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ABN 64 002 841 063

Job No: 13603/2
Our Ref: 13603/2-AA

16 November 2015

Binah By Design
P O Box 314
CASULA NSW 2170
Email: arefaieh@binah.com.au

Attention: Mr A Refaieh

Dear Sir

re: **Proposed Residential Development**
21 Atkinson Street, Liverpool
Preliminary Acid Sulfate Soil Assessment

This letter report provides a preliminary acid sulfate soil assessment for the above site, based on the test results of soil samples from four borehole locations.

We understand that the proposed development includes the demolition of existing structures, and construction of a residential building with seven storeys above the ground and one level of basement car park. The basement excavation is understood to be up to about 4.0m deep.

A preliminary acid sulfate soil assessment was required to ascertain if excavations for the development will disturb acid sulfate or potentially acid sulfate soils.

Background Information

The Soil Landscape Map of Penrith, Soil Landscape Series Sheet 9030, Scale 1:100,000 prepared by the Soil Conservation Service of NSW (Hazelton et al. 1989), indicate that the site is located within the Blacktown landscape area and typically consists of highly plastic and relatively impermeable residual soil. The site is also in close proximity to the boundary with the Luddenham Landscape area, which typically consists of poorly drained/relatively impermeable residual natural soils.

The Geological Map of Penrith, Geological Series Sheet 9030, Scale 1:100,000), published by the Department of Minerals and Energy(Clark and Jones 1991)) , indicate that the residual soil within the site is underlain by Triassic Age Bringelly Shale, belonging to the Wianamatta Group comprising shale, carbonaceous claystone, laminite and fine to medium grained lithic sandstone and rare coal.

Field sampling and laboratory testing of recovered soil samples was carried out to ascertain if soils to be excavated or disturbed during proposed works are acid sulfate soils or potentially acid sulfate soils.

Field Work
Field work for the investigation was carried out on 5 November 2015 and consisted of the following:

- A walk over survey to assess existing site conditions.
- Drilling four boreholes using a bob-cat mounted with an auger. Approximate borehole locations are indicated on the attached Drawing No 13603/2-AA1.
- Recovery of representative soil samples for laboratory testing.

Sub-surface Conditions
The site is irregular in shape, covering an area of 5412m^2. The following observations were made during field work:

- The site is bound by Atkinson Street to the south, railway corridor to the west, and Shepherd Street to the north and east.
- Most of the site is covered with hardstand / concrete surface..

Sub-surface conditions encountered in the boreholes are detailed in the attached borehole logs, and summarised below in Table 1.

TABLE 1

Borehole	Termination Depth (m)	Concrete Slab	Topsoil (m)	Fill (m)	Residual Soils (m)	Shale Bedrock (m)
BH1	2.2	0-0.15	-	0.15-0.25	0.25 – 1.3	>1.3 -2.2
BH2	2.2	0-0.15	-	0.15-2.2	-	NE
BH3	1.5		0 – 0.1	0.1 – 0.60	0.60 – 1.0	>1.0-1.5
BH4	1.2		0.0 – 0.1	0.1 – 1.2	NE	Possible bedrock >1.2

Topsoil	Silty Sand, fine to medium grained, dark brown with root fibres
Fill	Sand medium to coarse grained, brown, crushed shale gravel, fine to medium grained, black
	Silty clay, low to medium plasticity, with gravel and cobbles/boulders
	Sandy clay, low plasticity, dark brown, with gravel
	Clayey sand, fine medium grained, dark brown
Residual	Silty Clay, medium to high plasticity, grey, brown yellow brown, with ironstone and shale gravels
Bedrock	Shale, dark grey-brown, very low to low strength, extremely to distinctly weathered

Groundwater/seepage was encountered during drilling at about 2.2m. It should be noted that fluctuations in the level of groundwater might occur due to variations in rainfall and/or other factors.

