The Sikh Grammar School Sydney C/- PMDL



Preliminary Salinity and Geotechnical Assessment: The Sikh Grammar School -151 and 161 Tallawong Road, Rouse Hill, NSW



P1806439JR01V02 May 2019

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



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# 1 Development and Investigation Scope

The proposed development details and investigation scope are summarised in Table 1.

**Table 1:** Summary of proposed development and investigation scope.

Item	Details					
Property Address	151 and 161 Tallawong Road, Rouse Hill, NSW ('the site')					
Lot / DP	Lots 42 and 43, DP 30186					
LGA	Blacktown City Council (BCC)					
Assessment Purpose	Preliminary salinity and geotechnical assessment to support a State Significant Development Application (SSDA).					
Site Area	Approximately 4.05 ha (CSS, 2013)					
Proposed Development	We understand from a brief by client and proposal plans (PMDL, 2019) that the development will include:					
	<ul> <li>Construction of a new school comprising primary and secondary schools, an early learning centre, a community centre Gurdwara (a place of worship) and Langar (community dinning space), a boarding house, a library and staff lounge, a village green, sports pavilion and field and school drop-off and parking area. Some of the proposed buildings will likely extend into an area occupied by an existing site dam. The north east 1/3 as well as western corner of the new school footprint will include a basement carpark, requiring bulk excavations up to 4.0 m below ground level (mBGL).</li> <li>Future subdivision for low density residential developments to the south west of new school.</li> </ul>					
Investigation Scope of Work	<ul> <li>A general site walkover survey.</li> <li>Eleven boreholes (BH101 to BH111) up to 4.0 metres below ground level (mBGL) (refer Attachment B, and associated explanatory notes in Attachment F).</li> <li>Collection of soil and weathered rock samples for laboratory testing and future reference.</li> <li>Eleven Dynamic Cone Penetrometer (DCP) tests (DCP101 to DCP111) up to 2.6 mBGL (refer DCP 'N' counts in Attachment C).</li> <li>Investigation locations are shown in Figure 1, Attachment A.</li> </ul>					
Laboratory Testing	Testing, carried out by National Association of Testing Authorities (NATA) accredited laboratories, included:  o Soil Reactivity testing on three soil samples by Resource Laboratories.  o Chemical testing (Electrical Conductivity (EC), pH and soluble SO <sub>4</sub> ) on twenty four soil samples by Envirolab Services.  Laboratory test certificates are provided in Attachment D.					



# 2 General Site Details and Subsurface Conditions

General site details and encountered subsurface conditions are summarised in Table 2.

**Table 2:** Summary of site details based on desktop review, site walkover and site investigations.

Item	Comment
Topography	Within slightly undulating terrain
Typical slopes, aspect, elevation	The site generally has a north westerly and westerly aspect across the southern portion and south westerly aspect across the northern portion, with typical grades of between approximately 5 % and 15 %. Site elevation ranges between approximately 41.5 mAHD (western corner) and 54 mAHD (eastern corner).
Existing development	Current development at the site includes a single storey brick residential dwelling, located in the eastern corner.  A dam is located in the central portion of the site. An east to west aligned drainage depression extends across the central portion of the site and connects the site dam to other dams located to the southwest and northeast of the site.
Vegetation	Grass, shrubs and scattered trees
Drainage	Via overland flow into the drainage depression and existing dam.
Expected soil landscape	The NSW Environment and Heritage eSPADE website identifies the site in the Blacktown soil landscape, consisting of shallow to moderately deep hard setting mottled texture contrasting soils, red and brown podzolic soils on crests grading to yellow podzolic soils on lower slopes and in drainage lines.
Sub-surface soil / rock units	<ul> <li>Unit A: Topsoil comprising silt / clayey silt with consistencies varying from soft to very stiff up to approximately 0.2 mBGL.</li> <li>Unit B: Residual soil comprising generally very stiff grading to hard silty clay / clay up to between approximately 0.55 mBGL and 3.8 mBGL. A deeper soil profile in BH105 and BH110, encountered up to 3.8 mBGL and 2.7 mBGL, respectively, is inferred to be the result of more extensive rock weathering due to surface water infiltration along the drainage depression.</li> <li>Unit C: Weathered and inferred very low to low grading to low strength shale below V-bit refusal depths of between 0.55 mBGL and 3.8 mBGL. For the purpose of this report, rock below TC-bit refusal depths of 2.7 mBGL in BH101 and 3.2 mBGL in BH103 is assumed to be of medium strength shale with possible lower and / or higher strength bands. This should be confirmed / revised by further assessment, as necessary.</li> <li>Fill was not encountered during the drilling of the boreholes. However, it may be present in limited portions of the site, such as areas within and / or nearby previous / existing site developments.</li> </ul>
Groundwater	Groundwater inflow was not encountered during drilling of the boreholes up to 4.0 mBGL. Ephemeral perched groundwater may be encountered in the soil profile and / or at the soil / rock interface originating from infiltration of surface water during prolonged or intense rainfall events.  Should further information on permanent site groundwater levels, particularly across the zone of influence of dam and drainage depression, be required, additional investigation would need to be carried out (i.e. installation of groundwater monitoring wells).



## 3 Salinity Assessment

## 3.1 Documented Salinity Risk Potential

The 1:100,000 Salinity Potential in Western Sydney Map (DIPNR, 2002) maps the site in an area of moderate salinity potential with high salinity potential along surface drainage lines, e.g. creeks and at the lower slopes in Wianamatta shales (Figure 2, Attachment A).

## 3.2 Broad Scale Salinity Processes

In producing the Salinity Potential Map, the Western Sydney Regional Organisation of Councils (WSROC) developed a number of alternative models of processes by which salinity may occur in Western Sydney (WSROC, 2003, pgs. 16 to 20).

Table 3 presents a list of key broad scale salinity processes likely to impact the site, including summarised descriptions of each process.

## 3.3 Signs of Potential Saline Soils at the site

No obvious signs of possible saline conditions were observed at the site; for example:

- No water marks or salt crystals were observed on the ground surface.
- o Site surface drainage appeared generally good.
- o No evidence of concentrated surface erosion was observed.
- o Grass appeared healthy and uninhabited.

## 3.4 Assessed Salinity Risk Potential

In Table 3, the broad scale salinity processes have been assessed in terms of likelihood of occurring at the site, considering the proposed development, site observations and investigation findings.



**Table 3:** Potential for broad scale salinity processes at the site.

Key salinity	, ,	
process	Description	Potential at subject site
Localised concentration of salinity	Localised concentration of salts due to relatively high evaporation rates.  Usually associated with waterlogged soil and poor drainage.  Exacerbated by increased water use and/ or blocking of surface and subsurface water flow associated with urban development.	Moderate to High – No evidence of localised salt concentration and waterlogged soil and poor drainage observed. However, site dam, drainage depression, irrigation of gardens as well as dams nearby the site may have influenced site soil salinity.
Shale soil landscapes	In poorly drained duplex (texture contrast) soils, shallow subsurface water flows laterally across a clayey upper B-Horizon with salt usually accumulating in the clayey subsoil.  Salt concentrations may increase where subsurface water accumulates and evaporates, e.g. on lower slopes or natural and constructed flats in mid-slope.  Exacerbated by subsoils exposure through deep cutting, by installing buildings into the B-horizon and by impeding subsurface water flows.  Highly dispersive, erodible and poorly draining sodic soils due to salinity.	Moderate to High – The site is underlain by low permeable clays, overlying shale.  Water accumulation and evaporation of perched water in the existing dam and drainage depression on site as well as nearby dams may have resulted in salt accumulation in clays.
Deep groundwater salinity	Brackish or saline groundwater rises to a level where, through capillary action in the soil, the water with dissolved salts reaches the ground surface and evaporates, resulting in localised salt concentration.  Groundwater rises are typically caused by increased water infiltration, e.g. above average rainfall, vegetation loss, irrigation, increased water use in urban areas, construction of surface pits.  Exacerbated by buildings or infrastructure intercepting the zone of groundwater level fluctuation.	Low – Groundwater was not encountered in boreholes to 4.0 mBGL. The proposed development is not expected to intercept or raise groundwater levels.  Proposed structures are to be constructed with appropriate drainage measures installed.
Deeply weathered soil landscape	High salt loads with high sulphate levels related to un-mapped deeply weathered soil landscapes beneath fluvial gravel, sand and clay.  Usually in mid-slope or on hilltops affected by perched saline groundwater.	Moderate – No evidence of deeply weathered soils beneath alluvial soils was observed. Encountered soils on the site are residual.  Deeper weathering is likely to be present within / nearby existing drainage depression and dam.  Perched saline groundwater may have influenced site soil salinity.



## 3.5 Laboratory Testing

#### 3.5.1 Overview

The chemical testing (Electrical Conductivity (EC), pH and soluble SO<sub>4</sub>) was carried out for salinity classification and to assess an exposure classification for design of buried concrete structures. Sampling was targeted to achieve a representative coverage of site conditions in line with assessed subsurface profiles and the limited investigation scope.

## 3.5.2 Results – Salinity Classification

Laboratory test results for salinity classification are summarised in Table 4.

**Table 4:** Salinity test results.

Sample ID <sup>1</sup>	Material	EC <sub>(1:5)</sub> (dS/m)	EC <sub>e</sub> (dS/m) <sup>2</sup>	Salinity Classification <sup>3</sup>
6439/BH101/0.1/S/1	SILT	0.100	1.00	Non-saline
6439/BH101/0.3/S/1	Silty CLAY	0.044	0.308	Non-saline
6439/BH102/0.1/S/1	Clayey SILT	0.089	0.801	Non-saline
6439/BH102/0.3/S/1	Silty CLAY	0.061	0.427	Non-saline
6439/BH102/0.8/S/1	Silty CLAY	0.180	1.260	Non-saline
6439/BH103/0.1/S/1	Clayey SILT	0.088	0.792	Non-saline
6439/BH103/0.5/\$/1	Silty CLAY	0.200	1.400	Non-saline
6439/BH105/0.1/S/1	Clayey SILT	0.082	0.738	Non-saline
6439/BH105/0.5/S/1	Silty CLAY	0.084	0.588	Non-saline
6439/BH105/1.5/S/1	Silty CLAY	0.290	1.740	Non-saline
6439/BH106/0.1/S/1	Clayey SILT	0.056	0.504	Non-saline
6439/BH106/0.6/S/1	Silty CLAY	0.042	0.294	Non-saline
6439/BH107/0.1/S/1	SILT	0.051	0.510	Non-saline
6439/BH107/0.5/S/1	Silty CLAY	0.030	0.210	Non-saline
6439/BH107/1.0/S/1	Silty CLAY	0.059	0.413	Non-saline



Sample ID <sup>1</sup>	Material	EC <sub>(1:5)</sub> (dS/m)	EC <sub>e</sub> (dS/m) <sup>2</sup>	Salinity Classification <sup>3</sup>
6439/BH108/0.1/S/1	SILT	0.022	0.220	Non-saline
6439/BH108/0.5/S/1	Silty CLAY	0.091	0.637	Non-saline
6439/BH108/1.3/S/1	CLAY	0.430	2.580	Slightly saline
6439/BH109/0.1/S/1	SILT	0.120	1.200	Non-saline
6439/BH109/0.5/S/1	Silty CLAY	0.026	0.182	Non-saline
6439/BH110/0.1/S/1	Clayey SILT	0.086	0.774	Non-saline
6439/BH110/0.5/S/1	Silty CLAY	0.028	0.196	Non-saline
6439/BH110/1.0/S/1	CLAY	0.028	0.168	Non-saline
6439/BH110/2.0/S/1	CLAY	0.057	0.342	Non-saline

#### Notes:

- Project#/Borehole#/Depth (mBGL).
- <sup>2</sup> Based on EC to EC<sub>e</sub> multiplication factors from Table 6.1 in DLWC (2002).
- Based on Table 6.2 of DLWC (2002) where  $EC_e < 2$  dS/m = non-saline,  $EC_e$  of 2-4 dS/m = slightly saline,  $EC_e$  of 4-8 dS/m = moderately saline,  $EC_e$  of 8-16 dS/m = very saline and  $EC_e$  of >16 dS/m = highly saline.

Results indicate that residual silty clay at the tested locations can generally be categorised as non-saline. Only one sample returned slightly saline results (i.e. clay sample from 1 m depth in BH108).

## 3.5.3 Results – Exposure Classification

Sulphate and pH test results for exposure classification are summarised in Table 5.

