X-Travigant
C/- Precise Planning

martens consulting engineers

Preliminary Salinity Assessment: 30 Greenacre Drive, Tahmoor, NSW

P1706329JR01V01
January 2018

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

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

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Executive Summary

1. Background

A preliminary salinity assessment was undertaken to support a subdivision application. The objective included assessing the potential risk of soil salinity at the site associated with the proposed subdivision. This included a general site walkover, intrusive borehole drilling at 6 locations and collection of soil samples for laboratory chemical testing.

2. Assessment Results

Our findings are summarised as follows:

1. Site sub-surface materials consist of silt topsoil up to 0.4 m depth followed by residual clayey silt / silty clay / clay up to 1.7 m depth underlain by inferred low strength shale. Fill, encountered in two boreholes up to 0.8 mBGL, has likely been placed within the south eastern portion of the site for grading purposes.
2. Groundwater was not observed to investigation termination depths.
3. Twelve soil samples were sent to a NATA accredited laboratory for pH, EC and soluble sulfate testing. Results indicate that subsurface materials at tested locations are non-saline. It is expected that the site development will not be impacted by saline soils.
4. An exposure classification of 'A2' should be adopted in accordance with AS3600 (2009) for preliminary design of all buried concrete structures across the site.

3. Discussion and Conclusion

A specific saline soil management plan is not required. The site is considered acceptable for the proposed development.

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	30 Greenacre Drive, Tahmoor, NSW ('the site')
Lot / DP	Lot 7 in DP 263172
LGA	Wollondilly Shire Council (WSC)
Assessment Purpose	Preliminary salinity assessment to support a subdivision application.
Site Area	2.024 ha (based on SIX maps)
Proposed development	We understand from a plan of proposed subdivision that the development will include site subdivision for 35 low to medium density residential lots with internal access roads.
Investigation scope of work	o Six boreholes (BH101 to BH106) up to 1.7 m below ground level (mBGL) (refer Attachment B) o Collection of soil and weathered rock samples for laboratory testing and future reference Investigation locations are shown in Figure 1, Attachment A.

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. Bargo river is located approximately 300 m to the south of the site.
Typical slopes, aspect, elevation	North easterly aspect with grades generally < 10 %. Site elevation ranges between approximately 279 mAHD (south western corner) and 265 mAHD (north eastern corner).
Existing Development	A single storey brick rendered cottage, a pool and two metal cladding sheds
Vegetation	Grass and scattered trees
Drainage	Via overland flow to the north and northeast

Item	Comment
Sub-surface soil / rock units	Unit A: Topsoil comprising inferred firm silt up to approximately 0.4 mBGL. Unit B: Residual soil comprising inferred stiff grading to hard clayey silt / silty clay / clay up to approximately 1.7 mBGL. Unit C: Weathered and inferred low strength shale below V-bit refusal depths of between 1.1 mBGL (BH104) and 1.7 mBGL (BH106). Fill, encountered in BH102 and BH106 up to 0.8 mBGL, has likely been placed within the south eastern portion of the site for grading purposes.
Groundwater	Groundwater inflow was not encountered during drilling of the boreholes up to 1.7 mBGL. Should further information on permanent site groundwater levels be required, additional investigation would need to be carried out (i.e. installation of groundwater monitoring wells).

3 Salinity Assessment

3.1 Documented Salinity Risk Potential

The 1:100,000 *Salinity Potential in Western Sydney Map* (DIPNR, 2002) indicates the site to be located in an area of moderate salinity potential (Figure 2, Attachment A).

3.2 Broad Scale Salinity Processes

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

A list of key broad scale salinity processes likely to impact the site, including summarised descriptions of each process, is presented in Table 3.

3.3 Signs of Potential Saline Soils at the site

No obvious signs of saline conditions were observed at the site:

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

3.4 Assessed Salinity Risk Potential

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

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

Key salinity process	Description	Potential at subject site
Localised concentration of salinity	Localised concentration of salts due to relatively high evaporation rates. Usually associated with waterlogged soil and poor drainage. Exacerbated by increased water use and/ or blocking of surface and subsurface water flow associated with urban development.	Low – No evidence of localised salt concentration, waterlogged soil and poor drainage observed. However, nearby dams as well as Bargo river may have influenced site soil salinity.
Shale soil landscapes	In poorly drained duplex (texture contrast) soils, shallow subsurface water flows laterally across a clayey upper B-Horizon with salt usually accumulating in the clayey subsoil. Salt concentrations may increase where subsurface water accumulates and evaporates, e.g. on lower slopes or natural and constructed flats in mid-slope. Exacerbated by subsoils exposure through deep cutting, by installing buildings into the B-horizon and by impeding subsurface water flows. Highly dispersive, erodible and poorly draining sodic soils due to salinity.	Moderate to high – The site is underlain by low permeable silt and clay, overlying shale. Limited excavations are expected.
Deep groundwater salinity	Brackish or saline groundwater rises to a level where, through capillary action in the soil, the water with dissolved salts reaches the ground surface and evaporates, resulting in localised salt concentration. Groundwater rises are typically caused by increased water infiltration, e.g. above average rainfall, vegetation loss, irrigation, increased water use in urban areas, construction of surface pits. Exacerbated by buildings or infrastructure intercepting the zone of groundwater level fluctuation.	Low – Groundwater was not encountered in boreholes to 1.7 mBGL. The proposed development is not expected to intercept or raise groundwater levels. Proposed structures are to be constructed with appropriate drainage measures installed.
Deeply weathered soil landscape	High salt loads with high sulphate levels related to un-mapped deeply weathered soil landscapes beneath fluvial gravel, sand and clay. Usually in mid-slope or on hilltops affected by perched saline groundwater.	Low – No evidence of deeply weathered soils observed. Encountered soils on the site are residual.

3.5 Laboratory Testing

3.5.1 Overview

Twelve 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 SO_4). 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.

3.5.2 Results – Salinity Classification

Laboratory test results for salinity classification are summarised in Table 4. Laboratory test certificates are 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]
6329/BH101/0.1	SILT	0.150	1.500	Non-saline
6329/BH101/0.5	Clayey SILT	0.032	0.288	Non-saline
6329/BH102/0.1	SILT	0.098	0.980	Non-saline
6329/BH102/0.5	Clayey Silt	0.048	0.432	Non-saline
6329/BH102/1.0	Silty CLAY	0.021	0.168	Non-saline
6329/BH103/0.1	SILT	0.100	1.000	Non-saline
6329/BH103/0.5	Silty CLAY	0.050	0.400	Non-saline
6329/BH103/1.4	CLAY	0.100	0.700	Non-saline
6329/BH104/0.1	SILT	0.042	0.420	Non-saline
6329/BH104/0.5	SILT	0.028	0.280	Non-saline
6329/BH105/0.5	Clayey SILT	0.032	0.288	Non-saline
6329/BH105/1.0	Silty CLAY	0.039	0.312	Non-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 indicate that subsurface materials at tested locations can be categorised as non-saline.

3.5.3 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]
6308/BH101/0.4	1.500	6.3	28	A1
6308/BH101/0.7	0.288	6.0	31	A1
6308/BH102/0.1	0.980	6.2	66	A1
6308/BH102/1.2	0.432	5.5	43	A1/A2
6308/BH103/0.1	0.168	6.0	10	A1
6308/BH103/0.5	1.000	6.1	31	A1
6308/BH103/1.0	0.400	6.5	29	A1
6308/BH104/0.1	0.700	5.4	<10	A2
6308/BH104/0.4	0.420	5.8	10	A1
6308/BH104/1.1	0.280	5.9	10	A1
6308/BH105/0.4	0.288	6.1	31	A1
6308/BH105/0.7	0.312	5.6	24	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).

3.6 Conclusions and Recommendations

We conclude and recommend the following:

- Subsurface materials at tested locations are categorised as non-saline. No specified saline soil management strategies are required.
- An exposure classification of 'A2' should be adopted for preliminary design of buried concrete structures in accordance with AS3600 (2009).
- Carry out further assessment, including laboratory testing, to confirm characterisation of site salinity conditions, particularly in

proposed development areas, and assess potential ensuing implications following consideration of final development details.

4 References

Australian Survey Solutions (2017) Plan of proposed subdivision of lot 7 DP 263172 "30 GREENACRE DR, TAHMOOR", Ref 170719, Rev A, dated 28 Nov 2017.

Department of Infrastructure Planning and Natural Resources (DIPNR, 2002) *Salinity Potential in Western Sydney Map.*

Department of Land and Water Conservation (DLWC, 2002) *Site investigations for urban salinity.*

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.

Stroud W. J., Sherwin L., Roy H. N. and Baker C. J. (1985) *Wollongong - Port Hacking 1:100 000 Geological Sheet 9029-9129*, 1st edition, Geological Survey of New South Wales, Sydney.