Laboratory Testing

Laboratory testing to determine the presence of acid sulfate soils consisted of testing representative soil samples from BH1 to BH4 to determine **pH_{KCl}, pH_{ox}, TPA** (Titratable Peroxide Acidity), **TAA** (Titratable Actual Acidity), **TSA** (Titratable Sulfidic Acidity) **S_{POS}%** (Peroxide Oxidisable Sulphur) and **S_{CR}%** (Chromium Reducible Sulphur). Laboratory tests were carried out by SGS Australia Pty Ltd (NATA accredited) in accordance with SPOCAS (Suspension Peroxide Oxidation Combined Acidity & Sulfate) / Chromium Reducible Sulphur (SCR) methods recommended by the Queensland Acid Sulfate Soils Investigation Team (QASSIT) of the Queensland Department of Natural Resources, Mines and Energy (Qld DNRME 2004). The test results are attached, and summarised below in Table 2.

TABLE 2

Bohehole No	Depth (m)	Material Description	pH_{KCl}, Unit	pH_{ox}, Unit	TPA (pH6.5), mole H^+/t	TAA (pH6.5), mole H+/t	TSA (pH6.5), mole H+/t	S_{POS} % w/w	S_{CR} % w/w
BH1	1.0-1.2	Clay	6.7	8.4	<5	<5	<5	<0.005	<0.005
BH2	2.0-2.2	Sand	6.9	6.8	<5	<5	<5	<0.005	<0.005
BH3	0.6-0.8	Clay	7.4	7.8	<5	<5	<6	<0.005	0.006
BH3	1.3-1.5	Shale	8.8	8.7	<5	<5	<5	0.017	0.010
BH4	1.0-1.2	Clay	8.8	8.7	<5	<5	<5	0.009	0.006
Action Criteria for more than 1000 tonnes disturbed soil [a]					*18.0*	*18.0*	*18.0*	*0.03*	

pH_{KCl}: pH in a suspension of soil in a solution of 1M KCl extract
pH_{ox}: pH in a suspension of soil in a solution after peroxide digestion in SPOCAS method
TPA: Titratable Peroxide Acidity (moles H^+/tonne)
TAA: Titratable Actual Acidity (moles H^+/tonne)
TSA: Titratable Sufidic Acidity (moles H^+/tonne
S_{POS}: Peroxide Oxidisable Sulphur (% w/w)
S_{CR}: Chromium Reducible Sulphur (% w/w)
a: Acid Sulfate Soils Assessment Guidelines, NSW Acid Sulfate Soil Management Advisory Committee, 1998

Acid Sulfate Soil Assessment

The Acid Sulfate Management Advisory Committee, New South Wales recommends that assessment of acid sulfate soils or potentially acid sulfate soils at a site is carried out in stages, as follows:

Step 1 – Check the Acid Sulfate Soils Risk Map.

Step 2 – Check if the area meets the geomorphic or site criteria.

Step 3 – Analyse soil and/or water indicators.

Step 4 – Chemical analysis to confirm Acid Sulfate Soil and action level.

The Acid Sulfate Management Advisory Committee of New South Wales recommends a standardised approach for routine laboratory determination of actual and potential acid production from oxidisation of sulphides, which are present in acid sulfate soils.

Review of the Acid Sulfate Soil Risk Map of Liverpool (DLWC 1997) indicates that the site is located within an area of “No known Occurrence”, and in the proximity of an area of low probability of occurrence of acid sulfate soil materials within the soil profile, where acid sulfate soil material, if present, are sporadic and may be buried by alluvium and windblown sediments.

In circumstances where the existence of acid sulfate or potential acid sulfate soils is unlikely, tests that determine the actual pH and pH after oxidation are considered appropriate. An actual pH of less than 4 indicates a likelihood of acid sulfate soils, whilst pH values after oxidation (pH_{OX}) generally indicate the following:

- pH_{ox} of less than 3 – a high likelihood of potential acid sulfate soils.
- pH_{ox} of 3 to 4 – a likelihood of potential acid sulfate soils, but needs to be confirmed by additional testing.
- pH_{ox} of 4 to 5 – a possibility of potential acid sulfate soils.
- pH_{ox} greater than 5 with little reduction from actual pH – little acid generating ability in the soil.

