetrometer tests (CPT) as below:

Relative Density	%	SPT 'N' Value (blows/300mm)	CPT Cone Value (q_c Mpa)
Very loose	< 15	< 5	< 2
Loose	15 – 35	5 - 10	2 -5
Medium dense	35 – 65	10 - 30	5 - 15
Dense	65- 85	30 - 50	15 - 25
Very dense	> 85	> 50	> 25

Minor Components

Minor components in soils may be present and readily detectable, but have little bearing on general geotechnical classification. Terms include:

Term	Assessment	Proportion of Minor component In:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: < 5 % Fine grained soils: < 15 %
With some	Presence easily detectable by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 – 12 % Fine grained soils: 15 – 30 %

Soil Data

Explanation of Terms (2 of 3)

martens consulting engineers

Soil Agricultural Classification Scheme

In some situations, such as where soils are to be used for effluent disposal purposes, soils are often more appropriately classified in terms of traditional agricultural classification schemes. Where a Martens report provides agricultural classifications, these are undertaken in accordance with descriptions by Northcote, K.H. (1979) *The factual key for the recognition of Australian Soils*, Rellim Technical Publications, NSW, p 26 - 28.

Symbol	Field Texture Grade	Behaviour of moist bolus	Ribbon length	Clay content (%)
S	Sand	Coherence nil to very slight; cannot be moulded; single grains adhere to fingers	0 mm	< 5
LS	Loamy sand	Slight coherence; discolours fingers with dark organic stain	6.35 mm	5
CLS	Clayey sand	Slight coherence; sticky when wet; many sand grains stick to fingers; discolours fingers with clay stain	6.35mm - 1.3cm	5 - 10
SL	Sandy loam	Bolus just coherent but very sandy to touch; dominant sand grains are of medium size and are readily visible	1.3 - 2.5	10 - 15
FSL	Fine sandy loam	Bolus coherent; fine sand can be felt and heard	1.3 - 2.5	10 - 20
SCL$^-$	Light sandy clay loam	Bolus strongly coherent but sandy to touch, sand grains dominantly medium size and easily visible	2.0	15 - 20
L	Loam	Bolus coherent and rather spongy; smooth feel when manipulated but no obvious sandiness or silkiness; may be somewhat greasy to the touch if much organic matter present	2.5	25
Lfsy	Loam, fine sandy	Bolus coherent and slightly spongy; fine sand can be felt and heard when manipulated	2.5	25
SiL	Silt loam	Coherent bolus, very smooth to silky when manipulated	2.5	25 + > 25 silt
SCL	Sandy clay loam	Strongly coherent bolus sandy to touch; medium size sand grains visible in a finer matrix	2.5 - 3.8	20 - 30
CL	Clay loam	Coherent plastic bolus; smooth to manipulate	3.8 - 5.0	30 - 35
SiCL	Silty clay loam	Coherent smooth bolus; plastic and silky to touch	3.8 - 5.0	30- 35 + > 25 silt
FSCL	Fine sandy clay loam	Coherent bolus; fine sand can be felt and heard	3.8 - 5.0	30 - 35
SC	Sandy clay	Plastic bolus; fine to medium sized sands can be seen, felt or heard in a clayey matrix	5.0 - 7.5	35 - 40
SiC	Silty clay	Plastic bolus; smooth and silky	5.0 - 7.5	35 - 40 + > 25 silt
LC	Light clay	Plastic bolus; smooth to touch; slight resistance to shearing	5.0 - 7.5	35 - 40
LMC	Light medium clay	Plastic bolus; smooth to touch, slightly greater resistance to shearing than LC	7.5	40 - 45
MC	Medium clay	Smooth plastic bolus, handles like plasticine and can be moulded into rods without fracture, some resistance to shearing	> 7.5	45 - 55
HC	Heavy clay	Smooth plastic bolus; handles like stiff plasticine; can be moulded into rods without fracture; firm resistance to shearing	> 7.5	> 50

Soil Data

Explanation of Terms (3 of 3)

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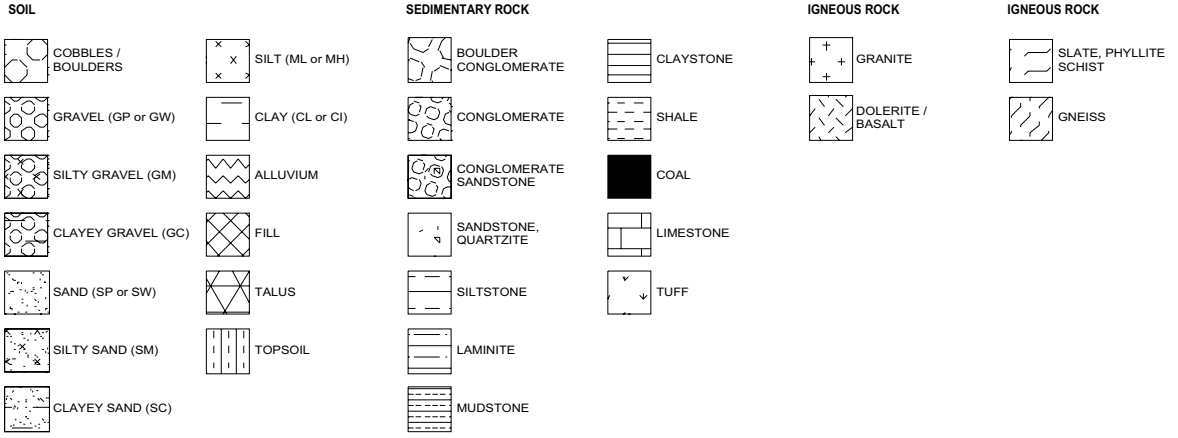
Symbols for Soil and Rock