Western Sydney Regional Organisation of Councils (WSROC, 2003) *Western Sydney Salinity Code of Practice.*

5 Attachment A – Figures

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Key:

⊕	Approximate borehole location
- - -	Indicative site boundary

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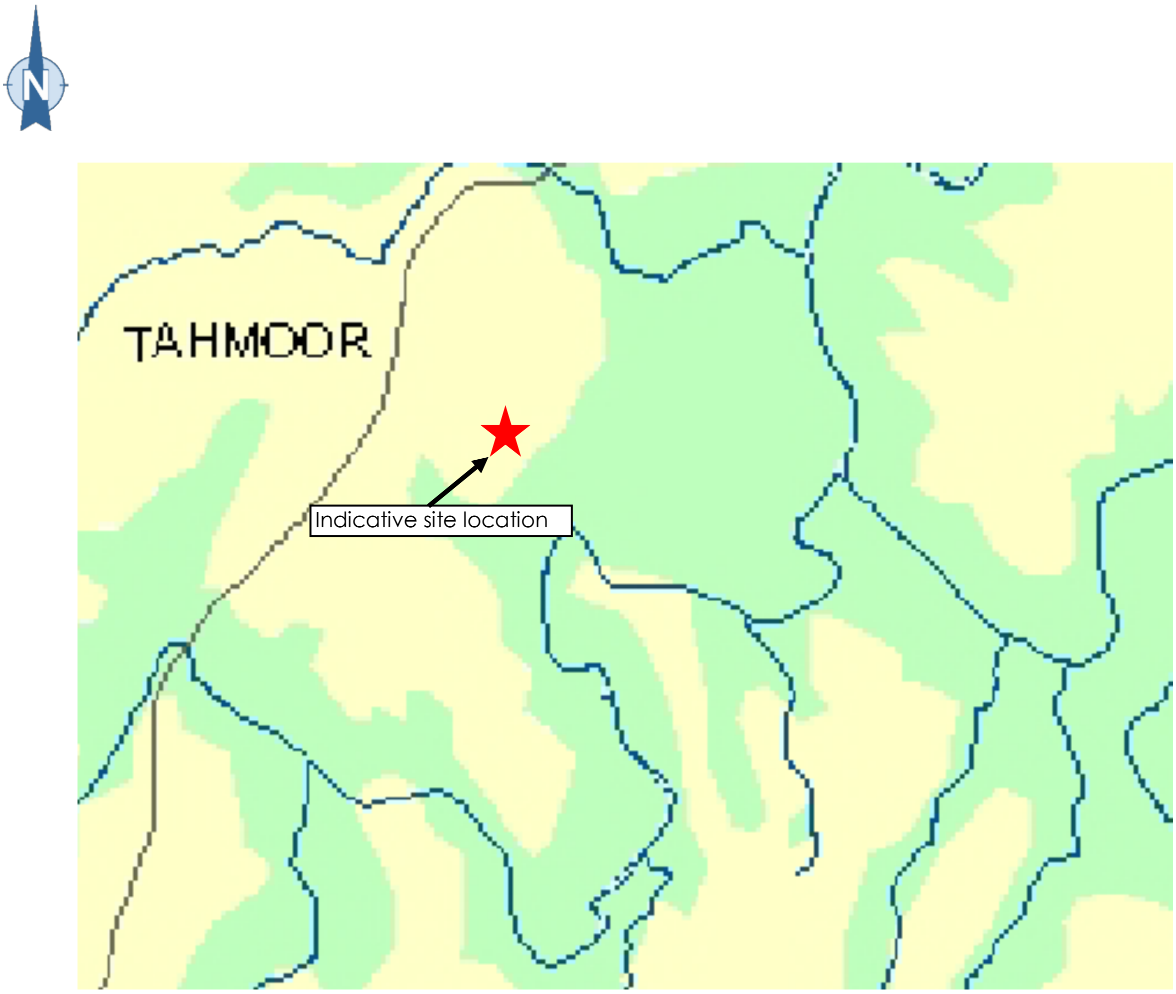
Drawn:	OT
Approved:	HN
Date:	02.01.2018
Scale:	NA

GEOTECHNICAL TESTING PLAN
30 Greenacre Drive, Tahmoor, NSW
(Source: Nearmap, 2017)