The laboratory test results summarised in Table 2 indicate the following.

- The pH_{kcl} values are range from 6.7 to 8.8, indicating that the soils at the proposed development site are likely to be slightly acidic to alkaline in nature.
    - The pH_{ox} values range from 6.8 to 8.7, indicating that it is unlikely that oxidation of soils at these depths will produce significant acid.

Other parameters used to assist in determination of acid sulfate and potentially acid sulfate soils are TAA, TPA or TSA.

The New South Wales Acid Sulfate Soils Management Advisory Committee recommends "Action Criteria" based on these results for three broad texture categories. Works in soils that exceed these "Action Criteria" (as shown in the following table) must have an acid sulfate soils management plan.

Type of Material		**Action Criteria 1-1000 tonnes of soil is disturbed**		**Action Criteria More than 1000 tonnes of soil is disturbed**	
Texture Range	**Approx Clay Content** (%<0.002mm)	**Sulphur Trail** % S oxidisable (oven dry basis) e.g. S_{POS} or S_{CR}	**Acid Trail** mol H^+/tonne (oven dry basis) e.g. TPA or TSA	**Sulphur Trail** % S oxidisable (oven dry basis) e.g. S_{POS} or S_{CR}	**Acid Trail** mol H^+/tonne (oven dry basis) e.g. TPA or TSA
Coarse Texture Sands to loamy sands	≤5	0.03	18	0.03	18
Medium Texture Sandy loams to light clays	5-40	0.06	36	0.03	18
Fine Texture Medium to heavy clays and silty clays	≥40	0.10	62	0.03	18

Based on borehole information, the soils likely to be disturbed during the proposed works are assessed to be of coarse to fine texture and the amount of soils to be disturbed is considered to be in excess of 1000 tonnes. Therefore, it is our assessment that:

- The Sulphur Trail results of S_{POS}/S_{SCR} at sampled depths were below the Action Criteria of 0.03%. It should be noted that S_{CR} method is particularly recommended for measuring the sulphide content close to the action limits and for soil with appreciable sulphur.

- The Acid trail results for all samples analysed were below the Action Criteria of 18 mol $^{H+}$/tonne.

Based on both the sulphur and acid trail assessments, it is considered that the soils likely to be disturbed during proposed works are unlikely to be acid sulfate or potentially acid sulfate. Therefore, the proposed excavation works may be carried out without an Acid Sulfate Soils Management Plan.

General
As the recommendations presented in this report are based on information from four boreholes to depths up to 2.2m from existing ground surface and laboratory tests on five representative soil samples, actual sub-surface conditions across the site might differ from those expected (interpreted). If such differences are encountered during construction, we recommend that this office is contacted for further advice.

If you have any questions, please do not hesitate to contact the undersigned.

Yours faithfully
GEOTECHNIQUE PTY LTD

DANDA SAPKOTA
Senior Environmental Engineer

Attached Drawing 13603/2-AA1 – Borehole Locations
Borehole Logs
SGS Laboratory Test Results

References

Clark, NR, and Jones 1991, *Geological Series Sheet 9030, Scale 1:100,000 (Penrith),* Department of Minerals and Energy, NSW, Sydney

Hazelton PA, Bannerman SM and Tillie, PJ 1989, *Soil Landscape Series Sheet 9030, Scale 1:100,000 (Penrith),* Soil Conservation Service of NSW, Sydney

Murphy C L (1997), *Acid Sulfate Soil Risk Map (Liverpool), edition 2,* Department of Land and Water Conservation (DLWC).

NSW ASMAAC 1998, *Acid Sulfate Soil Manual*, New South Wales, Acid Soil Management Advisory Committee.

QLD DNRME 2004, *Acid Sulfate Soils – Laboratory Methods Guidelines,*Queensland, Department of Natural Resources, Mines and Energy.

