GeoEnviro Consultancy Pty Ltd
Unit 5, 39-41 Fourth Avenue, Blacktown, NSW 2148, Australia
PO Box 1543, Macquarie Centre. North Ryde, NSW 2113
ABN 62 084 294 762
Tel : (02) 9679 8733
Fax : (02) 9679 8744

13th June 2018

Our Ref: JE17655A-r3

On the Park Development Pty Ltd ATF On the Park Developments Unit Trust
21 Solent Circuit
BAULKHAM HILLS NSW 2153

Dear Sir,

Re Proposed Residential Subdivision Development – Proposed Lots 1 to 3
Part Lots 11 & 12 in DP 1092788 and Part Lot 5 in DP 736961
No 9-13 Fern Creek Road Warriewood
Acid Sulfate Soil Assessment

1. Introduction

This letter report presents our assessment on the presence of potential acid sulfate soil at Part Lots 11 & 12 in DP 1092788 and Part Lot 5 in DP 736961 No 9-13 Fern Creek Road Warriewood as shown on the attached Drawing No 1. The assessment was commissioned by Mr Jim Davies of GDS Land, acting on behalf of On the Park Development Pty Ltd ATF On the Park Developments Unit Trust and the works were carried in general accordance with our proposal JE17655A-L2 dated 15th May 2018.

We understand that the proposed development will include the subdivision into 3 residential lots (Proposed Lots 1 to 3).

The purpose of this investigation was to assess the subsurface ground and groundwater conditions and based on the information obtained, to present our assessment on Acid Sulfate soil potential which may adversely impact on the site from the proposed development.

2. Site Description

The Subject Site is situated at the northern end of Fern Creek Road in Warriewood and occupies the southern portion of the site referred to as Lots 11-13 DP 1092788 and Lot 5 DP 736961, No 9-13 Fern Creek Road Warriewood. The site is irregular in shape extending about 300m in an east-westerly direction and about 150m in a north-southerly direction.

The site is situated on gently undulating terrain with ground surface within the site generally sloping towards the north to Fern Creek at angles of less than 3 degrees.

At the time of our investigation, all properties were vacant except No 9 Fern Creek Road which was used as a horse agistment with a horse enclosure and metal shed towards the rear of the property. No 11 had heavy vegetation with No 13 densely covered with trees and restricted access. No 12 was cleared of trees with a drainage and transmission line easement along the common property boundary with No 9. There was a long fill stockpile on property No 12 which may have originated from the excavation of the drainage construction.

3. Soil Landscape Map

The 1:100,000 Soil Landscape Map of Sydney prepared by the Soil Conservation Services of NSW indicates the site to be underlain by swamp soil belonging to the Warriewood landscape group consisting of deep Quaternary Sands

4. Geological Map

The 1:100,000 Geological Map of Sydney indicates the underlying bedrock to consist of interbedded laminite, shale, and quartz, to lithic-quartz sandstone of the Newport Formation.

5. Acid Sulfate Soil Risk Map

A review of the Acid Sulfate Soil Risk Map (Reference III) indicates the site to be situated in an area with no occurrence of acid sulfate soils.

6. Investigation Methodology

The fieldwork for the investigation was carried out on the 23rd May 2018 and consisted of excavation of five test pits (TP 101 to 105) using a rubber tyred backhoe as shown on the attached Drawing No 1.

The test pits were excavated through topsoil/fill and into the natural sandy and clayey profiles to depths of about 2.8m to 3.4m below existing ground surface.

Soil samples were collected from the test pits for laboratory analysis to aid assessment of acid sulfate soils. The samples were sent to Envirolab Services Pty Ltd, a laboratory accredited by the National Association of Testing Authorities (NATA) laboratory for pH and Peroxide pH test for a screen to determine acid sulfate soil potential.

Following the pH and Peroxide pH test, Peroxide Oxidation Combined Acidity and Sulfate (POCAS) tests on three samples were performed. The laboratory test results are detailed on the attached Laboratory Test Reports.

7. Subsurface Conditions

Reference should be made to the attached Table A for details of subsurface profiles encountered. The following is a generalised subsurface profile;

Topsoil and Topsoil/Fill

Topsoil and topsoil/fill was encountered on the surface of all test pits consisting of fine to medium grained Silty Sand. The topsoil and topsoil/fill was found to have thickness ranging from 200mm to 700mm.

Natural Soil

Underlying the topsoil/fill, natural soil was encountered in all test pits. The natural soil was found to consist of Silty Sand and Clayey Sand in the upper profiles with some medium plasticity Silty Clay encountered at lower depths in TP 102 and 103. The natural sandy and clayey soil was generally assessed to be dry to moist.

Bedrock

Bedrock was not encountered in any of the test pits which were taken a maximum depth of 3.4m below existing ground surface.

Groundwater

Groundwater was not encountered in any of the test pits.