Drawing:
FIGURE 1

Job No: P1706329JR01V01



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 underlaying 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 in lower slopes and drainage systems where water accumulation is high (ie. high relative wetness index).	* Soil Landscapes include Birrong (bi), Blacktown (bt) Berkshire Park (bp), Freemans Reach (fr), South Creek(sc0, 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, Rwn, Rwa) where run-on is high, resulting in seasonally high water tables and soil saturation.
🟨	**MODERATE SALINITY POTENTIAL** Areas on Wianamatta Group Shales and Tertiary Alluvial Terraces. Scattered areas of scalding and indicator vegetation have been noted but no concentrations have been mapped. Saline areas may occur in this zone, which have not yet been identified or may occur if risk factors change adversely.	* Areas of Agnes Banks (ab), Berkshire Park (bp), Blacktown (bt), Luddenham (lu) and Lucas Heights (lh). * Steeper areas with moderate to high local relief and well drained subsoils such as Picton (pn), West Pennant Hills (wp) and Glenorie (gn) are at a lower risk of developing salinty. * Soils are moderate to well-drained due to their elevated position in the landscape.	* Hill-slopes and hill-crests on Wianamatta Shales (Rwb, Rwn, 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 underlaying 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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Drawn:	OT	**1:100,000 MAP OF SALINITY POTENTIAL IN WESTERN SYDNEY** (Source: DIPNR, 2002)	Drawing No: **FIGURE 2**
Approved:	HN		
Date:	02.01.2018		
Scale:	Not to Scale		File No: P1706329JR01V01

6 Attachment B – Borehole Logs

CLIENT	X-Travigant C/- Precise Planning	COMMENCED	23/11/2017	COMPLETED	23/11/2017	**REF BH101**
PROJECT	Preliminary Salinity Assessment	LOGGED	DO	CHECKED		Sheet 1 OF 1
SITE	30 Greenacre Dr, Tahmoor, NSW	GEOLOGY	Ashfield Shale	VEGETATION	Grass	PROJECT NO. P1706329

EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	273 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.50 m depth	NORTHING		ASPECT	Northeast	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
AD/V	L	Not Encountered		273.00	P6329/101/0.1/S/1 D 0.10 m			ML	SILT, low liquid limit, dark brown, with organic materials, with fine to medium shale gravels, inferred firm.	D	F	TOPSOIL
			0.2									
				0.30 272.70	P6329/101/0.5/S/1 D 0.50 m			ML	Clayey SILT, low liquid limit, red/brown, with fine to medium shale gravels, inferred firm to stiff.		F - St	RESIDUAL SOIL
			0.4									
	M		0.6	0.60 272.40				CL-CI	Silty CLAY, low to medium plasticity, red/brown, with fine to medium shale gravels, inferred stiff.		St	
			0.8									
			1.0		P6329/101/1.0/S/1 D 1.00 m							
	H		1.2	1.20 271.80					Inferred very stiff to hard.		VSt - H	
AD/T	H		1.4	1.40 271.60	P6329/101/1.45/S/1 D 1.45 m				SHALE, dark grey, inferred low strength, distinctly weathered.			WEATHERED ROCK 1.40: V-bit refusal.
				1.50					Hole Terminated at 1.50 m			1.50: TC-bit refusal on inferred low to medium strength shale.
			1.6									
			1.8									

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

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Engineering Log - BOREHOLE

CLIENT	X-Travigant C/- Precise Planning	COMMENCED	23/11/2017	COMPLETED	23/11/2017	**REF BH102**
PROJECT	Preliminary Salinity Assessment	LOGGED	DO	CHECKED		Sheet 1 OF 1
SITE	30 Greenacre Dr, Tahmoor, NSW	GEOLOGY	Ashfield Shale	VEGETATION	Grass	PROJECT NO. P1706329
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	271 m	DATUM: AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.40 m depth	NORTHING		ASPECT	Northeast	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
AD/V	L	Not Encountered	0.2	271.00 0.30	P6329/102/0.1/S/1 D 0.10 m			ML	SILT, low liquid limit, dark brown, with organic materials, with fine to medium shale gravels, inferred firm.	D	F	FILL
	H		0.4 0.6	270.70 0.80	P6329/102/0.5/S/1 D 0.50 m			ML	Clayey SILT, low liquid limit with fine to medium shale gravels, inferred stiff to very stiff.		St - VSt	
	M		0.8 1.0 1.2	270.20 1.30	P6329/102/1.0/S/1 D 1.00 m			CL-CI	Silty CLAY, low to medium plasticity, brown/grey, with fine to medium shale gravels, inferred stiff.		St	RESIDUAL SOIL
	H			269.70 1.40	P6329/102/1.35/S/1 D 1.35 m				Inferred very stiff to hard.		VSt - H	WEATHERED ROCK
			1.4 1.6 1.8						Hole Terminated at 1.40 m			1.40: V-bit refusal on inferred low strength shale.

