

Mr Elias, Mr Maltese and Mr Petro
C/- AE Design Partnership



Preliminary Salinity and Geotechnical
Assessment:
1111-1141 Elizabeth Drive, Cecil Park,
NSW

ENVIRONMENTAL



WATER



WASTEWATER



GEOTECHNICAL



CIVIL



PROJECT
MANAGEMENT



P1706121JR02V02
September 2018

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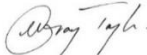
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Document and Distribution Status							
Author(s)		Reviewer(s)		Project Manager/ Director		Signature	
Hamed Naghibi		Ralph Erni		Gray Taylor			
Revision No.	Description	Status	Release Date	Document Location			
				File Copy	AE Design Partnership		
1	Preliminary Salinity and Geotechnical Assessment	Draft	02.02.2018	1H, 1P, 1E	1P		
1	Preliminary Salinity and Geotechnical Assessment	Final	11.04.2018	1H, 1P, 1E	1P		
2	Preliminary Salinity and Geotechnical Assessment	Final	06.09.2018	1H, 1P, 1E	1P		

Distribution Types: F = Fax, H = Hard copy, P = PDF document, E = Other electronic format. Digits indicate number of document copies.

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	1111-1141 Elizabeth Drive, Cecil Park, NSW ('the site')
Lot / DP	Lot 2, Section 4, DP 2954
LGA	Fairfield City Council (FCC)
Assessment Purpose	Preliminary salinity and geotechnical assessment to address requirements stated on Page 4 of State Significant Development - Secretary's Environmental Assessment Requirements (SEAR) by NSW Government, Department of Planning and Environment (reference document SSD8859 DOC/A3999091).
Site Area	7.38 ha (Project Surveyors, 2017)
Proposed development	We understand from a brief by the client and a subdivision layout that the development will include site subdivision for a new mixed-use highway service centre and associated internal access roads. Limited bulk excavation or filling (i.e. less than 1 m) will likely be required as part of associated construction works.
Investigation scope of work	<ul style="list-style-type: none"> o A general site walkover survey. o Nine boreholes (BH101 and BH109) up to 4.3 m below ground level (mBGL) (refer Attachment B, and associated explanatory notes in Attachment E). o Collection of soil and weathered rock samples for laboratory testing and future reference. <p>Investigation locations are shown in Figure 1, Attachment A.</p>

2 Findings

2.1 Site Details and Conditions

General site details are summarised in Table 2.

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

Item	Comment
Topography	Within slightly undulating terrain
Typical slopes, aspect, elevation	The site generally has a north westerly aspect across the western portion and north easterly aspect across the eastern portion, with grades generally < 10 %. Site elevation ranges between approximately 100 mAHD (northern boundary) and 117 mAHD (southern boundary).
Existing Development	<p>Current development, within the southern portion, includes a two storey brick house, a one storey fibro-cement house and four metal sheds.</p> <p>A man-made dam is located at the northern corner of the site. A drainage depression near the north western site boundary connects this site dam to another dam located approximately 60 m to the west of site.</p> <p>Signs of two smaller previously existing dams were observed in the north western portion of the site. A southeast to northwest aligned drainage channel along the central portion of the site intersects one of these smaller dams.</p>
Vegetation	Grass, shrubs and scattered trees within the southern and central portions of the site. Areas near the north eastern, northern, north western and western site boundaries are moderately to densely vegetated.
Drainage	Via overland flow into the drainage depressions and existing dam.
Expected soil landscape	The NSW Environment and Heritage eSPADE website identifies the site as having soils of the Luddenham soil landscape consisting of shallow dark podzolic soils or massive earthy clays on crests; moderately deep red podzolic soils on upper slopes; moderately deep yellow podzolic soils and prairie soils on lower slopes and drainage lines.
Sub-surface soil / rock units	<p><u>Unit A:</u> Topsoil comprising generally inferred soft to firm silt / clayey silt / silty clay up to approximately 0.5 mBGL.</p> <p><u>Unit B:</u> Residual soil as follows:</p> <ul style="list-style-type: none"> Areas within and adjacent to the previous / current dams, drainage depression and drainage channel: inferred firm to stiff silty clay up to approximately 1.5 mBGL, followed by inferred stiff clay up to approximately 4.3 mBGL. Deeper soil profile / increased rock weathering and lower material consistencies are inferred to be a result of surface water infiltration in dams and along the drainage depression / channel. The remainder of the site: generally inferred stiff to very stiff silty clay up to approximately 1.3 mBGL. <p><u>Unit C:</u> Weathered and inferred very low grading to low strength claystone up to TC-bit refusal at depths of between 1.1 mBGL and 3.3 mBGL. In BH108 (being close to the central drainage channel and previously existing smaller dam) drilling was terminated after V-bit refusal on inferred low strength claystone at a depth of approximately 4.8 mBGL (the depth to low to medium strength claystone is unknown).</p> <p>For the purpose of this report, rock below TC-bit refusal is assumed to be of low to medium strength with possible lower and / or higher strength bands. This should be confirmed / revised by further assessment, as necessary.</p>

Item	Comment
	Fill, comprising inferred firm clayey silt / silty clay, was encountered in BH101 and BH102 up to approximately 0.7 mBGL. It is expected to be present across the southern portion of the site and has likely been placed for previous development and / or landscaping purposes and is considered to be "uncontrolled".

3 Preliminary Hydrogeological Assessment

3.1 NSW Government Primary Industries Bore Search

A review of the NSW Department of Primary Industries Water (DPIW) real time groundwater bore database revealed that there is no bore located within 500 m of the site.

3.2 Groundwater observation

Groundwater inflow was not encountered during drilling of BH101 to BH107 and BH109 up to 3.3 mBGL. However, groundwater inflow was observed during drilling of BH108 at approximately 3.0 mBGL. excavation spoil below this depth, up to investigation termination depth of 4.30 mBGL (top of weathered rock), was encountered in a wet condition.

The groundwater is considered to be associated with seepage from the nearby central drainage channel and small dam.

3.3 Conclusion

Considering the proposed subdivision layout, we expect that the assumed limited bulk excavations for proposed development will not intercept the groundwater table.

Should further information on permanent site groundwater levels, particularly across the north and north western portions of the site (i.e. 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).

4 Salinity Assessment

4.1 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).

4.2 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.

4.3 Signs of Potential Saline Soils at the site

Signs of possible saline conditions were observed at the site; for example:

- Vegetation across some site portions appeared unhealthy and growth appeared inhibited.
- Evidence of concentrated surface erosion was observed.