8. Laboratory Test Results

For details of the laboratory test results, refer to the Laboratory Test Report attached. The following is a summary of the results;

pH and Peroxide Test

Test Pit	Depth (m)	pH (H2O)	pH (H2O2)	Reaction Rate
TP 101	0.7-0.8	6.2	4.8	Slight
	2.1-2.2	5.7	4.7	Slight
	3.0-3.1	5.1	3.9	Slight
TP 102	0.8-0.9	6.7	4.7	Slight
	1.9-2.0	5.2	4.0	Slight
	2.7-2.8	4.7	3.7	Slight
TP 103	0.4-0.5	5.6	4.3	Slight
	2.0-2.1	4.9	3.6	Slight
TP 104	0.2-0.3	5.6	3.6	Slight
	1.8-1.9	6.3	4.9	Slight
	2.8-2.9	6.5	5.0	Slight
TP 105	0.4-0.5	5.6	4.8	Slight
	1.5-1.6	5.9	5.0	Slight
	2.4-2.5	5.3	4.2	Slight

POCAS

Test Pit	Depth (m)	TAA (mol/t)	TPA (mol/t)	TSA (mol/t)	S_{kcl} (%)	S_P (%)	S_{pos} (%)
TP 101	3.0-3.1	31	25	<5	0.01	0.01	<0.005
TP 103	2.0-2.1	160	170	11	0.04	0.04	<0.005
TP 105	1.5-1.6	<5	<5	<5	<0.005	<0.005	<0.005

9. Comments

The Acid Sulfate Soil Manual (Reference IV) provides Action Criteria to trigger the need to prepare a management plan based on the percentage of oxidisable sulphur (or equivalent TPA, TAA) for broad categories of soil types. The manual also provides an indication of the treatment or risk category a disturbance of acid sulfate soils would entail and provides estimation of the quantity of lime involved if the total volume/mass of acid sulfate soils to be disturbed is known.

There are three factors considered to show a positive indication of potential acid sulfate soils. These factors are:

- The strength of the reaction with peroxide (it cannot be used alone as organic matter and other soil constituents such as manganese oxides can also cause a reaction);
- A pHox value less than 3 indicates potential acid sulfate soils (the more the pHox values falls below 3, the more positive the results); and
- The difference between field pH and pHox (a large difference gives a more definite indication of potential acid sulfate soils).

The following are our comments and assessment on the laboratory test results;

- All samples taken from the test pits were found to have a slight peroxide reaction with a slight drop in the pH values for the pHox test.
- The POCAS test indicates the soil samples from all samples to have oxidisable sulphur (S_{pos}) of less than 0.005%, which is less than the Action Criteria of 0.06% for sandy loams to light clays and 0.1% for medium to heavy clays and silty clays.
- The Total Potential Acidity (TPA) in the sandy soil encountered in TP 101 (3.0-3.1m) and TP 105 (1.5-1.6m) was found to be 25 mol/t and less than 5 mol/t respectively and therefore less than the Action Criteria of 36 mol/tonne for sandy loams and light clays.
- The TPA in the clayey soil in TP 103 (2.0-2.1m) was found to be 170mol/t above the Action Criteria of 62mol/t for medium to heavy clays and silty clays.

Based on the foregoing, we are of the opinion that the upper sandy soils are not significantly impacted by acid sulfate soils.

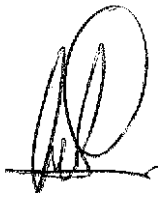
Not withstanding the above, the site should be monitored for acid sulphate soil reaction particular if the excavation works are undertaken deeper than 2.0m below existing ground surface. Common reactions displaying acid sulphate soil characteristics include pungent odour being released into the air, discolouration of soil (eg green and blue tinge) and leaching of iron from the soil.
for

In the event where acid sulphate soils are identified during construction, the following acid sulphate soil management strategy should be adopted;

- If acid sulfate soils are to be disturbed, the acid generation potential of the soil should be managed by neutralising any acid using 3% by weight of lime. Additional lime may be added as required. Alternatively the acid sulphate soil may be removed off-site to a landfill for treatment and disposal.
- The excavated acid sulfate soils should be treated immediately otherwise the excavated soil should be capped to retard the oxidation process.
- The excavated acid sulphate soils should be treated immediately otherwise the excavated soil should be capped with non-porous clay soils greater than 0.5m thick.
- All material to be removed from the site should be carried out by a licensed contractor. This material should be sealed and contained on the truck during haulage using appropriate lining and capping material.

If you have any queries regarding the above, please contact the undersigned.

Yours faithfully
GeoEnviro Consultancy Pty Ltd



Solern Liew CPEng NER
Director

Attachments: Drawing No 1 – Test Pit Location Plan
Table A: Summary of Test Pit Profile
Laboratory Test Certificates
Explanatory Notes

References:

I. *1:100,000 Soil Landscape Map of Sydney - Soil Conservation of NSW (Series Sheet 9130)*

II. *1:100,000 Geological Map of Sydney, 1: 100,000 Sheet 9130 – Department of Mineral Resources 1983*

III. *1:25,000 Acid Sulfate Soil Risk Map – Hornsby/Mona Vale – Edition Two - Land and Water Conservation*

IV. *Acid Sulfate Soil Manual – NSW Acid Sulfate Soil Management Advisory Committee August 1998*

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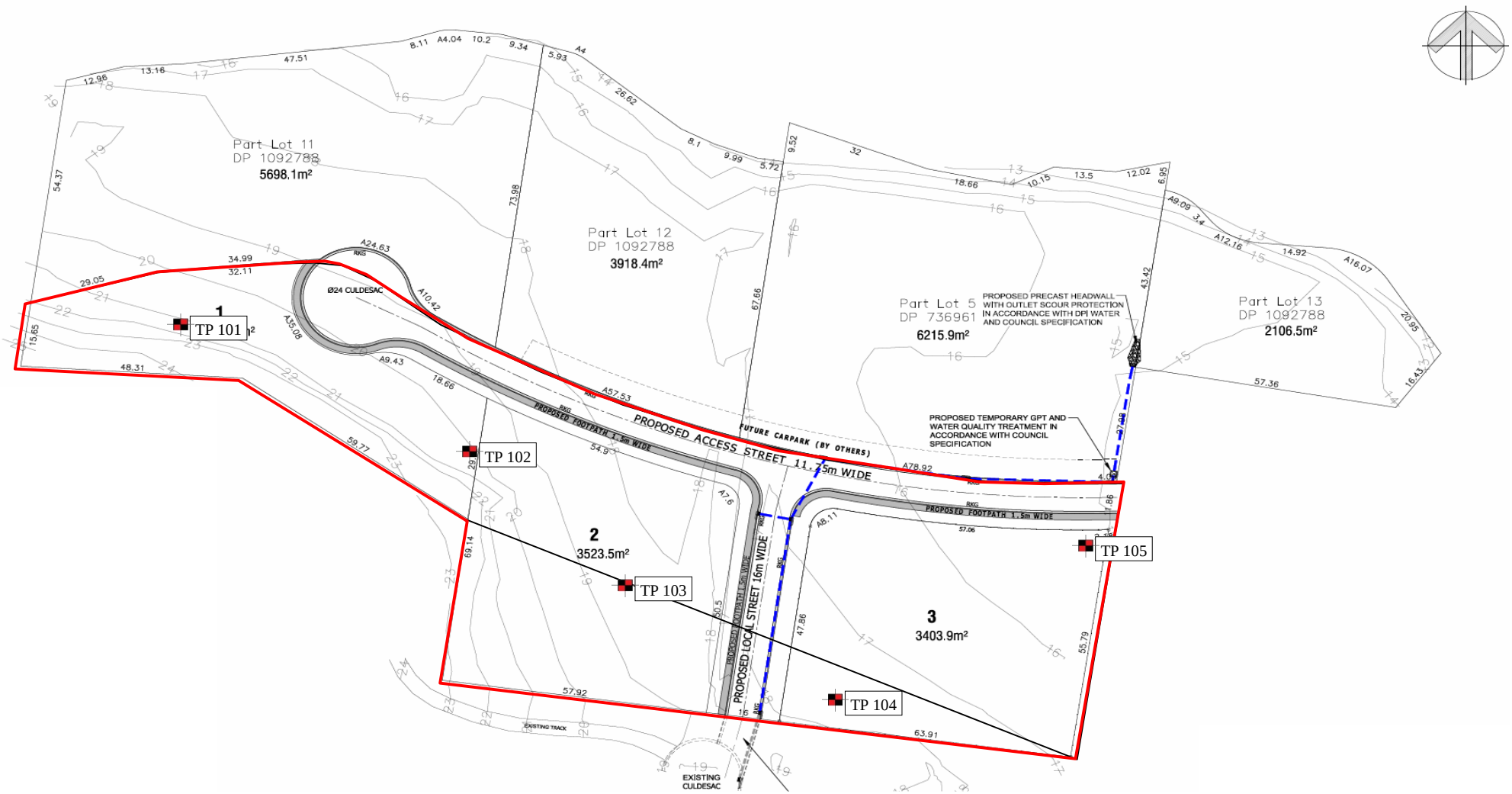

Legend

Test Pit

GeoEnviro Consultancy
Unit 5, 39-41 Fourth Avenue, Blacktown NSW 2148, Australia
Tel: (02) 96798733 Fax: (02) 96798744

Drawn By: AT	Date: 4/6/18	Frasers Property Australia	
Checked By: SL	Date: 4/6/18	9-13 Fern Creek Road Warriewood	
Revision By:	Date:	Test Pit Location Plan	
Scale: Not to Scale	A3	Project No: JE17655A-r3	Drawing No: 1

GeoEnviro Consultancy Pty Ltd
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Tel: (02) 96798733 Fax: (02) 96798744