**Table 5:** Exposure classification test results.

Sample ID <sup>1</sup>	EC <sub>e</sub> (dS/m) <sup>2</sup>	рΗ	Sulphate (SO <sub>4</sub> ) (mg/kg)	Exposure Classification <sup>3</sup>
6439/BH101/0.1/S/1	1.00	6.1	25	A1
6439/BH101/0.3/\$/1	0.308	5.9	20	A1
6439/BH102/0.1/S/1	0.801	5.6	22	A1
6439/BH102/0.3/\$/1	0.427	5.7	40	A1
6439/BH102/0.8/\$/1	1.260	6.7	70	A1



Sample ID <sup>1</sup>	EC <sub>e</sub> (dS/m) <sup>2</sup>	рН	Sulphate (SO <sub>4</sub> ) (mg/kg)	Exposure Classification <sup>3</sup>
6439/BH103/0.1/S/1	0.792	7.6	< 10	A1
6439/BH103/0.5/S/1	1.400	6.2	190	A1
6439/BH105/0.1/S/1	0.738	6.4	30	A1
6439/BH105/0.5/S/1	0.588	6.4	120	A1
6439/BH105/1.5/S/1	1.740	5.2	< 10	A2
6439/BH106/0.1/S/1	0.504	7.6	10	A1
6439/BH106/0.6/S/1	0.294	7.9	< 10	A1
6439/BH107/0.1/S/1	0.510	5.9	22	A1
6439/BH107/0.5/S/1	0.210	5.8	37	A1
6439/BH107/1.0/S/1	0.413	5.8	69	A1
6439/BH108/0.1/S/1	0.220	5.9	10	A1
6439/BH108/0.5/S/1	0.637	5.6	61	A1
6439/BH108/1.3/S/1	2.580	5.4	< 10	A2
6439/BH109/0.1/S/1	1.200	5.8	22	A1
6439/BH109/0.5/S/1	0.182	6.1	10	A1
6439/BH110/0.1/S/1	0.774	6.7	39	A1
6439/BH110/0.5/S/1	0.196	6.7	20	A1
6439/BH110/1.0/S/1	0.168	6.6	26	A1
6439/BH110/2.0/S/1	0.342	5.8	63	A1

#### Notes:

- Project#/Borehole#/Depth (mBGL).
- <sup>2</sup> From table 4.
- Exposure classification for buried reinforced concrete based on Tables 4.8.1 and 4.8.2 of AS 3600 (2009).

The following exposure classifications should be adopted for preliminary design of buried concrete structures in accordance with AS3600 (2009):

- o A1 for buried concrete structures up to 1 mBGL.
- A2 for buried concrete structures below 1 mBGL.



#### 3.6 Conclusions and Recommendations

We conclude and recommend the following:

- Subsurface materials at tested locations are generally categorised as non-saline with the exception of one sample in BH108, which is slightly saline. No specified saline soil management strategies are considered to be required.
- Exposure classifications of 'A1' and 'A2' should be adopted for preliminary design of buried concrete structures up to 1.0 mBGL and below 1.0 mBGL, respectively, in accordance with AS3600 (2009).
- Further assessment should be carried out, including laboratory testing, to confirm characterisation of site salinity conditions, particularly in proposed development areas, and assess potential ensuing implications following consideration of final development details.



## 4 Geotechnical Assessment

## 4.1 Soil Reactivity

A summary of soil reactivity test results is presented in Table 6.

**Table 6:** Summary of laboratory Soil Reactivity test results.

PH ID / Danib	AA aaba ataal	Atterberg Limits (%)			(%)	Plasticity	Potential Volume
BH ID / Depth	Material	LL <sup>1</sup>	PL <sup>1</sup>	PI¹	LS <sup>1</sup>	Classification	Change <sup>2</sup>
BH103/0.5	Silty CLAY	55	18	37	11.5	High	Medium
BH108/0.5	Silty CLAY	46	16	30	13.5	Medium	Medium
BH108/1.3	CLAY	60	18	42	17.5	High	Medium

#### Notes:

- 1. LL = Liquid limit, PL= Plastic limit, Pl=Plasticity index, LS = Linear shrinkage
- 2. Based on Hazelton and Murphy, 2016.

Laboratory test results indicate that the tested soil samples are generally of medium and high plasticity and will likely experience moderate ground movement due to soil moisture changes.

## 4.2 Preliminary Soil and Rock Strength Properties

Preliminary soil and rock strength properties, estimated from field test results in conjunction with borehole derived soil / rock profile data, as well as engineering assumptions, are summarised in Table 7.



**Table 7:** Preliminary material properties.

Layer	Material	Y <sub>in-situ</sub> 1 (kN/m³)	UCS <sup>2</sup> (MPa)	Ø' <sup>3</sup> (deg)	Cu ⁴ (kPa)	E' <sup>5</sup> (MPa)
TOPSOIL	SILT / Clayey SILT	15-17	NA 6	NA 6	NA 6	NA <sup>6</sup>
RESIDUAL:	Silty CLAY / CLAY (stiff to very stiff)	17-18	0.1-0.2	NA 6	50-100	10-20
RESIDUAL:	Silty CLAY / CLAY (hard)	19	0.4	NA <sup>6</sup>	200	30-40
	SHALE (very low to low strength)	22	0.5 – 1.0	28	NA <sup>6</sup>	50-100
WEATHERED ROCK:	SHALE (low strength)	23	1.0 – 3.0	28	NA 6	100-300
	SHALE (medium strength)	23	3.0 – 10.0	32	NA 6	300-500

#### Notes:

- 1. Material in-situ unit weight, based on visual assessment (±10%).
- 2. Expected range of unconfined compressive strength of intact material.
- 3. Effective internal friction angle  $(\pm 2)$  estimate, assuming drained conditions; may be dependent on rock defect conditions.
- 4. Undrained shear strength (±5 kPa) estimate assuming normally consolidated clay.
- 5. Expected range of effective elastic modulus (±10 %).
- 6. Not applicable.

## 4.3 Risk of Slope Instability

Evidence of extensive subsidence or recent gross slope instability was not observed on site. We consider the risk to property and loss of life by potential slope instability, such as landslide or soil creep, to be very low subject to the recommendations in this report and adoption of relevant engineering standards and guidelines. A detailed slope risk assessment in accordance with Australian Geomechanics Society's Landslide Risk Management Guidelines (2007) was not undertaken.

The proposed excavations may extend into the zone of influence of neighbouring properties, structures and / or other infrastructure to the north east and south east. The zone of influence is defined as an area of soil / rock, supporting features in question, below a nominal angle of between 30° and 45° for soils and 45° for rock, extending down and away from the base of the feature.

Recommendations presented in this report are provided to mitigate risks associated with potential excavation instability during construction



#### 4.4 Geotechnical Recommendations

The following recommendations are provided for the proposed development. Further general geotechnical recommendations are provided in Attachment E.

- 1. <u>Excavation</u>: Proposed basement excavations will encounter residual soils over weathered rock. In light of this, we recommend the following excavation equipment:
  - Soils and low strength rock: These should be readily excavated using conventional earthmoving equipment. A 'toothed' bucket or a ripping tyne (or similar) may be required to excavate rock.
  - Medium and higher strength rock: Hydraulic earthmoving equipment with rock hammer attachment or dozer fitted with a ripping tyne.
- 2. Excavation Support: Excavations in soils and extremely low to low strength rock must be temporarily and permanently battered back / shored / retained to maintain excavation stability and limit potential adverse impacts on neighbouring properties or other infrastructure located within the zone of influence of proposed excavations. Medium and / or higher strength rock, where encountered, may remain unsupported subject to confirmation on site by a geotechnical engineer. Appropriate support and / or excavation methodologies should be adopted by the excavation contractor and design engineer and approved by a geotechnical engineer.

If there is sufficient room to remain outside the zone of influence of existing structures / infrastructure, excavations in soils and weathered rock may be temporarily battered back at:

- o 1V:2H for soil and 1V:1.5H for rock, or
- 1V:1H, if covered with an appropriate protection facing,
   e.g. by soil nails and shotcrete.

Provided batters are subject to inspection and approval by a geotechnical engineer on site and followed by construction of permanent retaining structures.

Excavations in soils and weathered rock may be permanently battered back at grades of no greater than 1V:3H.



Temporary shoring may include cantilevered or anchored soldier pile walls with shotcrete infill panels. For shoring inside the zone of influence of adjoining properties / infrastructure, closer spaced soldier piles may need to be adopted.

Retaining wall design may adopt active ( $k_a$ ), at rest ( $k_0$ ) and passive ( $k_p$ ) earth pressure coefficients of 0.4, 0.55 and 2.5, respectively, for soils and 0.33, 0.50 and 3.0, respectively, for weathered rock.

Tieback anchors must not be installed across site boundaries unless written confirmation of acceptance is obtained from neighbouring property / asset owners.

Where installation of anchors is not possible, retaining walls may be supported by a suitable bracing system (i.e. wales and rakers).

Temporary walls may be designed to provide long term retention, with lateral restraint provided by building floor and roof slabs.

Retaining wall design should consider additional surcharge loading from live loads, new structures, construction equipment, backfill compaction and static water pressures unless subsoil drainage is provided behind retaining walls.

3. <u>Rock Support</u>: Unstable rock wedges as a result of presence of clay seams, weakly cemented (extremely weathered) seams, steeply dipping joints and other rock defects may have an adverse effect on unsupported rock face stability and construction safety. Geotechnical mapping of the excavation should be conducted in 1.5 m height increments to identify such features and allow early mitigation of risks of rock movement, such as by installation of rock bolts and / or sprayed concrete surfacing.

If full height retaining walls are to be constructed for long term stability, then such measures are not likely to be required, however temporary measures may be required to stabilise excavations during construction.

Rock bolts and sprayed concrete support should be specified in terms of performance requirements and installed / placed by contractors experienced in ground anchor technology and on advisement by an experienced geotechnical engineer. Rock support should not extend beyond property boundaries unless approval has been granted by relevant property owners or stakeholders. The actual amount of stabilisation which will be



- required cannot be quantified at this stage and can only be determined at the time of construction. MA can complete the necessary mapping and provide advice on support requirements.
- 4. <u>Footings and Foundations</u>: Allowable end bearing capacities for design of shallow and deepened footings are presented in Table 8, Section 4.5. Individual pad footings and all footings within building footprints should not span the interface between different foundation materials. Alternatively, inclusion of movement joints may mitigate impacts of differential movements.
  - All foundation excavations should be inspected by a geotechnical engineer to confirm encountered conditions satisfy design assumptions.
- 5. <u>Earthworks</u>: All earthworks, including filling of dam, should be carried out in accordance with AS3798 (2007) and BCC's requirements following removal of topsoil and other unsuitable materials, such as uncontrolled fill and soft or saturated soils. Removal of any silt deposits from an existing dam and drainage depression should be carried out under the guidance of a geotechnical engineer.

A qualified geotechnical engineer should inspect the condition of the exposed material to assess suitability of the prepared surface as foundation for footings or fill placement. This shall include proof rolling of exposed materials in accordance with Clause 5.5 of AS3798 (2007). If soft spots are identified, these shall be treated until conditions are assessed by the geotechnical engineer to be suitable. This may include one of the following methods:

- Removal and replacement with granular fill approved by the geotechnical engineer.
- In-situ stabilisation with cement / lime or similar binding agent to a depth of at least 300 mm. Use of this method and extent will depend on the condition of material to be stabilised.

Should re-use of excavated materials be considered for site filling, we recommend limiting material re-use to general fill areas, given the medium to high plasticity of the clays. Where site-won material is used as structural fill, stringent placement specifications are to be developed to ensure adequate compaction, including moisture conditioning of material and controls to limit over compaction. We recommend the use of low plasticity clay or granular material as structural fill.



#### Imported fill shall:

- Exclude any unsuitable materials as outlined in Clause 4.3 of AS3798 (2007), such as material containing toxic substances or soluble compounds.
- Imported fill shall contain < 20 % by mass of particles greater than 37.5 mm after field compaction in accordance with Clause 5.2 of AS3798 (2007).

Fill material shall be placed in horizontal layers of generally not more than 300 mm loose thickness and with a mixture of materials as uniform as possible. Layer thickness shall be appropriate for the compaction plant adopted and may be varied by the supervising engineer.

For areas likely to be subjected to a loading of up to 20 kPa, fill material shall be moisture conditioned and compacted to a minimum density index (DI) of 75% or density ratio (DR) of 98% at a standard compactive effort within -3% and +1% of optimum moisture content (OMC). For areas loaded to greater than 20 kPa, such as under pavements trafficked by heavy vehicles, the upper 300 mm of subgrade material shall be compacted to a DI of 80% or DR of 100% at a standard compactive effort within -3% and +1% of OMC.

For general fill areas (e.g. landscaped areas and playing fields), fill should be compacted to a DI of 70% or DR of 95% at a standard compactive effort within -3% and +1% of OMC.

6. <u>Drainage requirements</u>: Groundwater inflow, if encountered during excavation, is expected to be limited and manageable by sump and pump methods. Appropriate drainage measures should be provided behind the retaining walls to divert ephemeral seepage water away from structures and discharge into council approved discharge points downslope.