Imagery ©2015 NearMap.com

LEGEND

Borehole

0 8 16 24 32 40m

Scale 1:800

PREPARED BY:

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Binah By Design
Proposed Residential Development
21 Atkinson Street
Liverpool

Borehole Locations

Drawing No: 13603/2-AA1
Job No: 13603/2
Drawn By: MH
Date: 9 November 2015
Checked By: AI

File No: 13603-2
Layers: 0, AA1

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engineering log - borehole

Client : Binah By Design
Project : Proposed Residential Development
Location : 21 Atkinson Street, Liverpool

Job No. : 13603/2
Borehole No. : 1
Date : 05/11/2015
Logged/Checked by: AI

drill model and mounting : Bobcat Auger **slope :** **deg.** **R.L. surface :**

hole diameter : 250 **mm** **bearing :** **deg.** **datum :**

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
						0			CEMENT CONCRETE PAVEMENT				
									FILL: Crushed Shale Gravel, fine to medium grained, black				
								CI-CH	Silty CLAY, medium to high plasticity, grey and brown, with ironstone/shale gravel	M<PL	S-St		Possible fill
						0.5							
								CI	Silty CLAY, medium plasticity, yellow-brown, with shale gravel	M<PL	VSt-H		
				DS		1							
						1.5			SHALE, dark grey-brown, very low strength, extremely to distinctly weathered				Bedrock
				DS		2							
									Borehole No. 1 terminated at 2.2m				
						2.5							
						3							
						3.5							
						4							
						4.5							

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engineering log - borehole

Client : Binah By Design
Project : Proposed Residential Development
Location : 21 Atkinson Street, Liverpool

Job No. : 13603/2
Borehole No. : 2
Date : 05/11/2015
Logged/Checked by: AI

drill model and mounting : Bobcat Auger **slope :** **deg.** **R.L. surface :**

hole diameter : 250 **mm** **bearing :** **deg.** **datum :**

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
						0			CEMENT CONCRETE PAVEMENT				
									FILL: Sand, medium to coarse grained, brown				50mm
									FILL: Crushed Shale Gravel, fine to medium grained, black				Moderately compacted
						0.5			FILL: Silty Clay, low to medium plasticity, grey and brown, with gravel and cobbles				
									FILL: Sandy Clay, low plasticity, dark brown, with gravel				Moderately compacted
				DS		1							
						1.5			FILL: Clayey Sand, fine to medium grained, dark brown				Loosely compacted
				DS		2			SAND, medium to coarse grained, brown				Possible fill
									Borehole No. 2 terminated at 2.2m				
						2.5							
						3							
						3.5							
						4							
						4.5							

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engineering log - borehole

Client : Binah By Design
Project : Proposed Residential Development
Location : 21 Atkinson Street, Liverpool

Job No. : 13603/2
Borehole No. : 3
Date : 05/11/2015
Logged/Checked by: AI

drill model and mounting : Bobcat Auger **slope :** **deg.** **R.L. surface :**

hole diameter : 250 **mm** **bearing :** **deg.** **datum :**

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
						0			TOPSOIL: Silty Sand, fine to medium grained, dark brown, with gravel and roots				
									FILL: Silty Clay, low to medium plasticity, dark brown, with shale gravel and cobbles	M<PL			Moderately compacted
				DS		0.5		CI	Silty CLAY, medium plasticity, grey-brown, with ironstone/shale gravel	M<PL	VSt-H		
						1			SHALE, dark grey-brown, very low to low strength, extremely to distinctly weathered				
				DS		1.5			Borehole No. 3 terminated at 1.5m due to refusal in shale bedrock				
						2							
						2.5							
						3							
						3.5							
						4							
						4.5							

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engineering log - borehole

Client : Binah By Design
Project : Proposed Residential Development
Location : 21 Atkinson Street, Liverpool