Table A : Summary of Test Pit Profile

Client: GDS | Job Number: JE17655A-r3

Project: Proposed Residential Subdivision Development | Logged By: AT

Location: 9-13 Fern Creek Road Warriewood | Date: 23/5/18

Test Pit Number	Lot Number	Depth (m) From	Depth (m) To	Material Description
101	1011	0.00	0.70	Topsoil: Silty Sand: fine to medium grained, brown, moist
		0.70	2.00	(SM) Silty Sand: fine to medium grained, brown red with some clay, moist
		2.00	3.40	(SC) Clayey Sand: fine to medium grained, light brown, moist
102	1011	0.00	0.50	Topsoil/Fill: Silty Sand: fine to medium grained, brown with some glass fragments, moist
		0.50	1.00	(SM) Silty Sand: fine to medium grained, brown red with some clay, moist
		1.00	2.00	(SC) Clayey Sand: fine to medium grained, light brown red, moist
		2.00	2.40	(SC) Clayey Sand: fine to medium grained, grey red, moist
		2.40	3.10	(CI) Silty Clay: medium plasticity, grey red with trace of fine to medium grained sand and ironstone gravel, dry to moist
103	1011	0.00	0.35	Topsoil/Fill: Silty Sand: fine to medium grained, brown with some glass fragments, moist
		0.35	0.90	(SM) Silty Sand: fine to medium grained, light brown with some clay, moist
		0.90	1.80	(SC) Clayey Sand: fine to medium grained, light brown red, moist
		1.80	2.00	(SC) Clayey Sand: fine to medium grained, grey red, moist
		2.00	2.90	(CI) Silty Clay: medium plasticity, grey red with trace of fine to medium grained sand and ironstone gravel, dry to moist
104	1012	0.00	0.20	Topsoil/Fill: Silty Sand: fine to medium grained, brown, dry to moist
		0.20	1.80	(SP) Sand: fine to medium grained, grey white, dry
		1.80	2.50	(SM) Silty Sand: fine to medium grained, light brown with some clay, moist
		2.50	3.00	(SC) Clayey Sand: fine to medium grained, yellow brown, moist
105	1012	0.00	0.25	Topsoil/Fill: Silty Sand: fine to medium grained, brown, dry to moist
		0.25	1.50	(SP) Sand: fine to medium grained, grey white, dry
		1.50	2.20	(SM) Silty Sand: fine to medium grained, light brown with some clay, dry to moist
		2.20	2.80	(SC) Clayey Sand: fine to medium grained, yellow brown, moist

Notes:
MC = Moisture Content.
PL = Plastic Limit.
PP = Pocket Penetrometer.

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 192515

Client Details

Client	Geoenviro Consultancy Pty Ltd
Attention	Solern Liew
Address	PO Box 1543, Macquarie Centre, North Ryde, NSW, 2113

Sample Details

Your Reference	**JC17655A-r3, Warriewood**
Number of Samples	14 Soil
Date samples received	24/05/2018
Date completed instructions received	24/05/2018

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	31/05/2018
Date of Issue	31/05/2018

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Results Approved By
Nick Sarlamis, Inorganics Supervisor

Authorised By

Jacinta Hurst, Laboratory Manager

sPOCAS field test						
Our Reference		192515-1	192515-2	192515-3	192515-4	192515-5
Your Reference	UNITS	TP 101	TP 101	TP 101	TP 102	TP 102
Depth		0.7-0.8	2.1-2.2	3-3.1	0.8-0.9	1.9-2
Date Sampled		23/05/2018	23/05/2018	23/05/2018	23/05/2018	23/05/2018
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	28/05/2018	28/05/2018	28/05/2018	28/05/2018	28/05/2018
Date analysed	-	28/05/2018	28/05/2018	28/05/2018	28/05/2018	28/05/2018
pH_F (field pH test)*	pH Units	6.2	5.7	5.1	6.7	5.2
pH_{FOX} (field peroxide test)*	pH Units	4.8	4.7	3.9	4.7	4.0
Reaction Rate*	-	Slight	Slight	Slight	Slight	Slight

sPOCAS field test						
Our Reference		192515-6	192515-7	192515-8	192515-9	192515-10
Your Reference	UNITS	TP 102	TP 103	TP 103	TP 104	TP 104
Depth		2.7-2.8	0.4-0.5	2-2.1	0.2-0.3	1.8-1.9
Date Sampled		23/05/2018	23/05/2018	23/05/2018	23/05/2018	23/05/2018
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	28/05/2018	28/05/2018	28/05/2018	28/05/2018	28/05/2018
Date analysed	-	28/05/2018	28/05/2018	28/05/2018	28/05/2018	28/05/2018
pH_F (field pH test)*	pH Units	4.7	5.6	4.9	5.6	6.3
pH_{FOX} (field peroxide test)*	pH Units	3.7	4.3	3.6	3.6	4.9
Reaction Rate*	-	Slight	Slight	Slight	Slight	Slight

sPOCAS field test					
Our Reference		192515-11	192515-12	192515-13	192515-14
Your Reference	UNITS	TP 104	TP 105	TP 105	TP 105
Depth		2.8-2.9	0.4-0.5	1.5-1.6	2.4-2.5
Date Sampled		23/05/2018	23/05/2018	23/05/2018	23/05/2018
Type of sample		Soil	Soil	Soil	Soil
Date prepared	-	28/05/2018	28/05/2018	28/05/2018	28/05/2018
Date analysed	-	28/05/2018	28/05/2018	28/05/2018	28/05/2018
pH_F (field pH test)*	pH Units	6.5	5.6	5.9	5.3
pH_{FOX} (field peroxide test)*	pH Units	5.0	4.8	5.0	4.2
Reaction Rate*	-	Slight	Slight	Slight	Slight