4.4 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 observed. However, site dams, drainage depression / channel, irrigation of gardens as well as dams nearby the site may have influenced site soil salinity.

Shale soil landscapes	<p>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.</p> <p>Salt concentrations may increase where subsurface water accumulates and evaporates, e.g. on lower slopes or natural and constructed flats in mid-slope.</p> <p>Exacerbated by subsoils exposure through deep cutting, by installing buildings into the B-horizon and by impeding subsurface water flows.</p> <p>Highly dispersive, erodible and poorly draining sodic soils due to salinity.</p>	<p>Moderate to high – The site is underlain by low permeable clays, overlying claystone.</p> <p>Evidence of impeded surface vegetation growth and surface soil erosion observed.</p> <p>Water accumulation and evaporation of perched water in the existing / previous dam and drainage depression and drainage channel on site as well as nearby dams may have resulted in salt accumulation in clays.</p>
Deep groundwater salinity	<p>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.</p> <p>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.</p> <p>Exacerbated by buildings or infrastructure intercepting the zone of groundwater level fluctuation.</p>	<p>Low to Moderate – Groundwater inflow was observed at approximately 3.0 mBGL during drilling of one of the boreholes conducted near the drainage depression. This may have influenced site soil salinity within the north and north western portion of the site.</p> <p>Groundwater inflow was not encountered during drilling of the remaining boreholes up to 3.3 mBGL. The proposed development, which will not extend to the north western portion of the site, is not expected to intercept or raise groundwater levels.</p> <p>Proposed structures are to be constructed with appropriate drainage measures installed.</p>
Deeply weathered soil landscape	<p>High salt loads with high sulphate levels related to un-mapped deeply weathered soil landscapes beneath fluvial gravel, sand and clay.</p> <p>Usually in mid-slope or on hilltops affected by perched saline groundwater.</p>	<p>Moderate – No evidence of deeply weathered soils observed. Encountered soils on the site are residual.</p> <p>Deep weathering is likely to be present within / nearby existing drainage depression, drainage channel and dams.</p> <p>Perched saline groundwater may have influenced site soil salinity.</p>

4.5 Laboratory Testing

4.5.1 Overview

Sixteen soil samples were submitted to Envirolab Services, a National Association of Testing Authorities (NATA) accredited laboratory, for chemical testing (Electrical Conductivity (EC), pH and soluble SO₄). The testing 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.

4.5.2 Results – Salinity Classification

Laboratory test results for salinity classification are summarised in Table 4. A laboratory test certificate is provided in Attachment C.

Table 4: Salinity test results.

Sample ID ¹	Material	EC _(1:5) (dS/m)	EC _e (dS/m) ²	Salinity Classification ³
6121/101/1.0	Silty CLAY	0.440	3.08	Slightly saline
6121/102/1.0	Silty CLAY	0.180	1.26	Non-saline
6121/103/0.5	Silty CLAY	0.060	0.42	Non-saline
6121/103/0.9	Silty CLAY	0.056	0.39	Non-saline
6121/105/0.5	Silty CLAY	0.023	0.16	Non-saline
6121/106/0.5	Silty CLAY	0.044	0.31	Non-saline
6121/107/0.1	SILT	0.043	0.43	Non-saline
6121/107/0.5	Silty CLAY	0.120	0.96	Non-saline
6121/108/0.5	Silty CLAY	0.740	5.92	Moderately saline
6121/108/1.0	Silty CLAY	0.900	7.20	Moderately saline
6121/108/1.5	CLAY	0.720	5.04	Moderately saline
6121/108/2.0	CLAY	0.570	4.00	Moderately saline
6121/108/2.5	CLAY	0.790	5.53	Moderately saline
6121/109/0.5	Silty CLAY	0.240	1.68	Non-saline
6121/109/1.0	CLAY	0.460	3.22	Slightly saline
6121/109/1.5	CLAY	0.400	2.8	Slightly saline

Notes:

¹ Project#/Borehole#/Depth (mBGL).

² Based on EC to EC_e multiplication factors from Table 6.1 in DLWC (2002).

³ 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 can be summarised as the following:

- Dams, drainage depression, drainage channel and adjacent areas should be classified as moderately saline.
- Areas impacted by irrigation, such as gardens, should be classified as slightly saline.
- The remainder of the site can be classified as non-saline.

These areas are shown in Figure 1, Attachment A.

4.5.3 Results – Exposure Classification

Sulphate and pH test results for exposure classification are summarised in Table 5. A laboratory test certificate is presented in Attachment C.

Table 5: Exposure classification test results.

Sample ID ¹	EC _e (dS/m) ²	pH	Sulphate (SO ₄) (mg/kg)	Exposure Classification ³
6121/101/1.0	3.08	5.5	390	A1 / A2
6121/102/1.0	1.26	6.6	190	A1
6121/103/0.5	0.42	5.8	70	A1
6121/103/0.9	0.39	5.7	59	A1
6121/105/0.5	0.16	6.3	23	A1
6121/106/0.5	0.31	6.9	48	A1
6121/107/0.1	0.43	6.0	27	A1
6121/107/0.5	0.96	6.0	34	A1
6121/108/0.5	5.92	8.5	130	A2
6121/108/1.0	7.20	8.8	120	A2
6121/108/1.5	5.04	8.6	120	A2
6121/108/2.0	4.00	8.6	100	A2
6121/108/2.5	5.53	5.3	100	A2
6121/109/0.5	1.68	4.9	51	A2
6121/109/1.0	3.22	5.0	67	A2
6121/109/1.5	2.8	8.7	140	A1

Notes:

¹ Project#/Borehole#/Depth (mBGL).

² From table 4.

³ Exposure classification for buried reinforced concrete based on Tables 4.8.1 and 4.8.2 of AS 3600 (2009).

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

- A2 for areas impacted by irrigation of gardens, surrounding dams, drainage depression and drainage channel.
- A1 for the remainder of the site.