Job No. : 13603/2
Borehole No. : 4
Date : 05/11/2015
Logged/Checked by: AI

drill model and mounting : Bobcat Auger **slope :** **deg.** **R.L. surface :**

hole diameter : 250 **mm** **bearing :** **deg.** **datum :**

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
						0			TOPSOIL: Silty Sand, fine to medium grained, dark brown, with root fibres	M<PL			Variably compacted
				DS		0.5			FILL: Silty Clay, low to medium plasticity, dark brown, with gravel, cobbles and boulders				
				DS		1							
						1.5			Borehole No. 4 terminated at 1.2m due to refusal on possible shale bedrock				
						2							
						2.5							
						3							
						3.5							
						4							
						4.5							

KEY TO SYMBOLS

Symbol Description

Strata symbols

Pavement
(Bitumen, Concrete Slab, etc)

Fill

Silty Clay
medium to high plasticity

Silty Clay
medium plasticity

Shale

Sand

Topsoil

Descriptions of various line types (solid, dotted, etc.)

Profile change

Gradual profile change

Notes:

1. **Exploratory borings were drilled between 05/11/2015 and 05/11/2015 using a 50, 100 and 125mm diameter continuous flight power auger.**

2. **These logs are subject to the limitations, conclusions and recommendations in this report.**

3. **Results of tests conducted on samples recovered are reported on the logs.**

Log Symbols & Abbreviations (Non-cored Borehole Log)

Log Column	Symbol/Value		Description
Drilling Method	V-bit TC-bit RR DB BB		Hardened steel 'V' shaped bit attached to auger Tungsten Carbide bit attached to auger Tricone (Rock Roller) bit Drag bit Blade bit
Groundwater	Dry 		Groundwater not encountered to the drilled or auger refusal depth Groundwater level at depths shown on log Groundwater seepage at depths shown on log
Environment Sample	GP G P		Glass bottle and plastic bag sample over depths shown on log Glass bottle sample over depths shown on log Plastic bag sample over depths shown on log
PID Reading	100		PID reading in ppm
Geotechnical Sample	DS DB U_{50}		Disturbed Small bag sample over depths shown on log Disturbed Bulk sample over depths shown on log Undisturbed 50mm tube sample over depths shown on log
Field Test	N=10 3,5,5 N=R 10,15/100		Standard Penetration Test (SPT) 'N' value. Individual numbers indicate blows per 150mm penetration. 'R' represents refusal to penetration in hard/very dense soils or in cobbles or boulders. The first number represents10 blows for 150mm penetration whereas the second number represents 15 blows for 100mm penetration where SPT met refusal
	DCP/PSP	5 6 R/10	Dynamic Cone Penetration (DCP) or Perth Sand Penetrometer (PSP). Each number represents blows per 100mm penetration. 'R/10' represents refusal after 10mm penetration in hard/very dense soils or in gravels or boulders.
Classification	GP GW GM GC SP SW SM SC ML MI MH CL CI CH		Poorly Graded GRAVEL Well graded GRAVEL Silty GRAVEL Clayey GRAVEL Poorly graded SAND Well graded SAND Silty SAND Clayey SAND SILT / Sandy SILT / clayey SILT, low plasticity SILT / Sandy SILT / clayey SILT, medium plasticity SILT / Sandy SILT / clayey SILT, high plasticity CLAY / Silty CLAY / Sandy CLAY / Gravelly CLAY, low plasticity CLAY / Silty CLAY / Sandy CLAY / Gravelly CLAY, medium plasticity CLAY / Silty CLAY / Sandy CLAY / Gravelly CLAY, high plasticity
Moisture Condition Cohesive soils Cohesionless soils	 M<PL M=PL M>PL D M W		 Moisture content less than Plastic Limit Moisture content equal to Plastic Limit Moisture content to be greater than Plastic Limit Dry - Runs freely through hand Moist - Tends to cohere Wet - Tends to cohere