For soldier pile walls, strip drains with a non-woven geotextile filter fabric should be installed behind the shotcrete to dissipate the pore pressure build up behind the walls.

7. <u>Site Classification</u>: A preliminary site classification of 'H1' should be adopted for design of lightly loaded shallow footings, in accordance with AS 2870 (2011), subject to the recommendations presented in this report and CSIRO guidelines (CSIRO BTF 18, 2003). A preliminary site classification of 'P' should



be adopted, where footings are likely to be impacted by the presence of uncontrolled fill or soft foundation material, by cutting and filling of > 0.4 m thickness or by environments that could lead to exceptional moisture condition variations within foundation material, such as areas impacted by dam and drainage depression.

8. <u>Trafficability and Construction Assess</u>: Trafficability across exposed soil/subgrade materials is expected to be adequate in dry weather for most construction plant such as conventional rubber tyre plant, four-wheel drive plant and track mounted plant.

During wet weather, trafficability of all heavy machinery on exposed soil/sub-grade materials, particularly residual clay / silty clay, may be reduced. Provision for site grading, temporary open drains or toe/crest drains is suggested to collect any overland flow, prevent water ponding and hence minimise potential for any further soil/sub-grade softening or erosion, and to help improve trafficability. The use of granular fill or aggregate for temporary construction roads may be necessary to allow works during and immediately following wet weather.

## 4.5 Allowable Bearing Capacities

Table 8 presents allowable bearing capacities that may be adopted for design of shallow and deepened footings.



Table 8: Allowable bearing capacities.

Unit	Shallow Footings	Pile	es 1
Offili	ABC 2, 4	ABC 2, 4	ASF 3, 4
RESIDUAL: Silty CLAY / CLAY (stiff to very stiff) / 'Engineered' FILL <sup>5</sup>	100	NA 8	5
RESIDUAL: Silty CLAY / CLAY (hard)	250	NA <sup>8</sup>	20
WEATHERED ROCK: SHALE (very low to low strength)	350	700	60
WEATHERED ROCK: SHALE (low strength)	500	1000	150
WEATHERED ROCK: SHALE (medium strength)	1000	1500	250

#### Notes:

- 1. Assuming bored cast in-situ pile.
- 2. Allowable end bearing capacity (kPa) for footings embedded at least 0.3 m for lightly loaded footings, and piles embedded at least 0.5 m or 1 pile diameter, whichever is greater, into design material type subject to confirmation on site by a geotechnical engineer of inferred foundation conditions.
- 3. Allowable skin friction (kPa) below 1 m depth for bored pile in compression, assuming intimate contact between pile and foundation material. For up lift resistance, we recommend reducing ASF by 50% and checking against 'piston' and 'cone' pull-out mechanisms in accordance with AS2159 (2009).
- 4. ABC and ASF are given with estimated factors of safety of 3 and 2 respectively, generally adopted in geotechnical practice to limit settlement to an acceptable level for conventional building structures (< 1% of minimum footing width).</p>
- 5. Refer to earthworks in Section 4.4.



# 5 Proposed Additional Works

#### 5.1 Works at Construction Certificate

We recommend the following additional geotechnical assessments are carried out to develop the final design and prior to construction:

- 1. If higher end bearing pressures are required or to gain better understanding of rock conditions, carry out rock coring and point load testing of collected rock samples to assess rock strength.
- 2. Further salinity testing to confirm / revise preliminary salinity and exposure classifications and to delineate salinity conditions across soil profiles in development areas, if required, following consideration of final development details.
- 3. Review of the final design by a senior geotechnical engineer to confirm adequate consideration of the geotechnical risks and adoption of the recommendations provided in this report.

## 5.2 Construction Monitoring and Inspections

We recommend the following is inspected and monitored during construction of the project (Table 9).

**Table 9:** Recommended inspection / monitoring requirements during site works.

Scope of Works	Frequency/Duration	Who to Complete
Inspect excavation retention (shoring, retaining wall/anchoring) installations to assess need for additional support requirements.	Daily / As required <sup>2</sup>	Builder / MA <sup>1</sup>
Monitor groundwater seepage from excavation faces, if encountered, to assess stability of exposed materials, suitability of proposed drainage and additional drainage requirements.	When encountered	Builder / MA <sup>1</sup>
Inspect exposed material at foundation / subgrade level to verify suitability as foundation / lateral support / subgrade.	Prior to reinforcement set-up and concrete placement or fill placement	MA <sup>1</sup>
Quality Assurance of earthworks	During earthworks	NATA laboratory with MA audit and supervision
Monitor sedimentation downslope of excavated areas.	During and after rainfall events	Builder



Scope of Works	Frequency/Duration	Who to Complete
Monitor sediment and erosion control structures to assess adequacy and for removal of built up spoil.	After rainfall events	Builder

### Notes:

- 1. MA = Martens and Associates engineer
- 2. MA inspection frequency to be determined based on initial inspection findings in line with construction program.



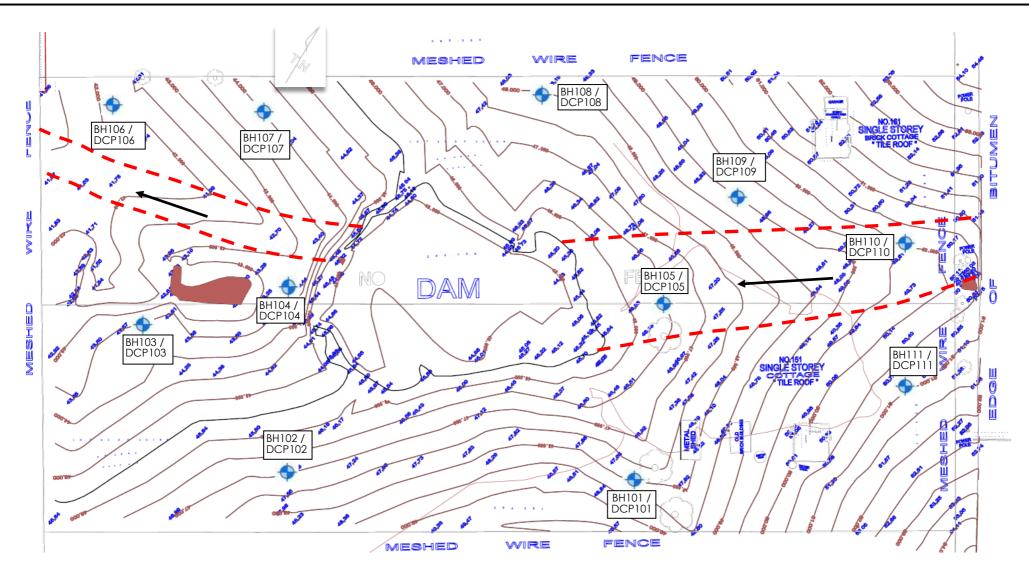
## 6 References

- Australian Geomechanics Society (2007) Practice Note Guidelines For Landslide Risk Management 2007, Journal and News of the Australian Geomechanics Society Volume 42 No 1 March 2007.
- Bertuzzi, R. and Pells, P. J. N. (2002) Geotechnical parameters of Sydney sandstone and shale, Australian Geomechanics, Vol. 37, No 5, pp 41-54.
- Cedar Surveying Services (2013) survey plan, Job No. 3828(2), dated November 2013 (CSS, 2013).
- Clark N. R. and Jones D. C. (1991) *Penrith 1:100 000 Geological Sheet 9030*, 1st edition, Geological Survey of New South Wales, Sydney.
- CSIRO BTF 18 (2003) Foundation Maintenance and Footing Performance: A homeowner's Guide.
- Department of Land and Water Conservation (DLWC, 2002) Site investigations for urban salinity.
- Hazelton, P. and Murphy, B. (2016) *Interpreting Soil Test Results*, CSIRO Publishing, Third Edition (Hazelton and Murphy, 2016).
- NSW Department of Environment & Heritage (eSPADE, NSW soil and land information), <a href="https://www.environment.nsw.gov.au">www.environment.nsw.gov.au</a>.
- PMDL (2019) Architectural Drawings, Project No. 2757, Drawing Nos. DA100, DA101, DA102, DA201 and DA301 and DA139 (PMDL, 2019).
- Standards Australia Limited (2017) AS 1726:2017, Geotechnical site investigations, SAI Global Limited.
- Standards Australia Limited (2011) AS 2870:2011, Residential slabs and footings, SAI Global Limited.
- Standards Australia Limited (2018) AS 3600:2018, Concrete Structures, SAI Global Limited.
- Western Sydney Regional Organisation of Councils (WSROC, 2003) Western Sydney Salinity Code of Practice.



7	Attachment A –	<b>Figures</b>
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Key:

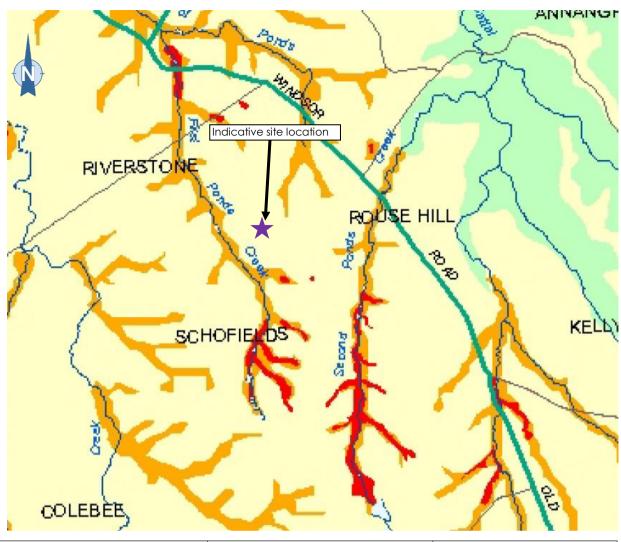
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Approximate borehole and DCP test location

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Indicative path of drainage depression

Martens & Associates Pty Ltd ABN 85	070 240 890	Environment   Water   Wastewater   Geotechnical   Civil   Ma	nagement
Drawn:	HN		Drawing:
Approved:	RE	GEOTECHNICAL SITE TESTING PLAN	FIGURE 1
Date:	22.05.2019	151 and 161 Tallawong Road, Rouse Hill, NSW	
	NA	(Source: CSS, 2013)	File No: P1806439JR01V02



MAPPING CATEGORY	ASSOCIATED SOIL LANDSCAPES	LANDFORM - GEOLOGY			
KNOWN SALINITY  Areas where there is a known occurrence of saline soil, or where air photo interpretation and field observations have confirmed more than one of these:  a - scalding  b - salt efflorescence c - vegetation dieback d - salt tolerant plant species e - waterlogging A high relative wetness index occurs in the se areas.	* Salinity outbreaks occur in Blacktown (bt), Luddenham (lu) and Richmond (ri) Soil Landscapes - common at breaks of slope, lower slopes and drainage lines. * Berk shire Park (bp) and Upper C astereagh (up) Soil Landscapes have localised salinity due to the impermeable nature of the day parent material.  * South Creek (sc), Monkey Creek (mk), Freemans Reach (fr) and Theres Park (tp) Soil Landscapes have common saline outbreaks due to high run-on and lowlocal relief.  * Soils in the above landscapes have high clay content in subsoils and are imperfectly to poorly drained.	* Break of slope, lower slope and drainage lines of Wilanamatta Shales (Rwb, Rwa and Rwm). * Localised salinity also occurs at the geological boundary between Tertiary Gravels (TI, Tr) and underlaying Wilanamatta Shales (Rwb, Rwa/ Quaternary Alluvials (Opd, Opa, Qn), Qal). * Localised salinity occurs in Quaternary Alluvium (Qal, Qpn, Qpd) with the drainage systems and wetland margins.			
HIGH SALINITY POTENTIAL  Areas where soil, geology, topography and groundwater conditions predispose a site to salinity. These conditions are similar to areas of known salinity (see above). These areas are most common in lower slopes and drainage systems where water accumulation is high (ie. high relative wetness index).	* Soil Land scapes include Birrong (bi), Blacktown (bi) Berkshire Park (bp), Freemans Reach (ft), South Creek(sc0, Theresa Park (tp), Richmond (ri) and Luddenham (u). Drainage systems and convergent slopes are areas of highest risk. * Soils in the se land scapes have high day content in the subsoils, lowperm eability and high run-on. * Soil profiles may display signs of high salt concentrations at depth (i.e. > 0.5m).	* Salinity is most likely to occur in lower slopes, foot-slopes, floodplains and creek lines on Quaternary Sediments (Qal, Qpn, Qpd, Qpc, Qpp, Qha)/Wanamatts Shales (Rwb, Rwn, Rwa) where run-on is high, resulting in seasonally high water tables and soil saturation.			
MODERATE SALINITY POTENTIAL  Areas on Wianamatta Group Shales and Tertiary Alluvial Terraces. Scattered areas of scalding and indicator vegetation have been noted but no concentrations have been mapped. Saline areas may occur in this zone, which have not yet been identified or may occur if risk factors change adversely.	* Areas of Agnes Banks (ab), Berkshire Park (bp), Blacktown (bt), Luddenham (lu) and Lucas Heights (lh).  * Steeper areas with moderate to high local relief and well drained subsoils such as Pidon (pn), West Pennart Hills (wp) and Glenorie (gn) are at a lower risk of developing salinty.  * Soils are moderate to well-drained due to their elevated position in the landscape.	* Hill-slopes and hill-crests on Wianamatta Shales (Rwb, Rwm, Rwa). * Raised abandoned alluvial terraces and drainage lines on Quatemary Alluvium (Qal, Qpn, Qpd, Qpc, Qpp) from Richmond to Camden and east to Rookwood. Localised areas of elevated, well-drained Tertiary Gravels (Ta, TI, Tr).			
VERY LOW SALINITY POTENTIAL  Areas where salinity processes do not operate or are of minor significance. Soils are rapidly drained and underlaying strata (Hawkesbury/Narrabeen Sand stone) are highly permeable, resulting in continual flushing and removal of salts in the landscape. No salinity has been observed in these areas and is not expected to occur.	* Rapidly drained soil landscapes with shallow soils include Warragamba (wb) and Hawkesbury (ha).  * Gymea (gy) and Faulconbridge (fb) Soil Landscapes consist of highly permeable sands with well-drained subsoils.  * Soils are well to rapidly drained.  * Soils have high sand content.	Occurring on Hawkesbury and Narrabeen Sandston (Rh, Rno).     Groundwater is relatively fresh in these areas due to the sandstone's elevated position in the landscape and highly permeable nature, resulting in continuous flushing of the system (removal of any accumulated salts).			