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Engineering Log - BOREHOLE

CLIENT	X-Travigant C/- Precise Planning	COMMENCED	23/11/2017	COMPLETED	23/11/2017	**REF BH103**
PROJECT	Preliminary Salinity Assessment	LOGGED	DO	CHECKED		Sheet 1 OF 1
SITE	30 Greenacre Dr, Tahmoor, NSW	GEOLOGY	Ashfield Shale	VEGETATION	Grass	PROJECT NO. P1706329
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	268 m	DATUM: AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.50 m depth	NORTHING		ASPECT	Northeast	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
AD/V	L	Not Encountered	0.2	268.00 *0.30*	P6329/103/0.1/S/1 D 0.10 m			ML	SILT, low liquid limit, dark brown, with organic materials, inferred firm.	D - M	F	TOPSOIL
			0.4 0.6 0.8	267.70 *0.80*	P6329/103/0.5/S/1 D 0.50 m			CL	Silty CLAY, low plasticity, dark brown, inferred firm to stiff.		F - St	RESIDUAL SOIL
	M		1.0 1.2	267.20 *1.30*	P6329/103/1.0/S/1 D 1.00 m			CI	CLAY, medium plasticity, brown/red, with fine shale gravels, trace of silt, inferred stiff.	D	St	
	H		1.4	266.70 *1.50*	P6329/103/1.4/S/1 D 1.40 m				Inferred very stiff to hard.		VSt - H	
			1.6 1.8						Hole Terminated at 1.50 m			1.50: V-bit refusal on inferred low strength shale.

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

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Engineering Log - BOREHOLE

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P1706329BH01V01 171127.GPJ <<DrawingFile>> 21/12/2017 13:56 8.30.004 Datgel Lab and In Situ Tool - DGD | Lib: Martens 2.00 2016-11-13 Prj: Martens 2.00 2016-11-13

CLIENT	X-Travigant C/- Precise Planning	COMMENCED	23/11/2017	COMPLETED	23/11/2017	**REF BH104**
PROJECT	Preliminary Salinity Assessment	LOGGED	DO	CHECKED		Sheet 1 OF 1
SITE	30 Greenacre Dr, Tahmoor, NSW	GEOLOGY	Ashfield Shale	VEGETATION	Grass	PROJECT NO. P1706329
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	278 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.10 m depth	NORTHING		ASPECT	Northeast	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
AD/V	L	Not Encountered		278.00	P6329/104/0.1/S/1 D 0.10 m P6329/104/0.3/S/1 D 0.30 m			ML	SILT, low liquid limit, light brown, with fine to medium gravels, inferred firm.	D	F	TOPSOIL
	L M H		0.4	0.40 277.60				ML	Clayey SILT, red/brown, with fine shale gravels, grey bands, inferred stiff.	D M	St	RESIDUAL SOIL
	H		1.0	1.00 277.00	P6329/104/1.0/S/1 D 1.00 m			CI-CH	CLAY, medium to high plasticity, brown / rred , with fine shae gravels, inferred very stiff to hard.	M	VSt - H	WEATHERED ROCK
				1.10					Hole Terminated at 1.10 m			1.10: V-bit refusal on inferred low strength shale.

0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8

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

martens

MARTENS & ASSOCIATES PTY LTD
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Engineering Log - BOREHOLE

CLIENT	X-Travigant C/- Precise Planning	COMMENCED	23/11/2017	COMPLETED	23/11/2017	**REF BH105**
PROJECT	Preliminary Salinity Assessment	LOGGED	DO	CHECKED		Sheet 1 OF 1
SITE	30 Greenacre Dr, Tahmoor, NSW	GEOLOGY	Ashfield Shale	VEGETATION	Grass	PROJECT NO. P1706329
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	275 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.20 m depth	NORTHING		ASPECT	Northeast	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
AD/V	L	Not Encountered	0.2	275.00	P6329/105/0.1/S/1 D 0.10 m			ML	SILT, low liquid limit, light brown, with medium shale gravels, inferred firm.	D	F	TOPSOIL
	M		0.4 0.6	0.30 274.70	P6329/105/0.5/S/1 D 0.50 m			ML	Clayey SILT, low liquid limit, red/light brown, with fine to medium gravels, inferred firm to stiff.		F - St	RESIDUAL SOIL
	M-H		0.8 1.0	0.80 274.20	P6329/105/1.0/S/1 D 1.00 m			CL-CI	Silty CLAY, low to medium plasticity, red/brown, grey bands, with fine shale gravels, inferred very stiff.		VSt	
	H			1.10 273.90	P6329/105/1.15/S/1 D 1.15 m				Inferred hard.		H	
			1.2 1.4 1.6 1.8	1.20					Hole Terminated at 1.20 m			1.20: V-bit refusal on inferred low strength shale.