Consistency Cohesive soils	Term	Undrained shear strength, C_u (kPa)	Hand Penetrometer (Qu)
VS	Very Soft	≤12	<25
S	Soft	>12 ≤25	25 – 50
F	Firm	>25 ≤50	50 – 100
St	Stiff	>50 ≤100	100 – 200
VSt	Very Stiff	>100 ≤200	200 – 400
H	Hard	>200	>400

Density Index Cohesionless soils	Term	Density Index, I_D (%)	SPT 'N' (blows/300mm)
VL	Very Loose	≤15	≤5
L	Loose	>15 ≤35	>5 ≤10
M	Medium Dense	>35 ≤65	>10 ≤30
D	Dense	>65 ≤85	>30 ≤50
VD	Very Dense	>85	>50

Hand Penetrometer	100 200	Unconfined compressive strength (q_u) in kPa determined using pocket penetrometer, at depths shown on log
Remarks	 Residual Alluvium Colluvial Aeolian Marine	Geological origin of soils Residual soils above bedrock River deposited Alluvial soils Gravity deposited Colluvial soils Wind deposited Aeolian soils Marine Soils

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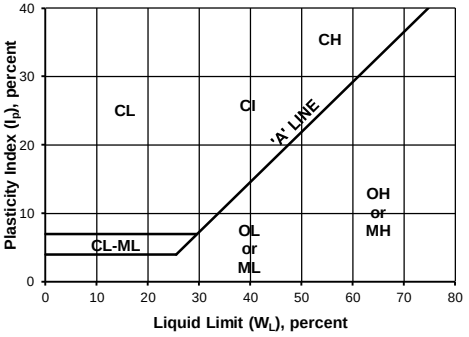
AS1726 – Unified Soil Classification System

Major Divisions		Particle size (mm)	Group Symbol	Typical Names	Field Identifications Sand and Gravels			Laboratory classification				
	BOULDERS	200						% (2) < 0.075mm	Plasticity of Fine Fraction	$C_u = D_{60}/D_{10}$	$C_c = (D_{30})^2/(D_{10}D_{60})$	Notes
	COBBLES	63										
COARSE GRAINED SOILS (more than half of material less 63mm is larger than 0.075mm)	GRAVELS (more than half of coarse fraction is larger than 2.36mm)	Coarse 20	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength			0-5	-	>4	between 1 and 3	1. Identify lines by the method given for fine grained soils 2. Borderline classifications occur when the percentage of fines (fraction smaller than 0.075mm size) is greater than 5% and less than 12%. Borderline classifications require the use of dual symbols e.g. SP-SM, GW-GC
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines, uniform gravels	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength			0-5	-	Fails to comply with above		
		Medium 6	GM	Silty gravels, gravel-sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength			12-50	Below 'A' line or I_p<4	-	-	
		Fine 2.36	GC	Clayey gravels, gravel-sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength			12-50	Above 'A' line or I_p>7	-	-	
	SANDS (more than half of coarse fraction is smaller than 2.36mm)	Coarse 0.6	SW	Well-graded sands, gravelly sands, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength			0-5	-	>6	between 1 and 3	
		Medium 0.2	SP	Poorly graded sands and gravelly sands; little or no fines, uniform sands	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength			0-5	-	Fails to comply with above		
		Fine 0.075	SM	Silty sands, sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength			12-50	Below 'A' line or I_p<4	-	-	
			SC	Clayey sand, sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength			12-50	Above 'A' line of I_p>7	-	-	
FINE GRAINED SOILS (more than half of material less than 63mm is smaller than 0.075mm)					**Dry Strength**	**Dilatancy**	**Toughness**					
	SILTS & CLAYS (liquid limit < 50%)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	None to low	Quick to slow	None	More than 50% passing 0.075mm	Below 'A' line			
			CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Medium to high	None to very slow	Medium		Above 'A' line			
			OL	Organic silts and organic silty clays of low plasticity	Low to medium	Slow	Low		Below 'A' line			
	SILTS & CLAYS (liquid limit > 50%)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	Low to medium	Slow to none	Low to medium		Below 'A' line			
			CH	Inorganic clays of medium to high plasticity, fat clays	High to very high	None	High		Above 'A' line			
			OH	Organic clays of medium to high plasticity, organic silts	Medium to high	None to very slow	Low to medium		Below 'A' line			
	HIGHLY ORGANIC SOILS		Pt	Peat and highly organic soils	Identified by colour, odour, spongy feel and generally by fibrous texture			Effervesces with H_2O_2				