4.6 Salinity Recommendations

Given the presence of slightly and moderately saline soil conditions across the site, we recommend that saline soil management strategies are prepared at construction certificate stage following review of proposed development levels. There may also be a need to undertake additional sampling, depending on the proposed cut / fill and final development levels. Preliminary management strategies should include a combination of, but not be limited to, the following:

- Maintaining natural water balance.
- Limiting irrigation.
- Limiting soil disturbance as much as possible, such as cut and fill, so saline or sodic subsoils are not exposed or groundwater is not intercepted.
- Planting of suitable salt-tolerant plant species.
- Retention of existing deep-rooted vegetation.
- Offset landscaping and gardens from building and retaining walls.
- Treating soils with gypsum before landscaping to suit selective species.
- Where consistent with future land use and landscaping plan, planting of deep-rooted, preferably native, trees to increase water absorption.
- Sealing, e.g. by lining, of stormwater detention ponds and water features to reduce infiltration.
- Preparing sediment and erosion control plans that take into account saline soils.
- Replacing excavated soils in their original order.
- Any long term irrigation or watering on-site is to be at a level that does not cause groundwater to become perched.

Typical management strategies for new buildings and services include:

- Limiting soil disturbance as far as practicable, such as compaction of soils, cutting and filling.
- Designing and building structures to limit interference with natural water flow on site.
- Using appropriate construction materials and techniques to salt proof buildings and infrastructure.
- Utilising damp proof courses and water proofing of slabs.
- Using exposure grade bricks / masonry below damp course or in retaining walls.
- Providing concrete strength and cover to steel reinforcing in accordance with AS 3600 (2009) and the exposure classifications outlined in Section 4.5.3.
- Limiting excess surface water infiltration into the soil by designing, installing and maintaining appropriate stormwater drainage (gutters, downpipes, pits and pipes).
- Further assessment including laboratory testing, to improve characterisation of site salinity conditions, particularly in proposed development areas, and assess potential ensuing implications on the proposed development and mitigation requirements.

5 Geotechnical Assessment

5.1 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 6.

Table 6: Preliminary estimated soil and rock properties.

Layer ¹	$\gamma_{in-situ}$ ² (kN/m ³)	Cu ³ (kPa)	Φ' ⁴ (deg)	E' ⁵ (MPa)
TOPSOIL / uncontrolled FILL	16	NA ⁶	NA ⁶	NA ⁶
RESIDUAL SOIL: Silty CLAY (firm to stiff)	17	25-50	NA ⁶	5-10
RESIDUAL SOIL: CLAY / Silty CLAY (stiff to very stiff)	18	50-100	NA ⁶	10-20
WEATHERED ROCK: CLAYSTONE (very low grading to low strength)	22	NA ⁶	28	75
WEATHERED ROCK: CLAYSTONE (low to medium strength)	23	NA ⁶	30	200

Notes:

- 1 Refer to borehole logs in Attachment B for material description details.
- 2 Inferred average In-situ unit weight for layer, based on visual assessment only (± 2 kN/m³).
- 3 Undrained shear strength range estimate (± 5 kPa) assuming normally consolidated clay.
- 4 Average effective internal friction angle estimate ($\pm 2^\circ$) assuming drained conditions; may be dependent on rock defect conditions.
- 5 Effective elastic modulus estimate ($\pm 10\%$, range provided for soil, depending on consistency).
- 6 Not applicable.

5.2 Risk of Slope Instability

No evidence of former or current slope movement was observed at the 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.

5.3 Geotechnical Recommendations

The following specific recommendations are provided for the proposed development:

1. Footings and Foundations: Shallow footings, such as pad and strip footings, or slab-on-ground may be adopted founding on at least stiff residual silty clay, following removal of unsuitable materials, such as topsoil and uncontrolled fill, where present. Individual pad footings and all footings within the building footprint should not span the interface between different foundation materials. Alternatively, inclusion of movement joints may mitigate impacts of differential movements. Shallow footings may be designed adopting allowable end bearing capacities of 100 kPa for stiff to very stiff residual soil, 350 kPa for very low grading to low strength claystone and 700 kPa for low to medium strength claystone.

Deepened footings such as piles founding in rock may be considered. Estimates of safe end bearing pressure and shaft friction for piles founding in low to medium strength rock are 1200 kPa and 200 kPa, respectively. For uplift resistance, we recommend reducing allowable shaft friction by 50% and checking against 'piston' and 'cone' pull-out mechanisms in accordance with AS2159 (2009).

Provided bearing capacities assume an embedment of at least 0.3 m into the design unit. Bearing capacity values should be confirmed by a geotechnical engineer on site during construction, as detailed in Section 6.2.

Further testing is required for higher bearing pressures.

2. Drainage requirements: Appropriate surface drainage measures should be provided to divert overland flows away from structures and discharge into council approved discharge points.
3. Site Classification: 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 or by environments that could lead to exceptional moisture condition variations within foundation material, such as areas impacted by dams, drainage depression and drainage channel.

Further general geotechnical recommendations are provided in Attachment D.

6 Proposed Additional Works

6.1 Works Prior to 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, 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. Detailed design of foundation structures.
4. Additional advice by Martens and Associates (MA) for cut and fill requirements, if applicable, following consideration of final development details.
5. 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.

6.2 Construction Monitoring and Inspections

We recommend the following is inspected and monitored during construction of the project (Table 7).

Table 7: Recommended inspection / monitoring requirements during site works.

Scope of Works	Frequency/Duration	Who to Complete
Inspect exposed material at foundation / subgrade level to verify suitability as foundation / lateral support / subgrade.	Prior to reinforcement set-up and concrete placement	MA ¹
Monitor sedimentation downslope of excavated areas.	During and after rainfall events	Builder
Monitor sediment and erosion control structures to assess adequacy and for removal of built up spoil.	After rainfall events	Builder
Quality Assurance of earthworks	During earthworks	NATA laboratory with MA audit and supervision

Notes:

¹ MA = Martens and Associates engineer

² MA inspection frequency to be determined based on initial inspection findings in line with construction program.

- AE Design Partnership (2018), *Subdivision Layout*, Drawing No. DA04, dated July 2018.
- 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.
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- Department of Infrastructure Planning and Natural Resources (DIPNR, 2002) *Salinity Potential in Western Sydney Map*.
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- Project Surveyors (2017), Job Ref. B03838, Drawing Nos. B03838-1 to 3, dated July 2017.
- 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 (2009) AS 3600:2009, *Concrete Structures*, SAI Global Limited.
- Western Sydney Regional Organisation of Councils (WSROC, 2003) *Western Sydney Salinity Code of Practice*.