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

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Engineering Log - BOREHOLE

CLIENT	X-Travigant C/- Precise Planning	COMMENCED	23/11/2017	COMPLETED	23/11/2017	**REF BH106**
PROJECT	Preliminary Salinity Assessment	LOGGED	DO	CHECKED		Sheet 1 OF 1
SITE	30 Greenacre Dr, Tahmoor, NSW	GEOLOGY	Ashfield Shale	VEGETATION	Grass	PROJECT NO. P1706329
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	269 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.70 m depth	NORTHING		ASPECT	Northeast	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
AD/V	L	Not Encountered	0.2	269.00 0.30	P6329/106/0.1/S/1 D 0.10 m			ML	FILL: SILT, low liquid limit, light brown, trace clay, with fine shale gravels, inferred firm.	D	F	FILL
	M		0.4 0.6	268.70 0.80	P6329/106/0.5/S/1 D 0.50 m			ML	FILL: Clayey SILT, low liquid limit, brown, with fine shale gravels, inferred stiff and very stiff.		St and VSt	
			0.8 1.0 1.2 1.4 1.6	268.20 1.70	P6329/106/1.0/S/1 D 1.00 m			CL	Silty CLAY, low plasticity, red/grey/dark brown, with fine to medium shale gravels, inferred stiff and very stiff.			RESIDUAL SOIL
			1.8						Hole Terminated at 1.70 m			1.70: V-bit refusal on inferred low strength shale.

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

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7 Attachment C – Laboratory Test Certificate

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

CERTIFICATE OF ANALYSIS 180644

Client Details

Client	Martens & Associates Pty Ltd
Attention	Orson Thien
Address	Suite 201, 20 George St, Hornsby, NSW, 2077

Sample Details

Your Reference	**P1706329**
Number of Samples	12 SOIL
Date samples received	24/11/2017
Date completed instructions received	24/11/2017

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	01/12/2017
Date of Issue	28/11/2017

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

Misc Inorg - Soil						
Our Reference		180644-1	180644-2	180644-3	180644-4	180644-5
Your Reference	UNITS	6329/BH101	6329/BH101	6329/BH102	6329/BH102	6329/BH102
Depth		0.1	0.5	0.1	0.5	1.0
Date Sampled		23/11/2017	23/11/2017	23/11/2017	23/11/2017	23/11/2017
Type of sample		SOIL	SOIL	SOIL	SOIL	SOIL
Date prepared	-	27/11/2017	27/11/2017	27/11/2017	27/11/2017	27/11/2017
Date analysed	-	27/11/2017	27/11/2017	27/11/2017	27/11/2017	27/11/2017
pH 1:5 soil:water	pH Units	6.3	6.0	6.2	5.5	6.0
Electrical Conductivity 1:5 soil:water	µS/cm	150	32	98	48	21
Sulphate, SO4 1:5 soil:water	mg/kg	28	31	66	43	10

Misc Inorg - Soil						
Our Reference		180644-6	180644-7	180644-8	180644-9	180644-10
Your Reference	UNITS	6329/BH103	6329/BH103	6329/BH103	6329/BH104	6329/BH104
Depth		0.1	0.5	1.4	0.1	0.5
Date Sampled		23/11/2017	23/11/2017	23/11/2017	23/11/2017	23/11/2017
Type of sample		SOIL	SOIL	SOIL	SOIL	SOIL
Date prepared	-	27/11/2017	27/11/2017	27/11/2017	27/11/2017	27/11/2017
Date analysed	-	27/11/2017	27/11/2017	27/11/2017	27/11/2017	27/11/2017
pH 1:5 soil:water	pH Units	6.1	6.5	5.4	5.8	5.9
Electrical Conductivity 1:5 soil:water	µS/cm	100	50	100	42	28
Sulphate, SO4 1:5 soil:water	mg/kg	31	29	<10	10	10

Misc Inorg - Soil			
Our Reference		180644-11	180644-12
Your Reference	UNITS	6329/BH105	6329/BH105
Depth		0.5	1.0
Date Sampled		23/11/2017	23/11/2017
Type of sample		SOIL	SOIL
Date prepared	-	27/11/2017	27/11/2017
Date analysed	-	27/11/2017	27/11/2017
pH 1:5 soil:water	pH Units	6.1	5.6
Electrical Conductivity 1:5 soil:water	µS/cm	32	39
Sulphate, SO4 1:5 soil:water	mg/kg	31	24

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

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	180644-2
Date prepared	-			27/11/2017	1	27/11/2017	27/11/2017		27/11/2017	27/11/2017
Date analysed	-			27/11/2017	1	27/11/2017	27/11/2017		27/11/2017	27/11/2017
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	1	6.3	6.3	0	102	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	1	150	140	7	98	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	1	28	31	10	105	98

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	11	27/11/2017	27/11/2017		[NT]	[NT]
Date analysed	-			[NT]	11	27/11/2017	27/11/2017		[NT]	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	11	6.1	6.1	0	[NT]	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	[NT]	11	32	33	3	[NT]	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	[NT]	11	31	30	3	[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.