Martens & Associates Pty	<b>Ltd</b> ABN 85 070 240 890	Environment   Water   Wastewater   Geotechnical   C	Civil   Management
Drawn:	HN		Drawing No:
Approved:	RE	1:100,000 MAP OF SALINITY POTENTIAL IN WESTERN SYDNEY	FIGURE 2
Date:	22.05.2019	(Source: DIPNR, 2002)	
Scale:	Not to Scale		File No: P1806439JR01V02

Attachment B - Borehole Logs 8



CLI	ENT	T-	Γhe Sikl	h Gramı	mar School Sydney c/-	- PN	1DL		COMMENCED	31/05/2018	COMPLETED	31/0	05/20	18		REF	BH101
PR	OJEC	T F	relimina	ary Salir	nity and Geotechnical	Asse	essme	ent	LOGGED	DOs	CHECKED	HN/	RE			1	
SIT	E	1	51 and	161 Tal	llawong Rd, Rouse Hil	I, NS	SW		GEOLOGY	Bringelly Shale	VEGETATION	Gra	ss			Sheet	1 OF 1 NO. P1806439
EQI	JIPME	:NT			4WD truck-mounted hydr	aulic	drill rig	1	EASTING		RL SURFACE	48 r	n			DATUM	AHD
EXC	CAVAC	ION E	DIMENSI	ONS .	Ø100 mm x 2.70 m depth				NORTHING		ASPECT	Nor	th			SLOPE	<10%
		Dril	ling		Sampling	_			<u>'</u>		Field Material D	escr	iptio	n		•	
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION		OCK MATERIAL DE			MOISTURE	CONSISTENCY DENSITY	T000	AD OBSI	CTURE AND DITIONAL ERVATIONS
	L		-	48.00 0.20	6439/BH101/0.1/S/1 D 0.10 m					plasticity; brown; trace				VSt	TOPSO		
	-		-	47.80	6439/BH101/0.3/S/1 D		<u>×</u>		Silty CLAY; mediun gravels.	n to high plasticity; brow	wn; with fine shale				RESID	UAL SOIL	
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			2.5 —					-									
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CLI	ENI		The Sik	h Gram	mar School Sydney c/-	· PN	ИDL		COMMENCED	31/05/2018	COMPLETED	31/05/20	18		KEF	БП102
	OJEC	+			nity and Geotechnical			ent	LOGGED	DOs	CHECKED	HN/RE			Sheet	1 OF 1
SIT	E	1	51 and	161 Ta	llawong Rd, Rouse Hill	, N	SW		GEOLOGY	Bringelly Shale	VEGETATION	Grass			PROJECT	NO. P1806439
EQL	JIPME	NT			4WD truck-mounted hydra	aulio	drill rig	1	EASTING		RL SURFACE	47 m			DATUM	AHD
EXC	AVAT	ION [	DIMENS	IONS	Ø100 mm x 0.90 m depth				NORTHING		ASPECT	Northwes	st		SLOPE	5-10%
		Dri	lling		Sampling	_				Fi	ield Material D	escriptio	n			
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	<i>DEPTH</i> RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/RC	CK MATERIAL DESC	CRIPTION	MOISTURE	CONSISTENCY DENSITY		AD	CTURE AND DITIONAL ERVATIONS
	L			47.00 <b>0.10</b>			W	ML	TOPSOIL: Clayey S shale gravels.	ILT; low plasticity; brown;	trace fine to med			TOPSO		
		pə.	-	46.90	6439/BH102/0.1/S/1 D 0.10 m		<u>x</u> _	CF (	Silty CLAY; medium	to high plasticity; brown;	with fine to mediu	/		RESIDU	JAL SOIL	
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∢		Not F	0.5 —	0.70			<u>x</u>					(~~~	,			-
	Н		-	46.30	6439/BH102/0.8/S/1 D 0.80 m		×		Light brown.				Н			
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DEE BUILD

CLI	ENT	1	The Sik	h Gramı	mar School Sydney c/-	PMD			COMMENCED	31/05/2018	COMPLETED	31/0	5/20	18		REF	BH103
PR	OJEC	TF	Prelimina	ary Salir	nity and Geotechnical	Assess	smei	nt	LOGGED	DOs	CHECKED	HN/F	HN/RE Sheet 1.0F				
SIT	E	1	151 and	161 Ta	llawong Rd, Rouse Hil	, NSW	,		GEOLOGY	Bringelly Shale	VEGETATION	Gras	ss			Sheet	1 OF 1 NO. P1806439
EQI	JIPME	NT			4WD truck-mounted hydr	aulic dr	II rig		EASTING		RL SURFACE	43.5	m			DATUM	AHD
EXC	AVAT	ION [	DIMENSI	ONS .	Ø100 mm x 3.20 m depth				NORTHING		ASPECT	Nort	hwes	st		SLOPE	<5%
		Dri	lling		Sampling					Fi	ield Material D	escri	iptio	n		ļ.	I
МЕТНОБ	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/RC	SOIL/ROCK MATERIAL DESCRIPTION						AD	CTURE AND DITIONAL ERVATIONS
	L		-	43.50 0.20	6439/BH103/0.1/S/1 D 0.10 m			ML T		ILT; low plasticity; dark br					TOPSO		-
ADM	M 0.5 — 6439/BH103/0.5/S/1 D								ilty CLAY; medium nedium shale grave	to high plasticity; red/bro	wn; with fine to	(-	M < <pl< td=""><td></td><td>RESIDU</td><td>JAL SOIL</td><td>- - - - -</td></pl<>		RESIDU	JAL SOIL	- - - - -
AD/T	М	Not Encountered	1.0 —	2.50 41.00	6439/BH103/2.0/R/1 D 2.00 m			Sd			low strength;					HERED ROG	
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CL	IENT	T	The Sikh	n Gram	mar School Sydney c/-	- PN	ИDL		COMMENCED	31/05/2018	COMPLETED	31/0	5/20	18		REF	BH104
PF	OJEC	TF	relimina	ary Salir	nity and Geotechnical	Ass	essme	ent	LOGGED	DOs	CHECKED	HN/F	RE				
SI	ΓΕ	1	51 and	161 Ta	llawong Rd, Rouse Hil	l, N	SW		GEOLOGY	Bringelly Shale	VEGETATION	Gras	ss			Sheet	1 OF 1 NO. P1806439
EQ	UIPME	NT			4WD truck-mounted hydro	aulic	drill rig	ı	EASTING		RL SURFACE	43.4	m			DATUM	AHD
EX	CAVAT	ION [	DIMENSI	ONS	Ø100 mm x 0.60 m depth				NORTHING		ASPECT	Nort	hwes	st		SLOPE	<5%
		Dril	lling		Sampling				<u>'</u>	F	ield Material D	escri	iptio	n		!	
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	<i>DEPTH</i> RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/RC	OCK MATERIAL DESC	CRIPTION		MOISTURE CONDITION	CONSISTENCY DENSITY		AD	CTURE AND DITIONAL ERVATIONS
	L	ered	_	43.40	6439/BH104/0.1/S/1 D				FOPSOIL: SILT; low	v plasticity; brown.				s	TOPSO	DIL	_
ADM	L-M	Not Encountered	-	<b>0.20</b> 43.20	0.10 m		×	CI- S CH I	Silty CLAY; medium nedium shale grave	n to high plasticity; red/bro	own; with fine to	· — –	M < <pl< td=""><td>-</td><td>RESIDI</td><td>JAL SOIL</td><td></td></pl<>	-	RESIDI	JAL SOIL	
		_	0.5	0.60	6439/BH104/0.5/S/1 D		x										_
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CL	IENT		The Sikl	n Gram	mar School Sydney c/	- PN	1DL		COMMENCED	31/05/2018	COMPLETED	31/0	)5/20	18	F	REF	BH105
PF	OJEC	CT F	Prelimina	ary Salii	nity and Geotechnical	Ass	essme	nt	LOGGED	DOs	CHECKED	HN/	RE				
SI	ΓE	1	151 and	161 Ta	llawong Rd, Rouse Hil	II, NS	SW		GEOLOGY	Bringelly Shale	VEGETATION	Gra	ss			heet ROJECT	1 OF 1 NO. P1806439
EQ	UIPME	NT			4WD truck-mounted hydr	aulic	drill rig		EASTING		RL SURFACE	46.5	5 m			MUTA	AHD
EX	CAVAT	TION I	DIMENSI	ONS	Ø100 mm x 3.80 m depth	1			NORTHING		ASPECT	Wes	st		S	SLOPE	5-10%
_			illing		Sampling	_				F	ield Material D		·				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	<i>DEPTH</i> RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/RC	SOIL/ROCK MATERIAL DESCRIPTION HOLLINGS							CTURE AND DITIONAL ERVATIONS
	L		-	46.50 0.20	6439/BH105/0.1/S/1 D 0.10 m			ML T		ILT; light brown; trace fine	. — — — —			S-F	TOPSOIL		- -
Andersign and the consequence and ground their consequence and the	L-M	Not Encountered	1.0 —  1.5 —  2.0 —  3.5 —  4.0 —	2.10 44.40 3.20 43.30				CH G		to high plasticity; red/bro			M ( <pl< th=""><th>Vst</th><th>RESIDUĀ</th><th>t refusal o</th><th>n inferred very low to</th></pl<>	Vst	RESIDUĀ	t refusal o	n inferred very low to
			4.0 —														- - - - - - -
					EXCAVATION LOG TO	O BI	REA	D IN CO	ONJUCTION WI	TH ACCOMPANYING	REPORT NOT	ES A	AND	ABBI	REVIATIO	NS	
	r	na	art	en	S			Suite	201, 20 George S	ASSOCIATES PTY LTD St. Hornsby, NSW 2077 9999 Fax: (02) 9476 8	Australia			En		erin	g Log -

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BOREHOLE

CL	ENT	-	The Sikh	n Gram	mar School Sydney c/-	- PN	1DL		COMMENCED	31/05/2018	COMPLETED	31/0	05/20	18		REF	BH106
PROJECT Preliminary Salinity and Geotechnical Assessment LOGGED DOs CHE																]	
SIT	Έ	1	51 and	161 Ta	llawong Rd, Rouse Hill	l, NS	SW		GEOLOGY	Bringelly Shale	VEGETATION	Gra	ss			Sheet PROJECT	1 OF 1 NO. P1806439
EQI	JIPME	NT			4WD truck-mounted hydra	aulic	drill rig		EASTING		RL SURFACE	42 r	n			DATUM	AHD
EXC	CAVAC	TION E	DIMENSI	ONS	Ø100 mm x 0.85 m depth				NORTHING		ASPECT	We	st			SLOPE	5-10%
			ling		Sampling	_				F	ield Material D		r –	_	1		
МЕТНОБ	PENETRATION RESISTANCE	WATER	DEPTH (metres)	<i>DEPTH</i> RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/RC	OCK MATERIAL DESC	CRIPTION		MOISTURE	CONSISTENCY DENSITY		STRUCTURE AND ADDITIONAL OBSERVATIONS	
		42.00 ML TOPSOIL: Clayey SILT; low plasticity; grey/brown.												St	TOPSC		-
AD/V	L 1 41.80													JAL SOIL	- - - - - - - - - - - - - - - - - - -		
			1.0 —						Total reminated at							ength shale.	_ - - -
			1.5 —														- - - - -
			2.0														- - - -
			2.5 —														- - - -
,			3.0 —														- - - -
			3.5 —														- - -
			4.0														- - -
			4.5 — - - -														-
,	_				I EXCAVATION LOG TO	) BI	REA	D IN C	CONJUCTION WI	TH ACCOMPANYING	REPORT NOT	ES /	AND	ABB	REVIAT	TONS	
	/		) .					Cuit		ASSOCIATES PTY LTE				Fn	ain	eerin	a Loa -