Unified Soil Classification Scheme (USCS)

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 63 mm and basing fractions on estimated mass)					USCS	Primary Name
COARSE GRAINED SOILS More than 50 % of material less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.0 mm.	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Gravel
				Predominantly one size or a range of sizes with more intermediate sizes missing	GP	Gravel
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	GM	Silty Gravel
				Plastic fines (for identification procedures see CL below)	GC	Clayey Gravel
		SANDS More than half of coarse fraction is smaller than 2.0 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of intermediate sizes missing.	SW	Sand
				Predominantly one size or a range of sizes with some intermediate sizes missing	SP	Sand
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	SM	Silty Sand
				Plastic fines (for identification procedures see CL below)	SC	Clayey Sand

FINE GRAINED SOILS More than 50 % of material less than 63 mm is smaller than 0.075 mm	IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 MM					
	DRY STRENGTH (Crushing Characteristics)	DILATANCY	TOUGHNESS	DESCRIPTION	USCS	Primary Name
	None to Low	Quick to Slow	None	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	ML	Silt
	Medium to High	None	Medium	Inorganic clays of low to medium plasticity, gravely clays, sandy clays, silty clays, lean clays	CL	Clay
	Low to Medium	Slow to Very Slow	Low	Organic slits and organic silty clays of low plasticity	OL	Organic Silt
	Low to Medium	Slow to Very Slow	Low to Medium	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	MH	Silt
	High	None	High	Inorganic clays of high plasticity, fat clays	CH	Clay
	Medium to High	None	Low to Medium	Organic clays of medium to high plasticity	OH	Organic Silt
HIGHLY ORGANIC SOILS	Readily identified by colour, odour, spongy feel and frequently by fibrous texture				Pt	Peat

Low Plasticity – Liquid Limit W_L < 35 % Medium Plasticity – Liquid limit W_L 35 to 60 % High Plasticity - Liquid limit W_L > 60 %

Rock Data

Explanation of Terms (1 of 2)

martens consulting engineers

Definitions

Descriptive terms used for Rock by Martens are given below and include rock substance, rock defects and rock mass.

Rock Substance — In geotechnical engineering terms, rock substance is any naturally occurring aggregate of minerals and organic matter which cannot, unless extremely weathered, be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Rock substance is effectively homogeneous and may be isotropic or anisotropic.

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

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

Degree of Weathering

Rock weathering is defined as the degree in rock structure and grain property decline and can be readily determined in the field.

Term	Symbol	Definition
Residual Soil	Rs	Soil derived from the weathering of rock. The mass structure and substance fabric are no longer evident. There is a large change in volume but the soil has not been significantly transported.
Extremely weathered	EW	Rock substance affected by weathering to the extent that the rock exhibits soil properties - ie. it can be remoulded and can be classified according to the Unified Classification System, but the texture of the original rock is still evident.
Highly weathered	HW	Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength may be increased or decrease compared to the fresh rock usually as a result of iron leaching or deposition. The colour and strength of the original rock substance is no longer recognisable.
Moderately weathered	MW	Rock substance affected by weathering to the extent that staining extends throughout the whole of the rock substance and the original colour of the fresh rock is no longer recognisable.
Slightly weathered	SW	Rock substance affected by weathering to the extent that partial staining or discolouration of the rock substance usually by limonite has taken place. The colour and texture of the fresh rock is recognisable.
Fresh	Fr	Rock substance unaffected by weathering

Rock Strength

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance is the direction normal to the bedding. The test procedure is described by the International Society of Rock Mechanics.

Term	Is (50) MPa	Field Guide	Symbol
Extremely weak	< 0.03	Easily remoulded by hand to a material with soil properties.	EW
Very weak	0.03 - 0.1	May be crumbled in the hand. Sandstone is 'sugary' and friable.	VW
Weak	0.1 - 0.3	A piece of core 150mm long x 50mm diameter may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.	W
Medium strong	0.3 - 1	A piece of core 150mm long x 50mm diameter can be broken by hand with considerable difficulty. Readily scored with a knife.	MS
Strong	1 - 3	A piece of core 150mm long x 50mm diameter cannot be broken by unaided hands, can be slightly scratched or scored with a knife.	S
Very Strong	3 - 10	A piece of core 150mm long x 50mm diameter may be broken readily with hand held hammer. Cannot be scratched with pen knife.	VS
Extremely strong	> 10	A piece of core 150mm long x 50mm diameter is difficult to break with hand held hammer. Rings when struck with a hammer.	ES

Rock Data

Explanation of Terms (2 of 2)

martens consulting engineers

Degree of Fracturing

This classification applies to diamond drill cores and refers to the spacing of all types of natural fractures along which the core is discontinuous. These include bedding plane partings, joints and other rock defects, but excludes fractures such as drilling breaks.