8 Attachment D – Notes About This Report

Information

Important Information About Your Report (1 of 2)

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

Engineering Reports - Limitations

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

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

Relative ground surface levels at borehole locations may not be accurate and should be verified by 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:

- 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.

- Changes in guidelines, standards and policy or interpretation of guidelines, standards and policy by statutory authorities.
- The actions of contractors responding to commercial pressures.
- Actual conditions differing somewhat from those inferred to exist, because no professional, no matter how qualified, can reveal precisely what is hidden by earth, rock and time.

  The actual interface between 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.

Soil Data

Explanation of Terms (1 of 3)

Definitions

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

The methods of description and classification of soils and rocks used in this report are 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.

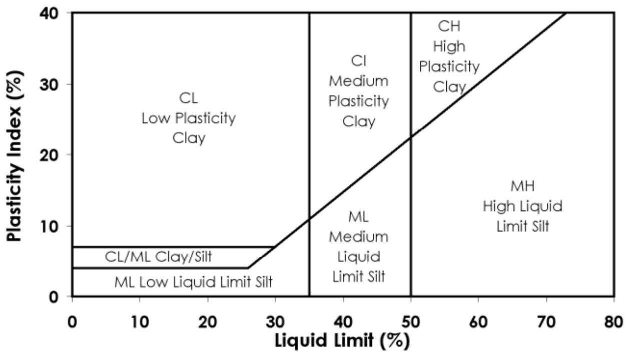
Particle Size

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 figures.
Stiff	50 - 100	8 – 15	The surface of the soil can be indented with the thumb, but not penetrated. Cannot be moulded by fingers.
Very Stiff	100 - 200	15 – 30	The surface of the soil can be marked, but not indented with thumb pressure. Difficult to cut with a knife. Thumbnail can readily indent.
Hard	> 200	> 30	The surface of the soil can be marked only with the thumbnail. Brittle. Tends to break into fragments.
Friable	-	-	Crumbles or powders when scraped by thumbnail.

Density of Granular Soils

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

Relative Density	%	SPT 'N' Value* (blows/300mm)	CPT Cone Value (q_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 %

Symbols for Soils and Other

SOILS

- COBBLES/BOULDERS
- GRAVEL (GP OR GW)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- SAND (SP OR SW)
- SILTY SAND (SM)
- CLAYEY SAND (SC)
- SILT (ML OR MH)
- ORGANIC SILT (OH)
- CLAY (CL, CI OR CH)
- SILTY CLAY
- SANDY CLAY
- PEAT
- TOPSOIL

OTHER

- FILL
- TALUS
- ■ ASPHALT
- CONCRETE

Unified Soil Classification Scheme (USCS)