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Engineering Log - BOREHOLE

CLIENT		1	Γhe Sikh	n Gram	mar School Sydney c/-	PΝ	IDL		COMMENCED	31/05/2018	COMPLETED 31/05			18	BH107		
PROJECT		T F	relimina	ary Salir	nity and Geotechnical	Ass	essme	ent	LOGGED	DOs	CHECKED	HN/	HN/RE Sheet				1.05.1
SIT	E	1	51 and	161 Ta	llawong Rd, Rouse Hill	, NS	GEOLOGY Bringelly Shale				VEGETATION	Gras	ss	1 OF 1 NO. P1806439			
EQI	JIPME	NT		4WD truck-mounted hydraulic drill rig					EASTING		RL SURFACE	44 n	n		С	DATUM	AHD
EXC	TAVA		DIMENSI	ONS	Ø100 mm x 1.30 m depth				NORTHING		ASPECT		Southwest SLOPE 5-10%				
Drilling Sampling								F	Field Material D		Ė						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	<i>DEPTH</i> RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/RC	OCK MATERIAL DES	CRIPTION		MOISTURE	CONSISTENCY DENSITY		ADI OBSE	CTURE AND DITIONAL ERVATIONS
			- -	44.00 <b>0.10</b> 43.90	6439/BH107/0.1/S/1 D 0.10 m		X	CI-	gravels.	y plasticity; brown; trace of to high plasticity; red/brooks.		: 		St	TOPSOIL RESIDUA		
AD/V	L-M	Not Encountered	0.5 —	0.90 43.10	6439/BH107/0.5/S/1 D 0.50 m				With grey.			(	M < <pl< td=""><td>VSt</td><td></td><td></td><td>- - - - -</td></pl<>	VSt			- - - - -
	М-Н		-	1.30	1.00 m		×		Hole Terminated at	1 20 m					1 30: V-bit	t refusal o	n inferred very low to
			2.5 —												lowstreng	ın snale.	
			-														-
B					EXCAVATION LOG TO	BI	REA	D IN C	ONJUCTION WI	TH ACCOMPANYING	REPORT NOT	ΓES A	AND	ABB	REVIATIO	ONS	
	/		24		_			Suite		ASSOCIATES PTY LTI St. Hornsby, NSW 2077				En	aine	erin	g Log -

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CLIENT		-	The Sikl	n Gramı	mar School Sydney c/	PMDL		COMMENCED	31/05/2018	COMPLETED 31/05/2018				REF	BH108	
PROJECT		CT F	Prelimina	ary Salir	nity and Geotechnical	DOs	CHECKED	HN/R	RE							
SIT	E	1	51 and	161 Ta	llawong Rd, Rouse Hil	, NSW		GEOLOGY	Bringelly Shale	VEGETATION	Grass	s			Sheet PROJECT	1 OF 1 NO. P1806439
EQI	JIPME	NT			4WD truck-mounted hydr	aulic drill r	ig	EASTING		RL SURFACE	48 m				DATUM	AHD
EXC	EXCAVATION DIMENSIONS Ø100 mm x 4.00 m depth							NORTHING		ASPECT	South	nwes	t		SLOPE	<5%
	Drilling Sampling						•	F	ield Material D		_					
МЕТНОБ	PENETRATION RESISTANCE	WATER	DEPTH (metres)	<i>DEPTH</i> RL	SAMPLE OR FIELD TEST	RECOVERED GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/RC	OCK MATERIAL DESC	CRIPTION	HOLLE	CONDITION	CONSISTENCY DENSITY		AD	ICTURE AND DITIONAL ERVATIONS
	L		_	48.00	0400/01400/04/04/0		ML	TOPSOIL: SILT; low	plasticity; dark brow; trac	ce clay.			St -	TOPSO	IL	
AD/V		Not Encountered	1.0 — 1.5 — 2.0 — 3.5 — 4.5 —	1.10 46.90 46.60	6439/BH108/0.1/S/1 D 0.10 m 6439/BH108/0.5/S/1 D 0.50 m		ML ChCH	Silty CLAY; medium shali fine to medium shali control fine to medium shali	to high plasticity; red/broe e gravels.  y; red/brown; with fine to regrey; inferred very low to	wn with grey; trac		-	St - VSt	RESIDU WEATH 1.40: V-	JAL SÕIL	EX
			-													
			-													
					EXCAVATION LOG TO	BE RE	AD IN C	ONJUCTION WI	TH ACCOMPANYING	REPORT NOT	TES AI	ND A	ABBI	REVIAT	IONS	
	<u>r</u>	na	art	en	S		Suit	e 201, 20 George S	ASSOCIATES PTY LTD St. Hornsby, NSW 2077 9999 Fax: (02) 9476 8	Australia		E	Ξn	gine	eerin	g Log -

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CL	ENT	1-	The Sikh	n Gramı	mar School Sydney c/-	PM	1DL		COMMENCED	31/05/2018	COMPLETED	31/0	)5/20°	18		REF	BH109
PROJECT Preliminary Salinity and G					ty and Geotechnical Assessment				LOGGED	DOs	CHECKED	HN/RE				1	
SIT	E	1	151 and 161 Tallawong Rd, Rouse Hill, NSW						GEOLOGY	Bringelly Shale	VEGETATION	Gra	Grass			Sheet	1 OF 1 NO. P1806439
EQ								EASTING		RL SURFACE	49 r				DATUM	AHD	
EXCAVATION DIMENSIONS Ø100					Ø100 mm x 4.00 m depth				NORTHING		ASPECT	Sou	thwes	st		SLOPE	5-10%
		Dril	ling		Sampling				•	ı	Field Material D	escr	iptio	n		1	
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION		CK MATERIAL DES			MOISTURE	CONSISTENCY DENSITY		AD OBSE	CTURE AND DITIONAL ERVATIONS
AD/V	L		0.5—	49.00 0.10 48.90 0.55 48.45	6439/BH109/0.1/S/1 D 0.10 m 6439/BH109/0.5/S/1 D 0.50 m		X ^ ^	CH m	ilty CLAY; medium ledium shale grave	grey; inferred very low to	prown; with fine to	(	M < <pl< td=""><td>)<sup>VSt</sup></td><td>WEATH 0.55: V-</td><td>UAL SOIL</td><td>CK</td></pl<>	) <sup>VSt</sup>	WEATH 0.55: V-	UAL SOIL	CK
			1.0 —														- - - -
	М	Intered	1.5 — - - -														- - - -
AD/T		Not Encountered	2.0 —														- - - -
			2.5 — - -												- - - -		
i.			3.0 —														- - - -
	н		3.5 —	<u>3.50</u> 45.50				lr	ferred low strength	1.							- - - -
			4.0  - - - 4.5 - -	4.00				Н	ole Terminated at	4.00 m							- - - - - -
	/		)1	on:	EXCAVATION LOG TO	BE	E REA		MARTENS &	TH ACCOMPANYING ASSOCIATES PTY LT St. Hornsby, NSW 2073	D	ΓES A					g Log -

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CLI	ENT	1	The Sikl	n Gramı	mar School Sydney c/-	- PMDL		COMMENCED	31/05/2018	COMPLETED	31/05	31/05/2018			REF	BH110
PR	OJEC	Preliminary Salinity and Geotechnical Assessment  151 and 161 Tallawong Rd, Rouse Hill, NSW					ent	LOGGED	DOs	CHECKED	HN/R	RE				
SIT	E	1	51 and	161 Tal	lawong Rd, Rouse Hil	I, NSW		GEOLOGY	Bringelly Shale	VEGETATION	Grass	s			Sheet PROJEC	1 OF 1 T NO. P1806439
EQL	JIPME	NT			4WD truck-mounted hydr	aulic drill ri	9	EASTING		RL SURFACE	50 m				DATUM	AHD
EXC	AVAT	ION [	DIMENSI	ONS ,	Ø100 mm x 2.70 m depth			NORTHING		ASPECT	South SLOPE 5-10			5-10%		
		Dri	lling		Sampling			•	F	ield Material D	escri	otio	n			
МЕТНОВ	PENETRATION RESISTANCE	WATER	DEPTH (metres)	<i>DEPTH</i> RL	SAMPLE OR FIELD TEST	RECOVERED GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/RC	MOISTURE CONDITION SOIL/ROCK MATERIAL DESCRIPTION SONDSISTENCY				CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS		
	L_		-	0.10 0.10 0.10 0.10 0.10					ILT; low plasticity; dark br to high plasticity; dark br				S	TOPSO RESIDU	IL JAL SOIL	
	L-M	red	0.5 — 1.0 —	<b>0.80</b> 49.20	6439/BH110/0.5/S/1 D 0.50 m 6439/BH110/1.0/S/1 D 1.00 m	x	CH C	CLAY; high plasticity	y; dark brown with red; wil	th fine shale grav	— - els.		St - VSt			- - - - - -
AD/V	М	1.00 m				ted/brown with gre	y bands.		(<	M <pl)< td=""><td>VSt</td><td></td><td></td><td>- - - - - -</td></pl)<>	VSt			- - - - - -		
,	I		- - - 2.5 —	2.70	2.00 m								Н			- - - -
			- 3.0 — - -				H	lole Terminated at	2.70 m						bit refusal ngth shale	on inferred very low to
			3.5 —													- - -
1			- - 4.0 —													- - -
			- - -													-
			4.5 — - - -													- - - -
<del>-</del>	<u> </u>			<u> </u>	 Excavation log to	D BE REA	D IN CC	ONJUCTION WI	TH ACCOMPANYING	REPORT NOT	TES A	ND.	L ABBI	L REVIAT	IONS	
4	<u>/</u> r	n/s	art	e n	<b>S</b>		Suite	201, 20 George S	ASSOCIATES PTY LTD St. Hornsby, NSW 2077	Australia		I	Ξn	gine	eerir	ng Log -

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CLIENT The Sikh Grammar School Sydney c/- PMDL						COMMENCED	31/05/2018	COMPLETED	31/0	)5/20	18		REF	BH111			
PRO	OJEC	ТР	relimina	ary Salir	nity and Geotechnical	Ass	essme	nt	LOGGED	DOs	CHECKED	HN/	RE			]	4.05.4
SIT	E	1	51 and	161 Ta	llawong Rd, Rouse Hill	, NS	SW		GEOLOGY	Bringelly Shale	VEGETATION	Gras	ss			Sheet PROJECT	1 OF 1 NO. P1806439
EQL	JIPME	NT			4WD truck-mounted hydra	aulic	drill rig		EASTING		RL SURFACE	51 n	n			DATUM	AHD
EXC	AVAT		IMENSI	ONS .	Ø100 mm x 1.10 m depth				NORTHING		ASPECT	Northwest SLOPE 5-10%			5-10%		
		Dril	ling		Sampling	_				F	ield Material D	-					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	<i>DEPTH</i> RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/RC	OCK MATERIAL DESC	CRIPTION		MOISTURE CONDITION	CONSISTENCY DENSITY		STRUCTURE AND ADDITIONAL OBSERVATIONS	
	_ L_	g	=	51.00 <i>0.10</i> 50.90	6439/BH111/0.1/S/1 D 0.10 m		X X	ML CI- CH	_ — — — — — —	ILT; low plasticity; brown. to high plasticity; brown/		 e			RESIDI	JAL SOIL	
AD/V	М	Not Encountered	0.5 —		6439/BH111/0.5/S/1 D 0.50 m		— × — × — ×					(	M < <pl< td=""><td>VSt</td><td></td><td></td><td>- - - - -</td></pl<>	VSt			- - - - -
	н		1.0 —	1.10			xx							н			- -
			_						Hole Terminated at	1.10 m					1.10: V low stre	-bit refusal o ength shale.	on inferred very low to -
			-														- -
			1.5 —														-
			-														-
			-														-
			2.0 —														-
			-														-
			-														-
			2.5														-
			=														-
			-														-
			3.0 —														-
			=														-
			-														-
			3.5 —														-
			-														-
			-														-
			=														-
			4.0 —														- -
			-														-
			-														-
			4.5 —														_
			=														- -
														-			
<u> </u>				-	EXCAVATION LOG TO	) Bi	RFA	D IN (	CONJUCTION WI	TH ACCOMPANYING	REPORT NOT	ES A	AND	ABR	REVIAT	TONS	
			) ,						MARTENS &	ASSOCIATES PTY LTI	o						a Loa -

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Engineering Log - BOREHOLE

Attachment C - DCP 'N' Counts 9



#### Dynamic Cone Penetrometer Test Log Summary



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Site	151 and 161 Tallawong Road, Rouse Hill, NSW	DCP Group Reference	P1806439JR01V01
Client	The Sikh Grammar School Sydney c/- PMDL	Log Date	31.05.18
Logged by	DOS		
Checked by	HN / RE		
Comments	DCPs commenced 50 mm below ground level.		