sPOCAS + %S w/w				
Our Reference		192515-3	192515-8	192515-13
Your Reference	UNITS	TP 101	TP 103	TP 105
Depth		3-3.1	2-2.1	1.5-1.6
Date Sampled		23/05/2018	23/05/2018	23/05/2018
Type of sample		Soil	Soil	Soil
Date prepared	-	28/05/2018	28/05/2018	28/05/2018
Date analysed	-	28/05/2018	28/05/2018	28/05/2018
pH $_{kcl}$	pH units	4.4	3.7	5.0
TAA pH 6.5	moles H^+ /t	31	160	<5
s-TAA pH 6.5	%w/w S	0.05	0.26	<0.01
pH $_{Ox}$	pH units	4.7	4.3	4.8
TPA pH 6.5	moles H^+ /t	25	170	<5
s-TPA pH 6.5	%w/w S	0.04	0.28	<0.01
TSA pH 6.5	moles H^+ /t	<5	11	<5
s-TSA pH 6.5	%w/w S	<0.01	0.02	<0.01
ANC_E	% $CaCO_3$	<0.05	<0.05	<0.05
a-ANC_E	moles H^+ /t	<5	<5	<5
s-ANC_E	%w/w S	<0.05	<0.05	<0.05
S_{KCl}	%w/w S	0.01	0.04	<0.005
S_P	%w/w	0.01	0.04	<0.005
S_{POS}	%w/w	<0.005	<0.005	<0.005
a-S_{POS}	moles H^+ /t	<5	<5	<5
Ca_{KCl}	%w/w	0.01	0.005	0.01
Ca_P	%w/w	0.01	0.007	0.01
Ca_A	%w/w	<0.005	<0.005	<0.005
Mg_{KCl}	%w/w	0.012	0.022	<0.005
Mg_P	%w/w	0.013	0.023	<0.005
Mg_A	%w/w	<0.005	<0.005	<0.005
S_{HCl}	%w/w S	0.009	0.034	<0.005
S_{NAS}	%w/w S	<0.005	<0.005	<0.005
a-S_{NAS}	moles H^+ /t	<5	<5	<5
s-S_{NAS}	%w/w S	<0.01	<0.01	<0.01
Fineness Factor	-	1.5	1.5	1.5
a-Net Acidity	moles H^+ /t	33	160	<5
s-Net Acidity	%w/w S	0.05	0.26	<0.01
Liming rate	kg $CaCO_3$ /t	2.4	12	<0.75
s-Net Acidity without -ANCE	%w/w S	0.052	0.26	<0.01
a-Net Acidity without ANCE	moles H^+ /t	33	160	<5
Liming rate without ANCE	kg $CaCO_3$ /t	2.4	12	<0.75

Method ID	Methodology Summary
Inorg-063	pH- measured using pH meter and electrode. Soil is oxidised with Hydrogen Peroxide or extracted with water. Based on section H, Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004. To ensure accurate results these tests are recommended to be done in the field as pH may change with time thus these results may not be representative of true field conditions.
Inorg-064	sPOCAS determined using titrimetric and ICP-AES techniques. Based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004.

QUALITY CONTROL: sPOCAS + %S w/w						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			28/05/2018	[NT]	[NT]	[NT]	[NT]	28/05/2018	[NT]
Date analysed	-			28/05/2018	[NT]	[NT]	[NT]	[NT]	28/05/2018	[NT]
pH $_{kcl}$	pH units		Inorg-064	[NT]	[NT]	[NT]	[NT]	[NT]	90	[NT]
TAA pH 6.5	moles H^+ /t	5	Inorg-064	<5	[NT]	[NT]	[NT]	[NT]	85	[NT]
s-TAA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
pH $_{Ox}$	pH units		Inorg-064	[NT]	[NT]	[NT]	[NT]	[NT]	96	[NT]
TPA pH 6.5	moles H^+ /t	5	Inorg-064	<5	[NT]	[NT]	[NT]	[NT]	93	[NT]
s-TPA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
TSA pH 6.5	moles H^+ /t	5	Inorg-064	<5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
s-TSA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
ANC_E	% $CaCO_3$	0.05	Inorg-064	<0.05	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
a-ANC_E	moles H^+ /t	5	Inorg-064	<5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
s-ANC_E	%w/w S	0.05	Inorg-064	<0.05	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
S_{KCl}	%w/w S	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
S_P	%w/w	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
S_{POS}	%w/w	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
a-S_{POS}	moles H^+ /t	5	Inorg-064	<5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Ca_{KCl}	%w/w	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Ca_P	%w/w	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Ca_A	%w/w	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Mg_{KCl}	%w/w	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Mg_P	%w/w	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Mg_A	%w/w	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
S_{HCl}	%w/w S	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
S_{NAS}	%w/w S	0.005	Inorg-064	<0.005	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
a-S_{NAS}	moles H^+ /t	5	Inorg-064	<5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
s-S_{NAS}	%w/w S	0.01	Inorg-064	<0.01	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Fineness Factor	-	1.5	Inorg-064	<1.5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
a-Net Acidity	moles H^+ /t	5	Inorg-064	<5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
s-Net Acidity	%w/w S	0.01	Inorg-064	<0.01	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Liming rate	kg $CaCO_3$ /t	0.75	Inorg-064	<0.75	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
s-Net Acidity without -ANCE	%w/w S	0.01	Inorg-064	<0.01	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
a-Net Acidity without ANCE	moles H^+ /t	5	Inorg-064	<5	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]

QUALITY CONTROL: sPOCAS + %S w/w						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Liming rate without ANCE	kg $CaCO_3$/t	0.75	Inorg-064	<0.75	[NT]	[NT]	[NT]	[NT]	[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.