Term	Description
Fragmented	The core is comprised primarily of fragments of length less than 20mm, and mostly of width less than core diameter.
Highly fractured	Core lengths are generally less than 20mm-40mm with occasional fragments.
Fractured	Core lengths are mainly 30mm-100mm with occasional shorter and longer sections.
Slightly fractured	Core lengths are generally 300mm-1000mm with occasional longer sections and occasional sections of 100mm-300mm.
Unbroken	The core does not contain any fractures.

Test Methods

Explanation of Terms (1 of 2)

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Sampling

Sampling is carried out during drilling or excavation 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 may be taken by pushing a thin-walled sample tube into the soils and withdrawing a soil sample 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. Other sampling methods may be used. Details of the type and method of sampling are given in the report.

Drilling Methods

The following is a brief summary of drilling methods currently adopted by the Company and some comments on their use and application.

Hand Excavation – in some situations, excavation using hand tools such as mattock and spade may be required due to limited site access or shallow soil profiles.

Hand Auger - the hole is advanced by pushing and rotating either a sand or clay auger generally 75-100mm in diameter into the ground. The depth of penetration is usually limited to the length of the auger pole, however extender pieces can be added to lengthen this.

Test Pits - these are excavated with a backhoe or a tracked excavator, allowing close examination of the *in-situ* soils if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (eg. Pengo) - the hole is advanced by a rotating plate or short spiral auger, generally 300mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5m) 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 sampling.

Continuous Sample Drilling - the hole is advanced by pushing a 100mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling in soils, since moisture content is unchanged and soil structure, strength *etc.* is only marginally affected.

Continuous Spiral Flight Augers - the hole 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 in sands above the water table. Samples are returned to the surface or, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling - the hole is advanced by a rotary bit, with water 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 'feel' and rate of penetration.

Rotary Mud Drilling - similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. from SPT).

Continuous Core Drilling - a continuous core sample is obtained using a diamond tipped core barrel, usually 50mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

Standard penetration tests are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in AS 1289 Methods of Testing Soils for Engineering Purposes - Test F3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760mm. 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 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

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

as 4, 6, 7
N = 13

(ii) In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm

as 15, 30/40 mm.

The results of the tests can be related empirically to the engineering properties of the soil. Occasionally, the test method is used to obtain samples in 50mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borelogs in brackets.

CONE PENETROMETER TESTING AND INTERPRETATION

Cone penetrometer testing (sometimes referred to as Dutch Cone - abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in AS 1289 - Test F4.1.

In the test, a 35mm diameter rod with a cone tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on separate 130mm long sleeve, immediately behind the cone. Tranducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) the information is output on continuous chart

Test Methods

Explanation of Terms (2 of 2)

recorders. The plotted results given in this report have been traced from the original records.

The information provided on the charts comprises:
Cone resistance - the actual end bearing force divided by the cross sectional area of the cone - expressed in MPA.
Sleeve friction - the frictional force of the sleeve divided by the surface area - expressed in kPa.
Friction ratio - the ratio of sleeve friction to cone resistance - expressed in percent.

There are two scales available for measurement of cone resistance. The lower (A) scale (0 - 5 Mpa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main (B) scale (0 - 50 Mpa) is less sensitive and is shown as a full line.

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1%-2% are commonly encountered in sands and very soft clays rising to 4%-10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range:

q_c (Mpa) = (0.4 to 0.6) N (blows/300mm)

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range:

q_c = (12 to 18) c_u

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculation of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes *etc*. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

DYNAMIC CONE (HAND) PENETROMETERS
Hand penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150mm increments of penetration. Normally, there is a depth limitation of 1.2m but this may be extended in certain conditions by the use of extension rods. Two relatively similar tests are used.

Perth sand penetrometer - a 16 mm diameter flat ended rod is driven with a 9kg hammer, dropping 600mm (AS 1289 - Test F 3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
Cone penetrometer (sometimes known as the Scala Penetrometer) - a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS 1289 - Test F 3.2). The test was developed initially for pavement sub-grade investigations, with correlations of the test results with California bearing ratio published by various Road Authorities.

LABORATORY TESTING
Laboratory testing is carried out in accordance with AS 1289 Methods of Testing Soil for Engineering Purposes. Details of the test procedure used are given on the individual report forms.

TEST PIT / BORE LOGS
The test pit / bore log(s) presented herein are an engineering and/or geological interpretation of the sub-surface conditions and their reliability will depend to some extent on frequency of sampling and the method of excavation / drilling. Ideally, continuous undisturbed sampling or excavation / 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 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, the frequency of sampling and the possibility of other than 'straight line' variation between the boreholes.

GROUND WATER
Where ground water levels are measured in boreholes, there are several potential problems:

In low permeability soils, ground water although present, may enter the hole slowly, or perhaps not at all during the time it 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 prior weather changes. They may not be the same at the time of construction as are indicated in the report.
The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations 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.