#### TEST DATA

						TEST DATA						
Depth Interval (m)	DCP 101	DCP 102	DCP 103	DCP 104	DCP 105	DCP 106	DCP 107	DCP 108	DCP 109	DCP 110	DCP 111	
0.15	13	10	12	2	3	5	5	6	9	2	12	
0.30	28	7	15	31	16	17	16	14	13	5	9	
0.45	30	14	18	40+	26	30 / 125 mm	19	11	16	6	9	
0.60	19	16	21	Terminated at	33	bounce at 0.475 m	16	17	19 / 100 mm	7	15	
0.75	18	22	26	0.5 m due to	30		27	23	bounce at 0.6 m	6	19	
0.90	27	24 / 100 mm	33	high 'N' counts	40+		35	15		7	25	
1.05	27 / 100 mm	bounce at 0.9 m	bounce at 0.95 m	riigir iv cooriis	Terminated at		40+	20 / 75 mm		6	35	
1.20	bounce at 1.05 m				0.95 m due to		Terminated at	bounce at 1.025 m		9	40+	
1.35					high 'N' counts		1.1 m due to			10	Terminated at	
1.50					riigir iv cooms		high 'N' counts			15	1.25 m due to	
1.65							mgir iv cooms			12	high 'N' counts	
1.80										15	riigir it cooms	
1.95										18		
2.10										20		
2.25										26 36		
2.40										36		
2.55										40+		
2.70										Terminated at		
2.85										2.6 m due to		
3.00										high 'N' counts		
3.15												
			-									
								_				

**Attachment D – Laboratory Test Certificates** 10





**Envirolab Services Pty Ltd** 

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

#### **CERTIFICATE OF ANALYSIS 193342**

Client Details	
Client	Martens & Associates Pty Ltd
Attention	Dan O'Sullivan
Address	Suite 201, 20 George St, Hornsby, NSW, 2077

Sample Details	
Your Reference	P1806439COC01V01
Number of Samples	24 Soil
Date samples received	05/06/2018
Date completed instructions received	05/06/2018

#### **Analysis Details**

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details		
Date results requested by	12/06/2018	
Date of Issue	08/06/2018	
NATA Accreditation Number 2901.	This document shall not be reproduced except in full.	
Accredited for compliance with ISC	D/IEC 17025 - Testing. Tests not covered by NATA are denoted with *	

**Results Approved By** 

Priya Samarawickrama, Senior Chemist

**Authorised By** 

Jacinta Hurst, Laboratory Manager



Misc Inorg - Soil						
Our Reference		193342-1	193342-2	193342-3	193342-4	193342-5
Your Reference	UNITS	6439/BH101/0.1/ S/1	6439/BH101/0.3/ S/1	6439/BH102/0.1/ S/1	6439/BH102/0.3/ S/1	6439/BH102/0.8/ S/1
Date Sampled		31/05/2018	31/05/2018	31/05/2018	31/05/2018	31/05/2018
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	07/06/2018	07/06/2018	07/06/2018	07/06/2018	07/06/2018
Date analysed	-	07/06/2018	07/06/2018	07/06/2018	07/06/2018	07/06/2018
pH 1:5 soil:water	pH Units	6.1	5.9	5.6	5.7	6.7
Electrical Conductivity 1:5 soil:water	μS/cm	100	44	89	61	180
Sulphate, SO4 1:5 soil:water	mg/kg	25	20	22	40	70

Misc Inorg - Soil						
Our Reference		193342-6	193342-7	193342-8	193342-9	193342-10
Your Reference	UNITS	6439/BH103/0.1/ S/1	6439/BH103/0.5/ S/1	6439/BH105/0.1/ S/1	6439/BH105/0.5/ S/1	6439/BH105/1.5/ S/1
Date Sampled		31/05/2018	31/05/2018	31/05/2018	31/05/2018	31/05/2018
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	07/06/2018	07/06/2018	07/06/2018	07/06/2018	07/06/2018
Date analysed	-	07/06/2018	07/06/2018	07/06/2018	07/06/2018	07/06/2018
pH 1:5 soil:water	pH Units	7.6	6.2	6.4	6.4	5.2
Electrical Conductivity 1:5 soil:water	μS/cm	88	200	82	84	290
Sulphate, SO4 1:5 soil:water	mg/kg	<10	190	30	120	<10

Misc Inorg - Soil						
Our Reference		193342-11	193342-12	193342-13	193342-14	193342-15
Your Reference	UNITS	6439/BH106/0.1/ S/1	6439/BH106/0.6/ S/1	6439/BH107/0.1/ S/1	6439/BH107/0.5/ S/1	6439/BH107/1.0/ S/1
Date Sampled		31/05/2018	31/05/2018	31/05/2018	31/05/2018	31/05/2018
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	07/06/2018	07/06/2018	07/06/2018	07/06/2018	07/06/2018
Date analysed	-	07/06/2018	07/06/2018	07/06/2018	07/06/2018	07/06/2018
pH 1:5 soil:water	pH Units	7.6	7.9	5.9	5.8	5.8
Electrical Conductivity 1:5 soil:water	μS/cm	56	42	51	30	59
Sulphate, SO4 1:5 soil:water	mg/kg	10	<10	22	37	69

Misc Inorg - Soil						
Our Reference		193342-16	193342-17	193342-18	193342-19	193342-20
Your Reference	UNITS	6439/BH108/0.1/ S/1	6439/BH108/0.5/ S/1	6439/BH108/1.3/ S/1	6439/BH109/0.1/ S/1	6439/BH109/0.5/ S/1
Date Sampled		31/05/2018	31/05/2018	31/05/2018	31/05/2018	31/05/2018
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	07/06/2018	07/06/2018	07/06/2018	07/06/2018	07/06/2018
Date analysed	-	07/06/2018	07/06/2018	07/06/2018	07/06/2018	07/06/2018
pH 1:5 soil:water	pH Units	5.9	5.6	5.4	5.8	6.1
Electrical Conductivity 1:5 soil:water	μS/cm	22	91	430	120	26
Sulphate, SO4 1:5 soil:water	mg/kg	10	61	<10	22	10

Misc Inorg - Soil					
Our Reference		193342-21	193342-22	193342-23	193342-24
Your Reference	UNITS	6439/BH110/0.1/ S/1	6439/BH110/0.5/ S/1	6439/BH110/1.0/ S/1	6439/BH110/2.0/ S/1
Date Sampled		31/05/2018	31/05/2018	31/05/2018	31/05/2018
Type of sample		Soil	Soil	Soil	Soil
Date prepared	-	07/06/2018	07/06/2018	07/06/2018	07/06/2018
Date analysed	-	07/06/2018	07/06/2018	07/06/2018	07/06/2018
pH 1:5 soil:water	pH Units	6.7	6.7	6.6	5.8
Electrical Conductivity 1:5 soil:water	μS/cm	86	28	28	57
Sulphate, SO4 1:5 soil:water	mg/kg	39	20	26	63

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

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Revision No: R00

QUALITY		Du	plicate		Spike Re	covery %				
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	193342-22
Date prepared	-			07/06/2018	1	07/06/2018	07/06/2018		07/06/2018	07/06/2018
Date analysed	-			07/06/2018	1	07/06/2018	07/06/2018		07/06/2018	07/06/2018
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	1	6.1	5.9	3	102	[NT]
Electrical Conductivity 1:5 soil:water	μS/cm	1	Inorg-002	<1	1	100	110	10	94	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	1	25	28	11	108	93

QUALIT		Du	plicate		Spike Re	covery %				
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-2	[NT]
Date prepared	-			[NT]	11	07/06/2018	07/06/2018		07/06/2018	
Date analysed	-			[NT]	11	07/06/2018	07/06/2018		07/06/2018	
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	11	7.6	7.7	1	102	
Electrical Conductivity 1:5 soil:water	μS/cm	1	Inorg-002	[NT]	11	56	57	2	96	
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	[NT]	11	10	10	0	91	

QUALITY CONTROL: Misc Inorg - Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	21	07/06/2018	07/06/2018			[NT]
Date analysed	-			[NT]	21	07/06/2018	07/06/2018			[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	21	6.7	6.9	3		[NT]
Electrical Conductivity 1:5 soil:water	μS/cm	1	Inorg-002	[NT]	21	86	75	14		[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	[NT]	21	39	38	3		[NT]

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

Blank This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.	ty Control Definitio	ns
	Blank glassware etc	
<b>Duplicate</b> This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.		
Matrix Spike  A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.	atrix Spike is to monitor t	
LCS (Laboratory Control Sample)  This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortice with analytes representative of the analyte class. It is simply a check sample.		
Surrogate Spike Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds while are similar to the analyte of interest, however are not expected to be found in real samples.		

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

#### **Laboratory Acceptance Criteria**

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

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Revision No: R00

ABN: 25 131 532 020

Sydney: 12/1 Boden Road Seven Hills NSW 2147 | PO Box 45 Pendle Hill NSW 2145

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## **Test Report**

Customer: Martens & Associates Pty Ltd Job number: 18-0078

Project:P1806439Report number: 1Location:The Sikh Grammar School SydneyPage: 1 of 1

## **Soil Index Properties**

Sampling method: Samples tested as received Test method(s): AS 1289.1.1, 2.1.1, 3.1.2, 3.2.1, 3.3.1

.3.4.1

			Results	
Laboratory sample no.	15410	15411	15412	
Customer sample no.	6439/BH103/ 0.5/S/1	6439/BH108/ 0.5/S/1	6439/BH108/ 1.3/S/1	
Date sampled	31/05/2018	31/05/2018	31/05/2018	
Material description	sandy silty CLAY, trace of gravel, brown mottled grey/red-brown	silty sandy CLAY, trace of gravel, brown mottled red- brown/grey	sandy silty CLAY, trace of gravel, red-brown mottled brown/grey	
Liquid limit (%)	55	46	60	
Plastic limit (%)	18	16	18	
Plasticity index (%)	37	30	42	
Linear shrinkage (%)	11.5	13.5	17.5	
Cracking / Curling / Crumbling	Cracking	Cracking	Cracking	
Sample history	Air dried	Air dried	Air dried	
Preparation	Dry sieved	Dry sieved	Dry sieved	

Approved Signatory: C. Greely Date: 21/06/2018



11	Attachment E – General Geotechnical Recommendations



# Geotechnical Recommendations

# Important Recommendations About Your Site (1 of 2)

These general geotechnical recommendations have been prepared by Martens to help you deliver a safe work site, to comply with your obligations, and to deliver your project. Not all are necessarily relevant to this report but are included as general reference. Any specific recommendations made in the report will override these recommendations.

#### **Batter Slopes**

Excavations in soil and extremely low to very low strength rock exceeding  $0.75\,\mathrm{m}$  depth should be battered back at grades of no greater than 1 Vertical (V): 2 Horizontal (H) for temporary slopes (unsupported for less than 1 month) and 1 V: 3 H for longer term unsupported slopes.

Vertical excavation may be carried out in medium or higher strength rock, where encountered, subject to inspection and confirmation by a geotechnical engineer. Long term and short term unsupported batters should be protected against erosion and rock weathering due to, for example, stormwater run-off.

Batter angles may need to be revised depending on the presence of bedding partings or adversely oriented joints in the exposed rock, and are subject to on-site inspection and confirmation by a geotechnical engineer. Unsupported excavations deeper than 1.0 m should be assessed by a geotechnical engineer for slope instability risk.

Any excavated rock faces should be inspected during construction by a geotechnical engineer to determine whether any additional support, such as rock bolts or shotcrete, is required.

#### **Earthworks**

Earthworks should be carried out following removal of any unsuitable materials and in accordance with AS3798 (2007). A qualified geotechnical engineer should inspect the condition of prepared surfaces to assess suitability as foundation for future fill placement or load application.

Earthworks inspections and compliance testing should be carried out in accordance with Sections 5 and 8 of AS3798 (2007), with testing to be carried out by a National Association of Testing Authorities (NATA) accredited testing laboratory.

#### **Excavations**

All excavation work should be completed with reference to the Work Health and Safety (Excavation Work) Code of Practice (2015), by Safe Work Australia. Excavations into rock may be undertaken as follows:

- 1. Extremely low to low strength rock conventional hydraulic earthmoving equipment.
- 2. <u>Medium strength or stronger rock</u> hydraulic earthmoving equipment with rock hammer or ripping tyne attachment.