8 **Attachment A – Figures**



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Scale:	NA

Environment | Water | Wastewater | Geotechnical | Civil | Management

GEOTECHNICAL TESTING PLAN
1111-1141 Elizabeth Drive, Cecil Park, NSW
 (Source: Survey plan by Project Surveyors, Job Ref. B03838, dated July 2017)

Drawing:	FIGURE 1
Job No: P1706121JR02V02	



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 these areas.	* Salinity outbreaks occur in Blacktown (bt), Luddenham (lu) and Richmond (ri) Soil Landscapes - common at breaks of slope, lower slopes and drainage lines. * Berkshire Park (bp) and Upper Castlereagh (up) Soil Landscapes have localised salinity due to the impermeable nature of the clay parent material. * South Creek (sc), Monkey Creek (mk), Freemans Reach (fr) and Theresa Park (tp) Soil Landscapes have common saline outbreaks due to high run-on and low local 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 Wianamatta Shales (Rwb, Rwa and Rwm). * Localised salinity also occurs at the geological boundary between Tertiary Gravels (Tl, Tr) and underlying Wianamatta Shales (Rwb, Rwa/Quaternary Alluvials (Qpd, Qpa, Qpl, Qal). * Localised salinity occurs in Quaternary Alluvium (Qal, Qpn, Qpd) which underlies many of 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 on lower slopes and drainage systems where water accumulation is high (i.e. high relative wetness index).	* Soil Landscapes include Birrong (bi), Blacktown (bt) Berkshire Park (bp), Freemans Reach (fr), South Creek (sc), Theresa Park (tp), Richmond (ri) and Luddenham (lu). Drainage systems and convergent slopes are areas of highest risk. * Soils in these landscapes have high clay content in the subsoils, low permeability 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) Wianamatta Shales (Rwb, Rwm, 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 Pidgin (pn), West Pennant Hills (vp) and Glenorie (gn) are at a lower risk of developing salinity. * 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 Quaternary Alluvium (Qal, Qpn, Qpd, Qpc, Qpp) from Richmond to Camden and east to Rookwood. Localised areas of elevated, well-drained Tertiary Gravels (Ta, Tl, Tr).
VERY LOW SALINITY POTENTIAL Areas where salinity processes do not operate or are of minor significance. Soils are rapidly drained and underlying strata (Hawkesbury/Narrabeen Sandstone) 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 Sandstone (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).

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Environment | Water | Wastewater | Geotechnical | Civil | Management


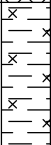
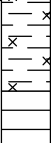
Drawn:	HN
Approved:	RE
Date:	22.01.2018
Scale:	Not to Scale

1:100,000 MAP OF SALINITY POTENTIAL IN WESTERN SYDNEY
(Source: DIPNR, 2002)

Drawing No:
FIGURE 2
File No: P1706121JR02V02

9 **Attachment B – Borehole Logs**

CLIENT	Mr Elias & Mr Maltese & Mr Petro.	COMMENCED	12/01/2018	COMPLETED	12/01/2018	REF BH101 Sheet 1 OF 1 PROJECT NO. P1706121	
PROJECT	Prelim. Salinity & Geotechnical Investigation	LOGGED	DO	CHECKED	HN/RE		
SITE	1111 - 1141 Elizabeth Drive, Cecil Park , NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass		
EQUIPMENT	4WD ute-mounted drill rig	EASTING		RL SURFACE	114 m	DATUM	AHD
EXCAVATION DIMENSIONS	ø100 mm x 3.30 m depth	NORTHING		ASPECT	NE	SLOPE	<5%

Drilling				Sampling		Field Material Description							
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY	DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADV	M			114.00				ML	FILL: Clayey SILT, low liquid limit, light brown, with fine grained gravels, inferred firm.				FILL
			0.5	113.50	P6121/101/0.5/S/1 D 0.50 m		CI	Silty CLAY, medium plasticity, brown and red-brown, some grey bands, inferred stiff to very stiff.		F	RESIDUAL SOIL		
			1.0		P6121/101/1.0/S/1 D 1.00 m				St - Vst				
			1.30	112.70									
AD/T	L	Not Encountered			P6121/101/1.5/R/1 D 1.50 m				CLAYSTONE, brown, inferred very low strength, distinctly weathered.				WEATHERED ROCK
			2.0		P6121/101/2.0/R/1 D 2.00 m					1.30: V-bit refusal.			
			2.5		P6121/101/2.5/R/1 D 2.50 m								
			3.0	111.00	P6121/101/3.0/R/1 D 3.00 m			Inferred low strength.					
			3.30						Hole Terminated at 3.30 m				3.30: TC-bit refusal on inferred low to medium strength claystone.
			3.5										
			4.0										
			4.5										

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



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**Engineering Log -
BOREHOLE**

CLIENT	Mr Elias & Mr Maltese & Mr Petro.	COMMENCED	12/01/2018	COMPLETED	12/01/2018	REF BH102 Sheet 1 OF 1 PROJECT NO. P1706121	
PROJECT	Prelim. Salinity & Geotechnical Investigation	LOGGED	DO	CHECKED	HN/RE		
SITE	1111 - 1141 Elizabeth Drive, Cecil Park , NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass		
EQUIPMENT	4WD ute-mounted drill rig	EASTING		RL SURFACE	113.5 m	DATUM	AHD
EXCAVATION DIMENSIONS	ø100 mm x 2.00 m depth	NORTHING		ASPECT	N	SLOPE	<5%

Drilling				Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS /ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADV	L	Not Encountered		113.50	P6121/102/0.1/S/1 D 0.10 m			CL- CI	FILL: Silty CLAY, low to medium plasticity, light brown, grey and red-brown, with fine to medium grained gravels, inferred firm.	D	F	FILL
			0.5	P6121/102/0.5/S/1 D 0.50 m								
			0.70									
			112.80									
AD/T	M	Not Encountered		1.0	P6121/102/1.0/S/1 D 1.00 m			CI	Silty CLAY, medium plasticity, red-brown, with grey bands, trace claystone gravels, inferred stiff to very stiff.	St - Vst		RESIDUAL SOIL
			1.10									
			112.40									
			1.5	P6121/102/1.5/R/1 D 1.50 m								
	L	Not Encountered		1.80					CLAYSTONE, brown, inferred very low strength, distinctly weathered.			WEATHERED ROCK 1.10: V-bit refusal.
			111.70									
			2.0									
			2.00									
	H	Not Encountered		2.0					Inferred low strength.			Hole Terminated at 2.00 m
		Not Encountered		2.5								2.00: TC-bit refusal on inferred low to medium strength claystone.
		Not Encountered		3.0								
		Not Encountered		3.5								
		Not Encountered		4.0								
		Not Encountered		4.5								