Use the gradation of material passing 63mm for classification of fractions according to the criteria given in 'Major Divisions'

Log Symbols & Abbreviations (Cored Borehole Log)

Log Column	Symbol	Description
Core Size		Nominal Core Size (mm)
	NQ	47
	NMLC	52
	HQ	63
Water Loss	◀	Complete water loss
	◁	Partial water loss
Weathering	FR	Fresh — Rock shows no sign of decomposition or staining
	SW	Slightly Weathered — Rock is slightly discoloured but shows little or no change of strength from fresh rock
	DW	Distinctly Weathered — Rock strength usually changed by weathering. The rock may be highly discoloured, usually by ironstaining. Porosity may be increased by leaching, or may be decreased by deposition of weathering products in pores
	EW	Extremely Weathered — Rock is weathered to such an extent that it has 'soil' properties, i.e. it either disintegrate or can be remoulded, in water
	RS	Residual Soil — Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but soil has not been significantly transported
Strength		Term — Point Load Strength Index (I_{s50}, MPa)
	EL	Extremely Low — ≤0.03
	VL	Very Low — >0.03 ≤0.1
	L	Low — >0.1 ≤0.3
	M	Medium — >0.3 ≤1
	H	High — >1 ≤3
	VH	Very High — >3 ≤10
	EH	Extremely High — >10
Defect Spacing		Description — Spacing (mm)
		Extremely closely spaced — <20
		Very closely spaced — 20 to 60
		Closely spaced — 60 to 200
		Medium spaced — 200 to 600
		Widely spaced — 600 to 2000
		Very widely spaced — 2000 to 6000
		Extremely widely spaced — >6000
Defect Description		
Type	Bp	Bedding parting
	Fp	Foliation parting
	Jo	Joint
	Sh	Sheared zone
	Cs	Crushed seam
	Ds	Decomposed seam
	Is	Infilled seam
Macro-surface geometry	St	Stepped
	Cu	Curved
	Un	Undulating
	Ir	Irregular
	Pl	Planar
Micro-surface geometry	Ro	Rough
	Sm	Smooth
	Sl	Slickensided
Coating or infilling	cn	clean
	sn	stained
	vn	veneer
	cg	coating

AS1726 – Identification of Sedimentary Rocks for Engineering Purposes

Grain Size mm		Bedded rocks (mostly sedimentary)									
More than 20	20	Grain Size Description				At least 50% of grains are of carbonate				At least 50% of grains are of fine-grained volcanic rock	
	6	RUDACEOUS		CONGLOMERATE Rounded boulders, cobbles and gravel cemented in a finer matrix		LIMESTONE and DOLOMITE (undifferentiated)		Calcirudite		Fragments of volcanic ejecta in a finer matrix	SALINE ROCKS
	2			Breccia Irregular rock fragments in a finer matrix						Rounded grains AGGLOMERATE Angular grains VOLCANIC BRECCIA	Halite Anhydrite
	0.6	ARENACEOUS	Coarse	SANDSTONE Angular or rounded grains, commonly cemented by clay, calcite or iron minerals				Calcarenite		Cemented volcanic ash	Gypsum
	0.2		Medium	Quartzite Quartz grains and siliceous cement						TUFF	
	0.06		Fine	Arkose Many feldspar grains Greywacke Many rock chips							
	0.002	ARGILLACEOUS		MUDSTONE	SILTSTONE Mostly silt	Calcareous Mudstone		Calcisiltite	CHALK	Fine-grained TUFF	
	Less than 0.002			SHALE Fissile	CLAYSTONE Mostly clay			Calcilutite		Very fine-grained TUFF	
Amorphous or crypto-crystalline				Flint: occurs as hands of nodules in the chalk Chert: occurs as nodules and beds in limestone and calcareous sandstone							COAL LIGNITE
				Granular cemented – except amorphous rocks							
				SILICEOUS		CALCAREOUS				SILICEOUS	CARBONACEOUS
				SEDIMENTARY ROCKS Granular cemented rocks vary greatly in strength, some sandstones are stronger than many Igneous rocks. Bedding may not show in hand specimens and is best seen in outcrop. Only sedimentary rocks, and some metamorphic rocks derived from them, contain fossils Calcareous rocks contain calcite (calcium carbonate) which effervesces with dilute hydrochloric acid						