<table>
<tr><td colspan="6">FIELD IDENTIFICATION PROCEDURES
(Excluding particles larger than 63 mm and basing fractions on estimated mass)</td><td>USCS</td><td>Primary Name</td></tr>
<tr><td rowspan="8">COARSE GRAINED SOILS
More than 50 % of material less than 63 mm is larger than 0.075 mm</td><td rowspan="16">(A 0.075 mm particle is about the smallest particle visible to the naked eye)</td><td rowspan="4">GRAVELS
More than half of coarse fraction is larger than 2.0 mm.</td><td rowspan="2">CLEAN GRAVELS (Little or no fines)</td><td colspan="2">Wide range in grain size and substantial amounts of all intermediate particle sizes.</td><td>GW</td><td>Gravel</td></tr>
<tr><td colspan="2">Predominantly one size or a range of sizes with more intermediate sizes missing</td><td>GP</td><td>Gravel</td></tr>
<tr><td rowspan="2">GRAVELS WITH FINES (Appreciable amount of fines)</td><td colspan="2">Non-plastic fines (for identification procedures see ML below)</td><td>GM</td><td>Silty Gravel</td></tr>
<tr><td colspan="2">Plastic fines (for identification procedures see CL below)</td><td>GC</td><td>Clayey Gravel</td></tr>
<tr><td rowspan="4">SANDS
More than half of coarse fraction is smaller than 2.0 mm</td><td rowspan="2">CLEAN SANDS (Little or no fines)</td><td colspan="2">Wide range in grain sizes and substantial amounts of intermediate sizes missing.</td><td>SW</td><td>Sand</td></tr>
<tr><td colspan="2">Predominantly one size or a range of sizes with some intermediate sizes missing</td><td>SP</td><td>Sand</td></tr>
<tr><td rowspan="2">SANDS WITH FINES (Appreciable amount of fines)</td><td colspan="2">Non-plastic fines (for identification procedures see ML below)</td><td>SM</td><td>Silty Sand</td></tr>
<tr><td colspan="2">Plastic fines (for identification procedures see CL below)</td><td>SC</td><td>Clayey Sand</td></tr>
<tr><td rowspan="8">FINE GRAINED SOILS
More than 50 % of material less than 63 mm is smaller than 0.075 mm</td><td colspan="6">IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 MM</td></tr>
<tr><td>DRY STRENGTH (Crushing Characteristics)</td><td>DILATANCY</td><td>TOUGHNESS</td><td>DESCRIPTION</td><td>USCS</td><td>Primary Name</td></tr>
<tr><td>None to Low</td><td>Quick to Slow</td><td>None</td><td>Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity</td><td>ML</td><td>Silt</td></tr>
<tr><td>Medium to High</td><td>None</td><td>Medium</td><td>Inorganic clays of low to medium plasticity [1], gravely clays, sandy clays, silty clays, lean clays</td><td>CL [2]</td><td>Clay</td></tr>
<tr><td>Low to Medium</td><td>Slow to Very Slow</td><td>Low</td><td>Organic slits and organic silty clays of low plasticity</td><td>OL</td><td>Organic Silt</td></tr>
<tr><td>Low to Medium</td><td>Slow to Very Slow</td><td>Low to Medium</td><td>Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts</td><td>MH</td><td>Silt</td></tr>
<tr><td>High</td><td>None</td><td>High</td><td>Inorganic clays of high plasticity, fat clays</td><td>CH</td><td>Clay</td></tr>
<tr><td>Medium to High</td><td>None</td><td>Low to Medium</td><td>Organic clays of medium to high plasticity</td><td>OH</td><td>Organic Silt</td></tr>
<tr><td colspan="2">HIGHLY ORGANIC SOILS</td><td colspan="4">Readily identified by colour, odour, spongy feel and frequently by fibrous texture</td><td>Pt</td><td>Peat</td></tr>
<tr><td colspan="8">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.</td></tr>
</table>

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

Rock Data

Explanation of Terms (1 of 2)

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

Rock Strength

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

Term	Is (50) MPa	Field Guide	Symbol
Very low	>0.03 ≤0.1	May be crumbled in the hand. Sandstone is 'sugary' and friable.	VL
Low	>0.1 ≤0.3	A piece of core 150mm long x 50mm diameter may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.	L
Medium	>0.3 ≤1.0	A piece of core 150mm long x 50mm diameter can be broken by hand with considerable difficulty. Readily scored with a knife.	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

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

SCR = Solid Core Recovery

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

RQD = Rock Quality Designation

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

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)

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

Planarity

Pl	Planar
Cu	Curved
Un	Undulating
St	Stepped
Ir	Irregular
Dis	Discontinuous

Roughness

Pol	Polished
Sl	Slickensided
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

Inclination

Inclination of defect is measured from perpendicular to and down the core axis.

Direction of defect is measured clockwise (looking down core) from magnetic north.

Test, Drill and Excavation Methods

Explanation of Terms (1 of 3)

Sampling

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

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

Undisturbed samples may be taken by pushing a thin-walled sampling tube, e.g. U_{50} (50 mm internal diameter thin walled tube), into soils and withdrawing a soil sample in a relatively undisturbed state. Such samples yield information on structure and strength and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils. Other sampling methods may be used. Details of the type and method of sampling are given in the report.

Drilling / Excavation Methods

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

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:

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

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

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

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	◁	Partial water loss
▷	Water inflow	◀	Complete water loss

GROUNDWATER NOT OBSERVED (NO)	The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.
GROUNDWATER NOT ENCOUNTERED (NX)	The borehole/test pit was dry soon after excavation. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period.

PENETRATION / EXCAVATION RESISTANCE

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

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

SAMPLING

D	Small disturbed sample	W	Water Sample	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
4,7,11	4,7,11 = Blows per 150mm.
N=18	'N' = Recorded blows per 300mm penetration following 150mm seating
DCP	Dynamic Cone Penetration test to AS1289.6.3.2-1997. 'n' = Recorded blows per 150mm penetration
Notes:	
RW	Penetration occurred under the rod weight only
HW	Penetration occurred under the hammer and rod weight only
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

CPT	Static cone penetration test
CPTu	CPT with pore pressure (u) measurement
PP	Pocket penetrometer test expressed as instrument reading (kPa)
FP	Field permeability test over section noted
VS	Field vane shear test expressed as uncorrected shear strength (sv = peak value, sr = residual value)
PM	Pressuremeter test over section noted
PID	Photoionisation Detector reading in ppm
WPT	Water pressure tests

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		