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

SAMPLE RECEIPT ADVICE

Client Details

Client	Geoenviro Consultancy Pty Ltd
Attention	Solern Liew

Sample Login Details

Your reference	JC17655A-r3, Warriewood
Envirolab Reference	192515
Date Sample Received	24/05/2018
Date Instructions Received	24/05/2018
Date Results Expected to be Reported	31/05/2018

Sample Condition

Samples received in appropriate condition for analysis	YES
No. of Samples Provided	14 Soil
Turnaround Time Requested	Standard
Temperature on Receipt (°C)	16.4
Cooling Method	Ice Pack
Sampling Date Provided	YES

Comments

Nil

Please direct any queries to:

Aileen Hie	Jacinta Hurst
Phone: 02 9910 6200	**Phone: 02 9910 6200**
Fax: 02 9910 6201	**Fax: 02 9910 6201**
Email: ahie@envirolab.com.au	**Email: jhurst@envirolab.com.au**

Analysis Underway, details on the following page:

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

Sample ID	sPOCAS field test	sPOCAS + %S w/w
TP 101-0.7-0.8	✓	
TP 101-2.1-2.2	✓	
TP 101-3-3.1	✓	✓
TP 102-0.8-0.9	✓	
TP 102-1.9-2	✓	
TP 102-2.7-2.8	✓	
TP 103-0.4-0.5	✓	
TP 103-2-2.1	✓	✓
TP 104-0.2-0.3	✓	
TP 104-1.8-1.9	✓	
TP 104-2.8-2.9	✓	
TP 105-0.4-0.5	✓	
TP 105-1.5-1.6	✓	✓
TP 105-2.4-2.5	✓	

The '✓' indicates the testing you have requested. **THIS IS NOT A REPORT OF THE RESULTS.**

Additional Info

Sample storage - Waters are routinely disposed of approximately 1 month and soils approximately 2 months from receipt.
Requests for longer term sample storage must be received in writing.

GeoEnviro Consultancy Pty Ltd
Unit 5, 39-41 Fourth Avenue, Blacktown NSW 2148, Australia
Tel: (02) 96798733 Fax: (02) 96798744

Laboratory Test Request/Chain of Custody Record

Job Details
Job Number: JE17655A-r3
Client:
Project: Proposed Residential Subdivision Development
Location: 9-13 Fern Creek Road Warriewood

Sample Date: 23/5/18
Sampled By: AT
Project Manager: SL
Store Location:

External Laboratory Details:
Laboratory name: Envirolab Services Pty Ltd
Address: 12 Ashley Street
Chatswood
Contact: Tania Notaris

Sampling Details			Sample Type		Test Required (\) / Test Performed(X)																					
Location	Depth (m)		Soil	Water	Metals (As Cd Cr Cu Pb Zn Ni Hg)	OCP / PCB		Combination 5	Combination 5a	Combination 12a		Asbestos		pH	EC	CEC/ESP	Cl / SO4	Resistivity		pH/H2O & pH/H2O2	sPOCAS					Keep Sample
	From	To																								
TP 101 1	0.70	0.80	DG																							
TP 101 2	2.10	2.20	DG																							
TP 101 3	3.00	3.10	DG																							
TP 102 4	0.80	0.90	DG																							
TP 102 5	1.90	2.00	DG																							
TP 102 6	2.70	2.80	DG																							
TP 103 7	0.40	0.50	DG																							
TP 103 8	2.00	2.10	DG																							
TP 104 9	0.20	0.30	DG																							
TP 104 10	1.80	1.90	DG																							
TP 104 11	2.80	2.90	DG																							
TP 105 12	0.40	0.50	DG																							
TP 105 13	1.50	1.60	DG																							
TP 105 14	2.40	2.50	DG																							

ENVIROLAB

Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200

Job No: 192515
Date Received: 24/5/18
Time Received: 18:40
Received by: KC EJ
Temp: Cool/Ambient
Cooling: Ice/Icepack
Security: Intact/Broken/None

Cool/ mbient
Ice/Icepack
Intact/Broken/None

Relinquished by				Received By ELS			
Laboratory	Name	Signature	Date	Laboratory	Name	Signature	Date
GeoEnviro Consultancy	Adrian Tejada		24/05/2018		KC.		24/5

Legend
DB Disturbed Sample (Bulk, Plastic bag)
DS Disturbed Sample (Small, Plastic bag)
DG Disturbed Sample (Glass Jar)
STP Standard Penetration Test Sample
U50 Undisturbed Sample, 50mm Tube
U75 Undisturbed Sample, 75mm Tube
WG Water Sample, Amber Glass Jar
WP Water Sample, Plastic Bottle
Y Keep Sample
N Discard Sample

EXPLANATORY NOTES

Introduction

These notes have been provided to amplify the geotechnical report with regard to investigation procedures, classification methods and certain matters relating to the Discussion and Comments sections. Not all notes are necessarily relevant to all reports.