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


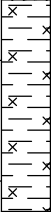










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**Engineering Log -
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CLIENT	Mr Elias & Mr Maltese & Mr Petro.	COMMENCED	12/01/2018	COMPLETED	12/01/2018	REF BH103 Sheet 1 OF 1 PROJECT NO. P1706121	
PROJECT	Prelim. Salinity & Geotechnical Investigation	LOGGED	DO	CHECKED	HN/RE		
SITE	1111 - 1141 Elizabeth Drive, Cecil Park , NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass		
EQUIPMENT	4WD ute-mounted drill rig	EASTING		RL SURFACE	107 m	DATUM	AHD
EXCAVATION DIMENSIONS	ø100 mm x 2.30 m depth	NORTHING		ASPECT	NE	SLOPE	<5%

Drilling				Sampling		Field Material Description								
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY	DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	
AD/V	L	Not Encountered		107.00	P6121/103/0.5/S/1 D 0.50 m P6121/103/0.9/S/1 D 0.90 m P6121/103/1.5/R/1 D 1.50 m P6121/103/2.0/R/1 D 2.00 m			ML	TOPSOIL: SILT, low liquid limit, light brown, with clay, inferred firm.	D	F		TOPSOIL	
			0.30											
	M			106.70				CI	Silty CLAY, medium plasticity, red-brown, with brown and grey bands, trace claystone gravels, inferred stiff to very stiff.		St - VSt	RESIDUAL SOIL		
			0.5											
AD/T	L	Not Encountered		1.00					CLAYSTONE, brown, inferred very low strength, distinctly weathered.				WEATHERED ROCK	
				106.00									1.00: V-bit refusal.	
			1.0											
			1.5											
AD/T	H	Not Encountered		1.70					Inferred low strength.					
				105.30										
			2.0											
			2.30											
				2.30					Hole Terminated at 2.30 m				2.30: TC-bit refusal on inferred low to medium strength claystone.	
				2.5										
				3.0										
				3.5										
				4.0										
				4.5										

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CLIENT	Mr Elias & Mr Maltese & Mr Petro.	COMMENCED	12/01/2018	COMPLETED	12/01/2018	REF BH104 Sheet 1 OF 1 PROJECT NO. P1706121	
PROJECT	Prelim. Salinity & Geotechnical Investigation	LOGGED	DO	CHECKED	HN/RE		
SITE	1111 - 1141 Elizabeth Drive, Cecil Park , NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass		
EQUIPMENT	4WD ute-mounted drill rig	EASTING		RL SURFACE	110 m	DATUM	AHD
EXCAVATION DIMENSIONS	ø100 mm x 1.10 m depth	NORTHING		ASPECT	NW	SLOPE	<5%

Drilling				Sampling			Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY	DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADV	L	Not Encountered		110.00	P6121/104/0.1/S/1 D 0.10 m P6121/104/0.5/S/1 D 0.50 m P6121/104/1.0/R/1 D 1.00 m			ML	TOPSOIL: SILT, low liquid limit, light brown, with clay, inferred firm.		F		TOPSOIL
	L-M					CI	Silty CLAY, medium plasticity, brown and red-brown, trace claystone gravels, inferred stiff to very stiff.	D	St - VSt	RESIDUAL SOIL			
	M												
	AD/T									CLAYSTONE, brown, inferred very low strength, distinctly weathered.			WEATHERED ROCK 0.80: V-bit refusal.
				1.10					Hole Terminated at 1.10 m				1.10: TC-bit refusal on inferred low to medium strength claystone.
			1.5										
			2.0										
			2.5										
			3.0										
			3.5										
			4.0										
			4.5										

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



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CLIENT	Mr Elias & Mr Maltese & Mr Petro.	COMMENCED	12/01/2018	COMPLETED	12/01/2018	REF BH105 Sheet 1 OF 1 PROJECT NO. P1706121	
PROJECT	Prelim. Salinity & Geotechnical Investigation	LOGGED	DO	CHECKED	HN/RE		
SITE	1111 - 1141 Elizabeth Drive, Cecil Park , NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass		
EQUIPMENT	4WD ute-mounted drill rig	EASTING		RL SURFACE	107 m	DATUM	AHD
EXCAVATION DIMENSIONS	ø100 mm x 1.40 m depth	NORTHING		ASPECT	NW	SLOPE	<5%

Drilling				Sampling		Field Material Description							
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY	DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	L	Not Encountered		107.00	P6121/105/0.1/S/1 D 0.10 m 0.30 106.70 P6121/105/0.5/S/1 D 0.50 m 0.70 106.30 P6121/105/1.0/R/1 D 1.00 m P6121/105/1.3/R/1 D 1.30 m			ML	TOPSOIL: SILT, low liquid limit, light brown, with clay, inferred firm.		F		TOPSOIL
	L-M					CI	Silty CLAY, medium plasticity, brown and red-brown, trace claystone gravels, inferred stiff to very stiff.	D	St - VSt	RESIDUAL SOIL			
	M-H						CLAYSTONE, brown, inferred very low strength, distinctly weathered.			WEATHERED ROCK 0.70: V-bit refusal.			
AD/T	L												
	M												
			1.5						Hole Terminated at 1.40 m				1.40: TC-bit refusal on inferred low to medium strength claystone.
			2.0										
			2.5										
			3.0										
			3.5										
			4.0										
			4.5										

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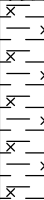
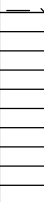



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BOREHOLE**

CLIENT	Mr Elias & Mr Maltese & Mr Petro.	COMMENCED	12/01/2018	COMPLETED	12/01/2018	REF BH106 Sheet 1 OF 1 PROJECT NO. P1706121	
PROJECT	Prelim. Salinity & Geotechnical Investigation	LOGGED	DO	CHECKED	HN/RE		
SITE	1111 - 1141 Elizabeth Drive, Cecil Park , NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass		
EQUIPMENT	4WD ute-mounted drill rig	EASTING		RL SURFACE	107 m	DATUM	AHD
EXCAVATION DIMENSIONS	ø100 mm x 1.90 m depth	NORTHING		ASPECT	NW	SLOPE	<5%