Exposed rock faces and loose boulders should be monitored to assess risk of block / boulder movement, particularly as a result of excavation vibrations.

#### Fill

Subject to any specific recommendations provided in this report, any fill imported to site is to comprise approved material with maximum particle size of two thirds the final layer thickness. Fill should be placed in horizontal layers of not more than 300 mm loose thickness, however, the layer thickness should be appropriate for the adopted compaction plant.

#### **Foundations**

All exposed foundations should be inspected by a geotechnical engineer prior to footing construction to confirm encountered conditions satisfy design assumptions and that the base of all excavations is free from loose or softened material and water. Water that has ponded in the base of excavations and any resultant softened material is to be removed prior to footing construction.

Footings should be constructed with minimal delay following excavation. If a delay in construction is anticipated, we recommend placing a concrete blinding layer of at least 50 mm thickness in shallow footings or mass concrete in piers / piles to protect exposed foundations.

A geotechnical engineer should confirm any design bearing capacity values, by further assessment during construction, as necessary.

#### **Shoring - Anchors**

Where there is a requirement for either soil or rock anchors, or soil nailing, and these structures penetrate past a property boundary, appropriate permission from the adjoining land owner must be obtained prior to the installation of these structures.

#### **Shoring - Permanent**

Permanent shoring techniques may be used as an alternative to temporary shoring. The design of such structures should be in accordance with the findings of this report and any further testing recommended by this report. Permanent shoring may include [but not be limited to] reinforced block work walls, contiguous and semi contiguous pile walls, secant pile walls and soldier pile walls with or without reinforced shotcrete infill panels. The choice of shoring system will depend on the type of structure, project budget and site specific geotechnical conditions.

Permanent shoring systems are to be engineer designed and backfilled with suitable granular

## Important Recommendations About Your Site (2 of 2)

material and free-draining drainage material. Backfill should be placed in maximum 100 mm thick layers compacted using a hand operated compactor. Care should be taken to ensure excessive compaction stresses are not transferred to retaining walls.

Shoring design should consider any surcharge loading from sloping / raised ground behind shoring structures, live loads, new structures, construction equipment, backfill compaction and static water pressures. All shoring systems shall be provided with adequate foundation designs.

Suitable drainage measures, such as geotextile enclosed 100 mm agricultural pipes embedded in free-draining gravel, should be included to redirect water that may collect behind the shoring structure to a suitable discharge point.

#### **Shoring - Temporary**

In the absence of providing acceptable excavation batters, excavations should be supported by suitably designed and installed temporary shoring / retaining structures to limit lateral deflection of excavation faces and associated ground surface settlements.

#### **Soil Erosion Control**

Removal of any soil overburden should be performed in a manner that reduces the risk of sedimentation occurring in any formal stormwater drainage system, on neighbouring land and in receiving waters. Where possible, this may be achieved by one or more of the following means:

- 1. Maintain vegetation where possible
- 2. Disturb minimal areas during excavation
- 3. Revegetate disturbed areas if possible

All spoil on site should be properly controlled by erosion control measures to prevent transportation of sediments off-site. Appropriate soil erosion control methods in accordance with Landcom (2004) shall be required.

#### **Trafficability and Access**

Consideration should be given to the impact of the proposed works and site subsurface conditions on trafficability within the site e.g. wet clay soils will lead to poor trafficability by tyred plant or vehicles.

Where site access is likely to be affected by any site works, construction staging should be organised such that any impacts on adequate access are minimised as best as possible.

#### **Vibration Management**

Where excavation is to be extended into medium or higher strength rock, care will be required when using a rock hammer to limit potential structural distress from excavation-induced vibrations where nearby structures may be affected by the works.

To limit vibrations, we recommend limiting rock hammer size and set frequency, and setting the hammer parallel to bedding planes and along defect planes, where possible, or as advised by a geotechnical engineer. We recommend limiting vibration peak particle velocities (PPV) caused by construction equipment or resulting from excavation at the site to 5 mm/s (AS 2187.2, 2006, Appendix J).

#### Waste – Spoil and Water

Soil to be disposed off-site should be classified in accordance with the relevant State Authority guidelines and requirements.

Any collected waste stormwater or groundwater should also be tested prior to discharge to ensure contaminant levels (where applicable) are appropriate for the nominated discharge location.

MA can complete the necessary classification and testing if required. Time allowance should be made for such testing in the construction program.

#### Water Management - Groundwater

If the proposed works are likely to intersect ephemeral or permanent groundwater levels, the management of any potential acid soil drainage should be considered. If groundwater tables are likely to be lowered, this should be further discussed with the relevant State Government Agency.

#### Water Management – Surface Water

All surface runoff should be diverted away from excavation areas during construction works and prevented from accumulating in areas surrounding any retaining structures, footings or the base of excavations.

Any collected surface water should be discharged into a suitable Council approved drainage system and not adversely impact downslope surface and subsurface conditions.

All site discharges should be passed through a filter material prior to release. Sump and pump methods will generally be suitable for collection and removal of accumulated surface water within any excavations.

#### **Contingency Plan**

In the event that proposed development works cause an adverse impact on geotechnical hazards, overall site stability or adjacent properties, the following actions are to be undertaken:

- 1. Works shall cease immediately.
- The nature of the impact shall be documented and the reason(s) for the adverse impact investigated.
- A qualified geotechnical engineer should be consulted to provide further advice in relation to the issue.



Attachment F - Notes About This Report 12





## Important Information About Your Report (1 of 2)

These notes have been prepared by Martens to help you interpret and understand the limitations of your report. Not all are necessarily relevant to all reports but are included as general reference.

#### **Engineering Reports - Limitations**

The recommendations presented in this report are based on limited investigations and include specific issues to be addressed during various phases of the project. If the recommendations presented in this report are not implemented in full, the general recommendations may become inapplicable and Martens & Associates accept no responsibility whatsoever for the performance of the works undertaken.

Occasionally, sub-surface conditions between and below the completed boreholes or other tests may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact Martens & Associates.

Relative ground surface levels at borehole locations may not be accurate and should be verified by onsite survey.

#### **Engineering Reports - Project Specific Criteria**

Engineering reports are prepared by qualified personnel. They are based on 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 (e.g. a three storey building), the information and interpretation may not be relevant if the design proposal is changed (e.g. 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, which 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 not consulted.

#### **Engineering Reports - Recommendations**

Your report is based on the assumption that site conditions, as may be revealed through selective point sampling, are indicative of actual conditions throughout an area. This assumption often cannot be substantiated until project implementation has commenced. 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 investigations 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.

Martens 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 a site assessment and 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), desktop studies 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 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 in relation 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 will depend partly on test point

# Important Information About Your Report (2 of 2)

(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.
- o 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 logged 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, Martens will be pleased to assist with investigation or providing 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 / assessment.

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, Martens 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 Martens report, retain Martens to work with other project professionals 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 - Geo-environmental 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 Martens' proposal for works.

Specific sampling guidelines and specialist equipment, techniques and personnel are typically used to perform geo-environmental 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

Geo-environmental 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 recognise 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 relates. 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.

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#### **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 typically based on Australian Standard 1726 and the Unified Soil Classification System (USCS) – refer Soil Data Explanation of Terms (2 of 3). In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

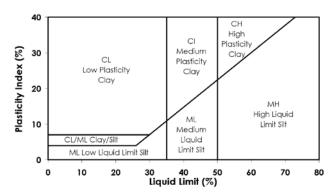
#### **Particle Size**

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

Division	Subdivision	Size (mm)
BOULDERS		>200
COBBLES		63 to 200
	Coarse	20 to 63
GRAVEL	Medium	6 to 20
Fine		2.36 to 6
	Coarse	0.6 to 2.36
SAND	Medium	0.2 to 0.6
Fine		0.075 to 0.2
SILT		0.002 to 0.075
CLAY		< 0.002

#### **Plasticity Properties**

Plasticity properties of cohesive soils can be assessed 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.

# Explanation of Terms (1 of 3)

#### **Consistency of Cohesive Soils**

Cohesive soils refer to predominantly clay materials.

Term	Cu (kPa)	Approx.	Field Guide
Very Soft	<12	2	A finger can be pushed well into the soil with little effort. Sample extrudes between fingers when squeezed in fist.
Soft	12 - 25	2 – 4	A finger can be pushed into the soil to about 25mm depth. Easily moulded in fingers.
Firm	25 - 50	4 – 8	The soil can be indented about 5mm with the thumb, but not penetrated. Can be moulded by strong pressure in the figures.
Stiff	50 - 100	8 – 15	The surface of the soil can be indented with the thumb, but not penetrated. Cannot be moulded by fingers.
Very Stiff	100 - 200	15 – 30	The surface of the soil can be marked, but not indented with thumb pressure. Difficult to cut with a knife. Thumbnail can readily indent.
Hard	> 200	> 30	The surface of the soil can be marked only with the thumbnail. Brittle. Tends to break into fragments.
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 standard penetration test (SPT) or Dutch cone penetrometer test (CPT) results as below:

Relative Density	%	SPT 'N' Value* (blows/300mm)	CPT Cone Value (q <sub>c</sub> 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

<sup>\*</sup> Values may be subject to corrections for overburden pressures and equipment type.

#### **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. 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 %



# Explanation of Terms (2 of 3)

#### Symbols for Soils and Other

SOILS

0 7

COBBLES/BOULDERS

GRAVEL (GP OR GW)



SILT (ML OR MH)

ORGANIC SILT (OH)

CLAY (CL, CI OR CH)



OTHER

FILL



TALUS



ASPHALT



CONCRETE

SILTY GRAVEL (GM)

SAND (SP OR SW)

SILTY SAND (SM)

CLAYEY GRAVEL (GC)



SANDY CLAY

SILTY CLAY



PEAT



TOPSOIL



CLAYEY SAND (SC)

# Unified Soil Classification Scheme (USCS)

	FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 63 mm and basing fractions on estimated mass)										
than		rse mm.	rse 1 mm.	rse mm.	AN VELS or no	W	vide range in grain siz	e and substantial amounts of all intermediate particle sizes.	GW	Gravel	
is larger		VELS alf of coa r than 2.C	CLEAN GRAVELS (Little or no fines)		Predominantly one	size or a range of sizes with more intermediate sizes missing	GP	Gravel			
OILS 63 mm i	(e)	GRAVELS More than half of coarse fraction is larger than 2.0 mm.	VELS FINES ciable int of ins of		Non-plastic fine	es (for identification procedures see ML below)	GM	Silty Gravel			
AINED So	aked ey	Mor	GRAVELS WITH FINES (Appreciable amount of fines)		Plastic fines	(for identification procedures see CL below)	GC	Clayey Gravel			
COARSE GRAINED SOILS More than 50 % of material less than 63 mm is larger than 0.075 mm	to the na	irse 0 mm	AN IDS or no		Wide range in grain	sizes and substantial amounts of intermediate sizes missing.	SW	Sand			
COA % of ma	visible	IDS alf of coa er than 2.	CLEAN SANDS (Little or no fines)		Predominantly one	SP	Sand				
than 50	particle	SAN e than ha is smalle	SAN e than ha is smalle	SAN e than ha is smalle	SANDS More than half of coarse fraction is smaller than 2.0 mm	IDS FINES ciable nt of ns)		Non-plastic fine	es (for identification procedures see ML below)	SM	Silty Sand
More	More than 5  Mallest partic SA More than fraction is sme fraction is sme (Appreciable amount of fines)				Plastic fines (for identification procedures see CL below)			Clayey Sand			
	the s		IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 MM								
FINE GRAINED SOILS More than 50 % of material less than 63 mm is smaller than 0.075 mm	0.075 mm particle is about the smallest particle visible to the naked eye)	DRY STRENG (Crushing Characteristi	DILATANO	CY	TOUGHNESS	DESCRIPTION	USCS	Primary Name			
LS than 6 nm	article i	None to Lo	Quick t	0	None	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	ML	Silt			
GRAINED SOILS f material less tl rr than 0.075 mr	d ww	Medium to High	None		Medium	Inorganic clays of low to medium plasticity <sup>1</sup> , gravely clays, sandy clays, silty clays, lean clays	CL <sup>2</sup>	Clay			
FINE GRAINED SOILS 50 % of material less tha smaller than 0.075 mm	(A 0.075	Low to Medium	Slow to V Slow	ery	Low	Organic slits and organic slity clays of low plasticity	OL	Organic Silt			
FINE of smalle	)	Low to Medium	Slow to Ve		Low to Medium	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	МН	Silt			
ore tha		High	None		High	Inorganic clays of high plasticity, fat clays	СН	Clay			
Ĭ		Medium to High	o None		Low to Medium	Organic clays of medium to high plasticity	ОН	Organic Silt			
	HIGHLY ORGANIC SOILS Readily identified by colour, odour, spongy feel and frequently by fibrous texture						Pt	Peat			

#### Notes:

- 1. Low Plasticity Liquid Limit  $W_L < 35 \%$  Medium Plasticity Liquid limit  $W_L 35 \text{ to } 60 \%$  High Plasticity Liquid limit  $W_L > 60 \%$ .
  - CI may be adopted for clay of medium plasticity to distinguish from clay of low plasticity.