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

Description and Classification Methods
The methods the description and classification of soils and rocks used in this report are based on Australian standard 1726, the SSA Site investigation Code, in general descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions. Identification and classification of soil and rock involves to a large extent, judgement within the acceptable level commonly adopted by current geotechnical practices.

Soil types are described according to the predominating particle size, qualified by the grading or other particles present (eg sandy clay) on the following bases:

Soil Classification	Particle Size
Clay	Less than 0.002mm
Silt	0.002 to 0.6mm
Sand	0.6 to 2.00mm
Gravel	2.00m to 60.00mm

Soil Classification	Particle size
Clay	less than 0.002mm
Silt	0.002 to 0.06mm
Sand	0.06 to 2.00mm
Gravel	2.00mm to 60.00mm

Cohesive soils are classified on the basis of strength, either by laboratory testing or engineering examination. The strength terms are defined as follows:

Classification	Undrained Shear Strength kPa
Very Soft	Less than 12
Soft	12 - 25
Firm	25 - 50
Stiff	50 - 100
Very Stiff	100 - 200
Hard	Greater than 200

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

Relative Dense	SPT 'N' Value (blows/300mm)	CPT Cone Value (q_c-Mpa)
Very Loose	Less than 5	Less than 2
Loose	5 - 10	2 - 5
Medium Dense	10 - 30	5 - 15
Dense	30 - 50	15 - 25
Very Dense	> 50	> 25

Rock types are classified by their geological names, together with descriptive terms on degrees of weathering strength, defects and other minor components. Where relevant, further information regarding rock classification, is given on the following sheet.

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

Disturbed samples taken during drilling provided information on plasticity, grained size, colour, type, moisture content, inclusions and depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin walled sample tube (normally know as U_{50}) into the soil and withdrawing a sample of the soil in a relatively undisturbed state. Such Samples yield information on structure and strength and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils. Details of the type and method of sampling are given in the report.

Field Investigation Methods
The following is a brief summary of investigation methods currently carried out by this company and comments on their use and application.

Hand Auger Drilling
The borehole is advanced by manually operated equipment. The diameter of the borehole ranges from 50mm to 100mm. Penetration depth of hand augered boreholes may be limited by premature refusal on a variety of materials, such as hard clay, gravels or ironstone.

Test Pits
These are excavated with a tractor-mounted backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descend into the pit. The depth of penetration is limited to about 3.0m for a backhoe and up to 6.0m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Care must be taken if construction is to be carried out near, or within the test pit locations, to either adequately recompact the backfill during construction, or to design the structure or accommodate the poorly compacted backfill.

Large Diameter Auger (eg Pengo)
The hole is advanced by a rotating plate or short spiral auger generally 300mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 05m) 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 Spiral Flight Augers
The hole is advanced by using 90mm - 115mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling or insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the augers flights, but they are very disturbed and may be highly mixed with soil of other stratum.

Information from the drilling (as distinct from specific sampling by SPT or undisturbed samples) is of relatively low reliability due to remoulding, mixing or softening of samples by ground water, resulting in uncertainties of the original sample depth.

Continuous Spiral Flight Augers (continued)
The spiral augers are usually advanced by using a V - bit through the soil profile refusal, followed by Tungsten Carbide (TC) bit, to penetrate into bedrock. The quality and continuity of the bedrock may be assessed by examination of the recovered rock fragments and through observation of the drilling penetration resistance.

Non - core Rotary Drilling (Wash Boring)
The hole is advanced by a rotary bit, with water being pumped down the drill rod and returned up the annulus, carrying the cuttings, together with some information from the "feel" and rate of penetration.

Rotary Mud Stabilised Drilling
This is similar to rotary drilling, but uses drilling mud as a circulating fluid, which may consist of a range of products, from bentonite to polymers such as Revert or Biogel. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg SPT and U_{50} samples).

Continuous Core Drilling
A continuous core sample is obtained using a diamond tipped core barrel. Providing full core recovery is achieved (which is not always possible in very weak rock and granular soils) this technique provides a very reliable (but relatively expensive) method of investigation. In rocks an NMLC triple tube core barrel which gives a core of about 50mm diameter, is usually used with water flush.

Portable Proline Drilling
This is manually operated equipment and is only used in sites which require bedrock core sampling and there is restricted site access to truck mounted drill rigs. The boreholes are usually advanced initially using a tricone roller bit and water circulation to penetrate the upper soil profile. In some instances a hand auger may be used to penetrate the soil profile. Subsequent drilling into bedrock involves the use of NMLC triple tube equipment, using water as a lubricant.

Standard Penetration Tests
Standard penetration tests are used mainly in non-cohesive soils, but occasionally also in cohesive soils, as a means of determining density or strength and of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289 "Methods of testing Soils for Engineering Purpose"- Test F31.