Drilling				Sampling			Field Material Description																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY	DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
ADV	L	Not Encountered		107.00	P6121/106/0.1/S/1 D 0.10 m			ML	TOPSOIL: Clayey SILT, low liquid limit, brown, trace fine to medium grained gravels, inferred firm.	D	F	St - Vst	TOPSOIL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
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			106.70	P6121/106/0.5/S/1 D 0.50 m			CI	Silty CLAY, medium plasticity, brown and red-brown, trace claystone gravels, inferred stiff to very stiff.	RESIDUAL SOIL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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AD/T	M	Not Encountered		1.00	P6121/106/1.0/S/1 D 1.00 m				CLAYSTONE, brown, inferred very low strength, distinctly weathered.				WEATHERED ROCK																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
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**Engineering Log -
BOREHOLE**

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CLIENT	Mr Elias & Mr Maltese & Mr Petro.	COMMENCED	12/01/2018	COMPLETED	12/01/2018	REF BH107 Sheet 1 OF 1 PROJECT NO. P1706121	
PROJECT	Prelim. Salinity & Geotechnical Investigation	LOGGED	DO	CHECKED	HN/RE		
SITE	1111 - 1141 Elizabeth Drive, Cecil Park , NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass		
EQUIPMENT	4WD ute-mounted drill rig	EASTING		RL SURFACE	104 m	DATUM	AHD
EXCAVATION DIMENSIONS	ø100 mm x 1.60 m depth	NORTHING		ASPECT	NE	SLOPE	<5%

Drilling				Sampling			Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY	DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	L	Not Encountered	104.00		P6121/107/0.1/S/1 D 0.10 m			ML	TOPSOIL: SILT, low liquid limit, light brown, with clay, inferred firm.		F		TOPSOIL
			0.30										
			103.70					CI	Silty CLAY, medium plasticity, brown and red-brown, trace claystone gravels, inferred stiff to very stiff.		D		RESIDUAL SOIL
			0.5		P6121/107/0.5/S/1 D 0.50 m						St - VSt		
AD/T	M		0.90										
			103.10		P6121/107/1.0/R/1 D 1.00 m				CLAYSTONE, brown, inferred very low strength, distinctly weathered.				WEATHERED ROCK 0.90: V-bit refusal.
			1.5		P6121/107/1.5/R/1 D 1.50 m								
			1.60										
			2.0						Hole Terminated at 1.60 m				1.60: TC-bit refusal on inferred low to medium strength claystone.
			2.5										
			3.0										
			3.5										
			4.0										
			4.5										

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


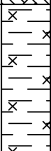
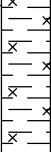






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**Engineering Log -
BOREHOLE**

CLIENT	Mr Elias & Mr Maltese & Mr Petro.	COMMENCED	12/01/2018	COMPLETED	12/01/2018	REF BH108 Sheet 1 OF 1 PROJECT NO. P1706121	
PROJECT	Prelim. Salinity & Geotechnical Investigation	LOGGED	DO	CHECKED	HN/RE		
SITE	1111 - 1141 Elizabeth Drive, Cecil Park , NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass		
EQUIPMENT	4WD ute-mounted drill rig	EASTING		RL SURFACE	105.5 m	DATUM	AHD
EXCAVATION DIMENSIONS	ø100 mm x 4.30 m depth	NORTHING		ASPECT	NW	SLOPE	<5%

Drilling				Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADV	L			105.50	P6121/108/0.1/S/1 0.10 m			ML	TOPSOIL: SILT, low liquid limit, brown, trace clay and organic materials, inferred soft to firm.		S - F	TOPSOIL
			0.5	105.00	P6121/108/0.5/S/1 0.50 m			CL- CI	Silty CLAY, low to medium plasticity, dark brown, with red bands, inferred firm to stiff.		D / M	RESIDUAL SOIL
			1.0		P6121/108/1.0/S/1 1.00 m						F - St	
			1.5	104.00	P6121/108/1.5/S/1 1.50 m			CL- CH	CLAY, medium to high plasticity, brown and red-brown, with fine grained claystone gravels, inferred stiff.		M	
			2.0		P6121/108/2.0/S/1 2.00 m							
	L-M	 Water inflow.	2.5		P6121/108/2.5/S/1 2.50 m						St	
			3.0									
			3.5									
			4.0									
			4.30									
			4.5						Hole Terminated at 4.30 m			4.30: V-bit refusal on inferred very low strength claystone.

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




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**Engineering Log -
BOREHOLE**

CLIENT	Mr Elias & Mr Maltese & Mr Petro.	COMMENCED	12/01/2018	COMPLETED	12/01/2018	REF BH109 Sheet 1 OF 1 PROJECT NO. P1706121	
PROJECT	Prelim. Salinity & Geotechnical Investigation	LOGGED	DO	CHECKED	HN/RE		
SITE	1111 - 1141 Elizabeth Drive, Cecil Park , NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass		
EQUIPMENT	4WD ute-mounted drill rig	EASTING		RL SURFACE	100.5 m	DATUM	AHD
EXCAVATION DIMENSIONS	ø100 mm x 1.80 m depth	NORTHING		ASPECT	NW	SLOPE	<10%

Drilling					Sampling		Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY	DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADV	L	Not Encountered		100.50 0.10	P6121/109/0.1/S/1 0.10 m			CL -	TOPSOIL: Silty CLAY, low to medium plasticity, brown and grey, inferred soft to firm. Silty CLAY, medium plasticity, brown and red-brown, trace claystone gravels, inferred firm to stiff.	S - F	D		TOPSOIL
				100.40			CI	RESIDUAL SOIL					
	L-M		0.5		P6121/109/0.5/S/1 0.50 m					F - St			
	M		1.0	1.00 99.50	P6121/109/1.0/S/1 1.00 m			CI	CLAY, medium plasticity, red-brown with grey bands, with fine grained claystone gravels, inferred stiff to very stiff.	St - VSt			
1.5		1.60 98.90	P6121/109/1.5/S/1 1.50 m										
AD/T				1.80					CLAYSTONE, brown, inferred very low strength, distinctly weathered.				WEATHERED ROCK 1.60: V-bit refusal.
			2.0						Hole Terminated at 1.80 m				1.80: TC-bit refusal on inferred low to medium strength claystone.
			2.5										
			3.0										
			3.5										
			4.0										
			4.5										

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



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**Engineering Log -
BOREHOLE**

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P1706121BH01V01180122.GPJ <DrawingFile> 01/02/2018 10:05 8.30.004 D:\ggl Lab and In Silu Tool - DGC\ Lib\Martens 2.00 2016-11-13 P1706121BH01V01180122.GPJ

10 Attachment C – Laboratory Test Certificate

CERTIFICATE OF ANALYSIS 183348

Client Details

Client	Martens & Associates Pty Ltd
Attention	Jeff Fulton, Hamed Naghibi
Address	Suite 201, 20 George St, Hornsby, NSW, 2077