# Explanation of Terms (3 of 3)

#### 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	Bolus coherent and rather spongy; smooth feel when Loam 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
НС	Heavy clay	Smooth plastic bolus; handles like stiff plasticine; can be moulded into rods without fracture; firm resistance to shearing	> 7.5	> 50



# Explanation of Terms (1 of 2)

#### Symbols for Rock

#### SEDIMENTARY ROCK

**BRECCIA** 



CONGLOMERATIC SANDSTONE

SANDSTONE/QUARTZITE

SILTSTONE MUDSTONE/CLAYSTONE

SHALE

METAMORPHIC ROCK



SLATE, PHYLLITE, SCHIST



**GNEISS** 



METASANDSTONE



METASILTSTONE



METAMUDSTONE



Descriptive terms used for Rock by Martens are based on AS1726 and encompass rock substance, defects and mass.

**GRANITE** 

COAL

LIMESTONE

LITHIC TUFF

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

DOLERITE/BASALT

terms. Rock substance is effectively homogeneous and may be isotropic or anisotropic.

**IGNEOUS ROCK** 

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

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 of decline in rock structure and grain property and can be determined in the field.

Term	Symbol	Definition
Residual soil <sup>1</sup>	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 <sup>1</sup>	EW	Rock substance affected by weathering to the extent that the rock exhibits soil properties - i.e. 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 <sup>2</sup>	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 <sup>2</sup>	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

- 1 Rs and EW material is described using soil descriptive terms.
- 2. The term "Distinctly Weathered" (DW) may be used to cover the range of substance weathering between EW and SW

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

Term	Is (50) MPa	Field Guide	Symbol
Very low	>0.03 ≤0.1	May be crumbled in the hand. Sandstone is 'sugary' and friable.	VL
Low	>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.	L
Medium	>0.3 ≤1.0	A piece of core 150mm long x 50mm diameter can be broken by hand with considerable difficulty. Readily scored with a knife.	М
High	>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.	Н
Very high	>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.	VH
Extremely high	>10	A piece of core 150mm long x 50mm diameter is difficult to break with hand held hammer. Rings when struck with a hammer.	EH



# Explanation of Terms (2 of 2)

#### 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 exclude fractures such as drilling breaks (DB) or handling breaks (HB).

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

#### **Rock Core Recovery**

TCR = Total Core Recovery

SCR = Solid Core Recovery

RQD = Rock Quality Designation

 $= \frac{\text{Length of core recovered}}{\text{Length of core run}} \times 100\%$ 

 $= \frac{\Sigma Length \, of \, cylindrical \, core \, recovered}{Length \, of \, core \, run} \times 100\%$ 

 $= \frac{\sum Axial \, lengths \, of \, core > 100 \, mm \, long}{Length \, of \, core \, run} \times 100\%$ 

#### **Rock Strength Tests**

- ▼ Point load strength Index (Is50) axial test (MPa)
- ► Point load strength Index (Is50) diametral test (MPa)
- Unconfined compressive strength (UCS) (MPa)

#### **Defect Type Abbreviations and Descriptions**

Defect Type (with inclination given)		Planarity		Roughness		
BP	Bedding plane parting	PI	Planar	Pol	Polished	
FL	Foliation	Cu	Curved	SI	Slickensided	
CL	Cleavage	Un	Undulating	Sm	Smooth	
JT	Joint	St	Stepped	Ro	Rough	
FC	Fracture	Ir	Irregular	VR	Very rough	
SZ/SS	Sheared zone/ seam (Fault)	Dis	Discontinuous			
CZ/CS	CZ/CS Crushed zone/ seam		s	Coating or Filling		
DZ/DS FZ IS VN CO HB DB		Thickness  Zone > 100 mm  Seam > 2 mm < 100 mm  Plane < 2 mm		Cn Clean Sn Stain Ct Coating Vnr Veneer Fe Iron Oxide X Carbonaceous Oz Quartzite MU Unidentified mineral		
		Inclination  Inclination of defect is measured from perpendicular to and down the core axis.  Direction of defect is measured clockwise (looking down core) from magnetic north.				

# Test, Drill and Excavation Methods Explanation of Terms (1 of 3)

#### 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 or excavation 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 sampling tube, e.g.  $U_{50}$  (50 mm internal diameter thin walled tube), into 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 / Excavation Methods**

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

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

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

<u>Test Pits</u> - these are excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils and, if it is safe to descend into the pit, collection of bulk disturbed samples. The depth of penetration is limited to about 3 m for a backhoe and up to 6 m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (e.g. Pengo) - the hole is advanced by a rotating plate or short spiral auger, generally 300 mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

<u>Continuous Sample Drilling (Push Tube)</u> - the hole is advanced by pushing a 50 - 100 mm 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.

<u>Continuous Spiral Flight Augers</u> - the hole is advanced using 90 - 115 mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling or insitu 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).

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

#### In-situ Testing and Interpretation

#### Cone Penetrometer Testing (CPT)

Cone penetrometer testing (sometimes referred to as Dutch Cone) described in this report has been carried out using an electrical friction cone penetrometer.

The test is described in AS 1289.6.5.1-1999 (R2013). In the test, a 35 mm 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 a separate 130 mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the push rod centre to an amplifier and recorder unit mounted on the control truck. As penetration occurs (at a rate of approximately 20 mm per second) the information is output on continuous chart recorders. The plotted results given in this report have been traced from the original records. The information provided on the charts comprises:

- (i) Cone resistance (qc) the actual end bearing force divided by the cross sectional area of the cone, expressed in MPa.
- (ii) Sleeve friction (q<sub>1</sub>) the frictional force of the sleeve divided by the surface area, expressed in kPa.
- (iii) 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:

 $q_c \text{ (MPa)} = (0.4 \text{ to } 0.6) \text{ N (blows/300 mm)}$ 

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

 $q_c = (12 \text{ to } 18) C_u$ 

# Test, Drill and Excavation Methods Explanation of Terms (2 of 3) Sequence of the estimate unconfined compressive to the field of the

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.

#### Standard Penetration Testing (SPT)

Standard penetration tests are used mainly in noncohesive 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 1289.6.3.1-2004. The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm penetration depth increments and the 'N' value is taken as the number of blows for the last two 150 mm depth increments (300 mm total penetration). In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued. The test results are reported in the following form:

Where full 450 mm penetration is obtained with successive blow counts for each 150 mm of say 4, 6 and 7 blows:

as 4, 6, 7 N = 13

(ii) 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 50 mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borehole logs in brackets.

#### 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 (PSP) - a 16 mm diameter flat ended rod is driven with a 9 kg hammer, dropping 600 mm. The test, described in AS 1289.6.3.3-1997 (R2013), was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling

Cone penetrometer (DCP) - sometimes known as the Scala Penetrometer, a 16 mm rod with a 20 mm diameter cone end is driven with a 9 kg hammer dropping 510 mm. The test, described in AS 1289.6.3.2-1997 (R2013), was developed initially for pavement sub-grade investigations, with correlations of the test results with California Bearing Ratio published by various Road Authorities.

#### **Pocket Penetrometers**

The pocket (hand) penetrometer (PP) is typically a light weight spring hand operated device with a stainless steel

strength, qu, (UCS in kPa) of a fine grained soil in field conditions. In use, the free end of the piston is pressed into the soil at a uniform penetration rate until a line, engraved near the piston tip, reaches the soil surface level. The reading is taken from a gradation scale, which is attached to the piston via a built-in spring mechanism and calibrated to kilograms per square centimetre (kPa) UCS. The UCS measurements are used to evaluate consistency of the soil in the field moisture condition. The results may be used to assess the undrained shear strength, Cu, of fine grained soil using the approximate relationship:

 $q_u = 2 \times C_u$ .

It should be noted that accuracy of the results may be influenced by condition variations at selected test surfaces. Also, the readings obtained from the PP test are based on a small area of penetration and could give misleading results. They should not replace laboratory test results. The use of the results from this test is typically limited to an assessment of consistency of the soil in the field and not used directly for design of foundations.

#### Test Pit / Borehole Logs

Test pit / borehole log(s) presented herein are an engineering and / or geological interpretation of the subsurface conditions. Their reliability will depend to some extent on frequency of sampling and methods 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 test pit / borehole logs 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 test pits / boreholes, the frequency of sampling and the possibility of other than 'straight line' variation between the test pits / boreholes.

#### **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.

#### **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.

# Test, Drill and Excavation Methods

# Explanation of Terms (3 of 3)

#### **DRILLING / EXCAVATION METHOD**

НА	Hand Auger	RD	Rotary Blade or Drag Bit	NQ	Diamond Core - 47 mm
AD/V	Auger Drilling with V-bit	RT	Rotary Tricone bit	NMLC	Diamond Core - 51.9 mm
AD/T	Auger Drilling with TC-Bit	RAB	Rotary Air Blast	HQ	Diamond Core - 63.5 mm
AS	Auger Screwing	RC	Reverse Circulation	HMLC	Diamond Core - 63.5 mm
HSA	Hollow Stem Auger	CT	Cable Tool Rig	DT	Diatube Coring
S	Excavated by Hand Spade	PT	Push Tube	NDD	Non-destructive digging
BH	Tractor Mounted Backhoe	PC	Percussion	PQ	Diamond Core - 83 mm
JET	Jetting	Ε	Tracked Hydraulic Excavator	Χ	Existing Excavation

#### **SUPPORT**

Nil	No support	S	Shotcrete	RB	Rock Bolt
С	Casing	Sh	Shoring	SN	Soil Nail
WB	Wash bore with Blade or Bailer	WR	Wash bore with Roller	T	Timberina

#### WATER

✓ Water level at date shown✓ Partial water loss✓ Water inflow✓ Complete water loss

GROUNDWATER NOT OBSERVED (NO)

The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.

GROUNDWATER NOT ENCOUNTERED (NX)

The borehole/test pit was dry soon after excavation. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period.

#### PENETRATION / EXCAVATION RESISTANCE

- L Low resistance: Rapid penetration possible with little effort from the equipment used.
- M Medium resistance: Excavation possible at an acceptable rate with moderate effort from the equipment used.
- H High resistance: Further penetration possible at slow rate & requires significant effort equipment.
- R Refusal/ Practical Refusal. No further progress possible without risk of damage/ unacceptable wear to digging implement / machine.

These assessments are subjective and dependent on many factors, including equipment power, weight, condition of excavation or drilling tools, and operator experience.

#### **SAMPLING**

D	Small disturbed sample	W	Water Sample	С	Core sample
В	Bulk disturbed sample	G	Gas Sample	CONC	Concrete Core

#### U63 Thin walled tube sample - number indicates nominal undisturbed sample diameter in millimetres

#### **TESTING**

SPT	Standard Penetration Test to AS1289.6.3.1-2004	CPT	Static cone penetration test
4,7,11	4,7,11 = Blows per 150mm.	CPTu	CPT with pore pressure (u) measurement
N=18	'N' = Recorded blows per 300mm penetration following 150mm seating	PP	Pocket penetrometer test expressed as instrument reading (kPa)
DCP	Dynamic Cone Penetration test to AS1289.6.3.2-1997. 'n' = Recorded blows per 150mm penetration	FP	Field permeability test over section noted
Notes:		VS	Field vane shear test expressed as uncorrected
RW	Penetration occurred under the rod weight only		shear strength (sv = peak value, sr = residual value)
HW	Penetration occurred under the hammer and rod weight	PM	Pressuremeter test over section noted
	only	PID	Photoionisation Detector reading in ppm
HB 30/80mm	Hammer double bouncing on anvil after 80 mm penetration	WPT	Water pressure tests
N=18	Where practical refusal occurs, report blows and penetration for that interval		

#### SOIL DESCRIPTION

#### **ROCK DESCRIPTION**

Density		Cons	Consistency		Moisture		gth	Weathering	
VL	Very loose	VS	Very soft	D	Dry	VL	Very low	EW	Extremely weathered
L	Loose	S	Soft	M	Moist	L	Low	HW	Highly weathered
MD	Medium dense	F	Firm	W	Wet	M	Medium	MW	Moderately weathered
D	Dense	St	Stiff	Wp	Plastic limit	Н	High	SW	Slightly weathered
VD	Very dense	VSt	Very stiff	WI	Liquid limit	VH	Very high	FR	Fresh
		Н	Hard			EH	Extremely high		