The test is carried out in a borehole by driving a 50mm diameter split sample tube under the impact of a 63Kg hammer with a free fall of 769mm. It is normal for the tube to be driven in three successive 150mm increments and the "N" value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rocks, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

- In a case where full penetration is obtained with successive blows counts for each 150mm of, say 4, 6, and 7 blows.

  as 4, 6, 7
  N = 13

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

  as 15,30/40mm

The results of the tests can be related empirically to the engineering properties of the soil. Occasionally the test methods is used to obtain samples in 50mm diameter thin walled samples tubes in clays. In these circumstances, the best results are shown on the bore logs in brackets.

Dynamic Cone Penetration Test
A modification to the SPT test is where the same driving system is used with a solid 60^0 tipped steel cone of the same diameter as the SPT hollow sampler. The cone can be continuously driven into the borehole and is normally used in areas with thick layers of soft clays or loose sand. The results of this test are shown as 'N_c' on the bore logs, together with the number of blows per 150mm penetration.

Cone Penetrometer Testing and Interpretation
Cone penetrometer testing (sometimes referred to as Dutch Cone-CPT) described in this report, has been carried out using an electrical friction cone penetrometer and the test is described in Australian Standard 1289 test F5.1.

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

As penetration occurs (at a rate of approximately 20mm per second) the information is output on continuous chart recorders. The plotted results in this report have been traced from the original records. The information provided on the charts comprises:

- Cone resistance - the actual end bearing force divided by the cross sectional area of the cone, expressed in Mpa.
- Sleeve friction - the frictional force on the sleeve divided by the surface area, expressed in kPa.
- Friction ratio - the ratio of sleeve friction to cone resistance, expressed in percentage.

There are two scales available for measurement of cone resistance. The lower "A" scale (0-5Mpa) 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 (0-50Mpa) 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 frictions in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and very soft clays, rising to 4% to 10% in stiff clays.

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

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

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 estimate of modulus or compressibility values to allow calculation of foundation settlements. Inferred stratification, as shown on the attached report, is assessed from the cone and friction traces, from experience and information from nearby boreholes etc.

Cone Penetrometer Testing and Interpretation continued
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 or soil classification is required, direct drilling and sampling may be preferable.

Portable Dynamic Cone Penetrometer (AS1289)
Portable dynamic cone penetrometer tests are carried out by driving a rod in to the ground with a falling weight hammer and measuring the blows per successive 100mm increments of penetration.

There are two similar tests, Cone Penetrometer (commonly known as Scala Penetrometer) and the Perth Sand Penetrometer. Scala Penetrometer is commonly adopted by this company and consists of a 16mm rod with a 20mm diameter cone end, driven with a 9kg hammer, dropping 510mm (AS 1289 Test F3.2).

Laboratory Testing
Laboratory testing is carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedures are given on the individual report forms.

Engineering Logs
The engineering logs presented herein are an engineering and/or geological interpretation of the sub-surface conditions and their reliability will depend to some extent on frequency of sampling and the method of drilling. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, however, this is not always practicable or possible to justify economically. As it is, the boreholes represent only a small sample of the total sub-surface profile. Interpretation of the information and its application to design and construction should take into account the spacing of boreholes, frequency of sampling and the possibility of other than "straight line" variations between the boreholes.

Ground water
Where ground water levels are measured in boreholes, there are several potential problems:
- In low permeability soils, ground water although present, may enter the hole slowly, or perhaps not at all, during the investigation period.
- A localised perched water table may lead to a erroneous indication of the true water table.
- Water table levels will vary from time to time, due to the seasons or recent weather changes. They may not be the same at the time of construction as 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 be washed out of the hole if any water observations are to be made.

More reliable measurements can be made by installing stand pipes, which are read at intervals over several days, or weeks for low permeability soils. Piezometers sealed in a particular stratum may be interference from a perched water table or surface water.

Engineering Reports
Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal is changed, say to a twenty storey building. If this occurs, the company will be pleased to review the report and sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of sub-surface conditions, discussions of geotechnical aspects and recommendations or suggestions for design and construction. However, the company cannot always anticipate or assume responsibility for:
- Unexpected variations in ground conditions. The potential for this will depend partly on bore spacing and sampling frequency.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of contractors responding to commercial pressures.

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

Site Anomalies
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the company request immediate notification. Most problems are much more readily resolved when conditions are exposed than at some later stage, well after the event.

Reproduction of Information for Contractual Purposes
Attention is drawn to the document “Guidelines for the Provision of Geotechnical Information trader Documents”, published by the Institute of Engineers Australia. Where information obtained for this investigation is provided for tender purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The Company would be pleased to assist in this regard and/or make additional copies of the report available for contract purpose, at a nominal charge.

Site Inspection

The Company will always be pleased to provide engineering inspection services for geotechnical aspect of work to which this report is related. This could range from a site visit to confirm that the conditions exposed are as expected, to full time engineering presence on site

Review of Design
Where major civil or structural developments are proposed, or where only a limited investigation has been completed, or where the geotechnical conditions are complex, it is prudent to have the design reviewed by a Senior Geotechnical Engineer.