Sample Details

Your Reference	<u>Preliminary Geotechnical and Salinity Assesment</u>
Number of Samples	16 Soil
Date samples received	16/01/2018
Date completed instructions received	16/01/2018

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	23/01/2018
Date of Issue	24/01/2018
Reissue Details	This report replaces R00 created on 19/01/2018 due to: sample ID error Client COC had old sample ID numbers. ID's have been ammended on advice from Daniel O'Sullivan.
NATA Accreditation Number 2901. This document shall not be reproduced except in full.	
Accredited for compliance with ISO/IEC 17025 - Testing. Tests not covered by NATA are denoted with *	

Results Approved By

Priya Samarawickrama, Senior Chemist

Authorised By



David Springer, General Manager

Client Reference: Preliminary Geotechnical and Salinity Assesment

Misc Inorg - Soil						
Our Reference		183348-1	183348-2	183348-3	183348-4	183348-5
Your Reference	UNITS	6121/BH101/1.0	6121/BH102/1.0	6121/BH103/0.5	6121/BH103/0.9	6121/BH105/0.5
Date Sampled		12/01/2018	12/01/2018	12/01/2018	12/01/2018	12/01/2018
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	18/01/2018	18/01/2018	18/01/2018	18/01/2018	18/01/2018
Date analysed	-	18/01/2018	18/01/2018	18/01/2018	18/01/2018	18/01/2018
pH 1:5 soil:water	pH Units	5.5	6.6	5.8	5.7	6.3
Electrical Conductivity 1:5 soil:water	µS/cm	440	180	60	56	23
Sulphate, SO4 1:5 soil:water	mg/kg	390	190	70	59	23

Misc Inorg - Soil						
Our Reference		183348-6	183348-7	183348-8	183348-9	183348-10
Your Reference	UNITS	6121/BH106/0.5	6121/BH107/0.1	6121/BH107/0.5	6121/BH108/0.5	6121/BH108/1.0
Date Sampled		12/01/2018	12/01/2018	12/01/2018	12/01/2018	12/01/2018
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	18/01/2018	18/01/2018	18/01/2018	18/01/2018	18/01/2018
Date analysed	-	18/01/2018	18/01/2018	18/01/2018	18/01/2018	18/01/2018
pH 1:5 soil:water	pH Units	6.9	6.0	6.1	8.5	8.8
Electrical Conductivity 1:5 soil:water	µS/cm	44	43	120	740	900
Sulphate, SO4 1:5 soil:water	mg/kg	48	27	34	130	120

Misc Inorg - Soil						
Our Reference		183348-11	183348-12	183348-13	183348-14	183348-15
Your Reference	UNITS	6121/BH108/1.5	6121/BH108/2.0	6121/BH109/0.5	6121/BH109/1.0	6121/BH109/1.5
Date Sampled		12/01/2018	12/01/2018	12/01/2018	12/01/2018	12/01/2018
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	18/01/2018	18/01/2018	18/01/2018	18/01/2018	18/01/2018
Date analysed	-	18/01/2018	18/01/2018	18/01/2018	18/01/2018	18/01/2018
pH 1:5 soil:water	pH Units	8.6	8.6	5.3	4.9	5.0
Electrical Conductivity 1:5 soil:water	µS/cm	720	570	240	460	400
Sulphate, SO4 1:5 soil:water	mg/kg	120	100	100	51	67

Misc Inorg - Soil		
Our Reference		183348-16
Your Reference	UNITS	6121/BH108/2.5
Date Sampled		12/01/2018
Type of sample		Soil
Date prepared	-	18/01/2018
Date analysed	-	18/01/2018
pH 1:5 soil:water	pH Units	8.7
Electrical Conductivity 1:5 soil:water	µS/cm	790
Sulphate, SO4 1:5 soil:water	mg/kg	140

Client Reference: Preliminary Geotechnical and Salinity Assesment

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 Analyser.

Client Reference: Preliminary Geotechnical and Salinity Assesment

QUALITY CONTROL: Misc Inorg - Soil					Duplicate			Spike Recovery %		
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			18/01/2018	1	18/01/2018	18/01/2018		18/01/2018	[NT]
Date analysed	-			18/01/2018	1	18/01/2018	18/01/2018		18/01/2018	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	1	5.5	5.5	0	102	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	1	440	390	12	102	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	1	390	380	3	115	[NT]

QUALITY CONTROL: Misc Inorg - Soil					Duplicate			Spike Recovery %		
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	11	18/01/2018	18/01/2018		[NT]	[NT]
Date analysed	-			[NT]	11	18/01/2018	18/01/2018		[NT]	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	11	8.6	8.6	0	[NT]	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	[NT]	11	720	750	4	[NT]	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	[NT]	11	120	110	9	[NT]	[NT]

Result Definitions

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

Quality Control Definitions

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.
Duplicate	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.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified 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 which 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.

11 **Attachment D – 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 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. Medium strength or stronger rock - 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.
2. The nature of the impact shall be documented and the reason(s) for the adverse impact investigated.
3. A qualified geotechnical engineer should be consulted to provide further advice in relation to the issue.

12 **Attachment E – Notes About This Report**

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 on-site 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:

- o Unexpected variations in ground conditions - the potential will depend partly on test point

(eg. excavation or borehole) spacing and sampling frequency, which are often limited by project imposed budgetary constraints.

- o 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.
- o 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.

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.

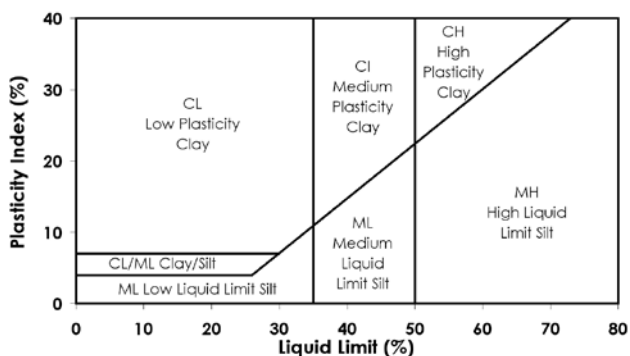
Particle Size

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
GRAVEL	Coarse	20 to 63
	Medium	6 to 20
	Fine	2.36 to 6
SAND	Coarse	0.6 to 2.36
	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.

Consistency of Cohesive Soils

Cohesive soils refer to predominantly clay materials.

Term	C _u (kPa)	Approx. SPT "N"	Field Guide
Very Soft	<12	2	A finger can be pushed well into the soil with little effort. 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 fingers.
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 _c MPa)
Very loose	< 15	< 5	< 2
Loose	15 - 35	5 - 10	2 - 5
Medium dense	35 - 65	10 - 30	5 - 15
Dense	65 - 85	30 - 50	15 - 25
Very dense	> 85	> 50	> 25

* 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 %

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 63 mm and basing fractions on estimated mass)					USCS	Primary Name	
COARSE GRAINED SOILS More than 50 % of material less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.0 mm.	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Gravel	
				Predominantly one size or a range of sizes with more intermediate sizes missing	GP	Gravel	
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	GM	Silty Gravel	
				Plastic fines (for identification procedures see CL below)	GC	Clayey Gravel	
		SANDS More than half of coarse fraction is smaller than 2.0 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of intermediate sizes missing.	SW	Sand	
				Predominantly one size or a range of sizes with some intermediate sizes missing	SP	Sand	
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	SM	Silty Sand	
				Plastic fines (for identification procedures see CL below)	SC	Clayey Sand	
FINE GRAINED SOILS More than 50 % of material less than 63 mm is smaller than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 MM					
		DRY STRENGTH (Crushing Characteristics)	DILATANCY	TOUGHNESS	DESCRIPTION	USCS	Primary Name
		None to Low	Quick to Slow	None	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	ML	Silt
		Medium to High	None	Medium	Inorganic clays of low to medium plasticity ¹ , gravely clays, sandy clays, silty clays, lean clays	CL ²	Clay
		Low to Medium	Slow to Very Slow	Low	Organic silts and organic silty clays of low plasticity	OL	Organic Silt
		Low to Medium	Slow to Very Slow	Low to Medium	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	MH	Silt
		High	None	High	Inorganic clays of high plasticity, fat clays	CH	Clay
		Medium to High	None	Low to Medium	Organic clays of medium to high plasticity	OH	Organic Silt
HIGHLY ORGANIC SOILS	Readily identified by colour, odour, spongy feel and frequently by fibrous texture				Pt	Peat	
Notes: 1. Low Plasticity – Liquid Limit $W_L < 35 \%$ Medium Plasticity – Liquid limit $W_L 35$ to 60% High Plasticity - Liquid limit $W_L > 60 \%$. 2. CI may be adopted for clay of medium plasticity to distinguish from clay of low plasticity.							

Soil Agricultural Classification Scheme

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

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

Symbols for Rock

SEDIMENTARY ROCK



BRECCIA



CONGLOMERATE



CONGLOMERATIC SANDSTONE



SANDSTONE/QUARTZITE



SILTSTONE



MUDSTONE/CLAYSTONE



SHALE



COAL



LIMESTONE



LITHIC TUFF

IGNEOUS ROCK



GRANITE



DOLERITE/BASALT

METAMORPHIC ROCK



SLATE, PHYLLITE, SCHIST



GNEISS



METASANDSTONE



METASILTSTONE



METAMUDSTONE

Definitions

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

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

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

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

Degree of Weathering

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

Term	Symbol	Definition
Residual soil ¹	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 ¹	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 ²	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 ²	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

Notes:

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

Rock strength is defined by the Point Load Strength Index (I_s 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	I_s (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.	M
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.	H
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

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

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

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

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

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
	PI Planar Cu Curved Un Undulating St Stepped Ir Irregular Dis Discontinuous	Pol Polished Sl Slicksided Sm Smooth Ro Rough VR Very rough
	Thickness Zone > 100 mm Seam > 2 mm < 100 mm Plane < 2 mm	Coating or Filling Cn Clean Sn Stain Ct Coating Vnr Veneer Fe Iron Oxide X Carbonaceous Qz Quartzite MU Unidentified mineral
BP Bedding plane parting FL Foliation CL Cleavage JT Joint FC Fracture SZ/SS Sheared zone/ seam (Fault) CZ/CS Crushed zone/ seam DZ/DS Decomposed zone/ seam FZ Fractured Zone IS Infilled seam VN Vein CO Contact HB Handling break DB Drilling break	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. U₅₀ (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.

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

Hand Auger - the hole is advanced by pushing and rotating either a sand or clay auger, generally 75-100 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.

Test Pits - these are excavated with a backhoe or a tracked excavator, allowing close examination of the in-situ 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.

Continuous Sample Drilling (Push Tube) - 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.

Continuous Spiral Flight Augers - the hole is advanced using 90 - 115 mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface or, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling - the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

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

Continuous Core Drilling - a continuous core sample is obtained using a diamond tipped core barrel 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 (q_c) - the actual end bearing force divided by the cross sectional area of the cone, expressed in MPa.
- (ii) Sleeve friction (q_f) - 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:

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

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)

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

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

Standard Penetration Testing (SPT)

Standard penetration tests are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample.

The test procedure is described in AS 1289.6.3.1-2004. 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:

- (i) 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

loading piston, used to estimate unconfined compressive strength, q_u , (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, C_u , 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

HA	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	E	Tracked Hydraulic Excavator	X	Existing Excavation

SUPPORT

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

WATER

- ☐ Water level at date shown
☐ Water inflow

- ☐ Partial water loss
☐ 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	C	Core sample
B	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.	FP	Field permeability test over section noted
	'n' = Recorded blows per 150mm penetration	VS	Field vane shear test expressed as uncorrected shear strength (sv = peak value, sr = residual value)
Notes:		PM	Pressuremeter test over section noted
RW	Penetration occurred under the rod weight only	PID	Photoionisation Detector reading in ppm
HW	Penetration occurred under the hammer and rod weight only	WPT	Water pressure tests
HB 30/80mm	Hammer double bouncing on anvil after 80 mm penetration		
N=18	Where practical refusal occurs, report blows and penetration for that interval		

SOIL DESCRIPTION

Density	Consistency	Moisture
VL Very loose	VS Very soft	D Dry
L Loose	S Soft	M Moist
MD Medium dense	F Firm	W Wet
D Dense	St Stiff	Wp Plastic limit
VD Very dense	VSt Very stiff	Wl Liquid limit
	H Hard	

ROCK DESCRIPTION

Strength	Weathering
VL Very low	EW Extremely weathered
L Low	HW Highly weathered
M Medium	MW Moderately weathered
H High	SW Slightly weathered
VH Very high	FR Fresh
EH Extremely high	