AS1726 – Identification of Metamorphic and Igneous Rocks for Engineering Purposes

Obviously foliated rocks (mostly metamorphic)		Rocks with massive structure and crystalline texture (mostly igneous)						Grain size (mm)
Grain size description			Grain size description	Pegmatite			Pyrosenite	More than 20
		MARBLE						20
COARSE	GNEISS Well developed but often widely spaced foliation sometimes with schistose bands	QUARTZITE	COARSE	GRANITE	Diorite	GABBRO	Peridorite	6
	Migmatite Irregularly foliated: mixed schists and gneisses	Granulite HORNFELS		These rocks are sometimes phorphyritic and are then described, for example, as porphyritic granite				2
MEDIUM	SCHIST Well developed undulose foliation; generally much mica	Amphibolite	MEDIUM	Micorgranite	Microdiorite	Dolerite		0.6
		Serpentine		These rocks are sometimes phorphyritic and are then described as porphyries				0.2
								0.06
FINE	PHYLLITE Slightly undulose foliation; sometimes 'spotted'		FINE	RHYOLITE	ANDESITE	BASALT		0.002
	SLATE Well developed plane cleavage (foliation)			These rocks are sometimes phorphyritic and are then described as porphyries				Less than 0.002
	Mylonite Found in fault zones, mainly in igneous and metamorphic areas			Obsidian	Volcanic glass			Amorphous or cryptocrystalline
CRYSTALLINE				Pale<----------->Dark				
SILICEOUS		Mainly SILICEOUS		ACID Much quartz	INTERMEDIATE Some quartz	BASIC Little or no quartz	ULTRA BASIC	
METAMORPHIC ROCKS Most metamorphic rocks are distinguished by foliation which may impart fissility. Foliation in gneisses is best observed in outcrop. Non-foliated metamorphics are difficult to recognize except by association. Any rock baked by contact metamorphism is described as 'hornfels' and is generally somewhat stronger than the parent rock Most fresh metamorphic rocks are strong although perhaps fissile			IGNEOUS ROCKS Composed of closely interlocking mineral grains. Strong when fresh; not porous Mode of occurrence : 1 Batholith; 2 Laccoliths; 3 Sills; 4 Dykes; 5 Lava Flows; 6 Veins					

ANALYTICAL REPORT

WORLD RECOGNISED ACCREDITATION

CLIENT DETAILS

Contact	Indra Jworchan
Client	Geotechnique
Address	P.O. Box 880 NSW 2751
Telephone	02 8594 0400
Facsimile	02 8594 0499
Email	au.environmental.sydney@sgs.com
Project	**13603-2**
Order Number	**SE145719**
Samples	5

LABORATORY DETAILS

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Facsimile	+61 07 4035 5122
Email	AU.Environmental.Cairns@sgs.com
SGS Reference	**CE118143 R0**
Date Received	09 Nov 2015
Date Reported	11 Nov 2015

COMMENTS

Accredited for compliance with ISO/IEC 17025. NATA accredited laboratory 2562(3146)

SIGNATORIES

Anthony Nilsson
Operations Manager

Parameter	Units	LOR	Sample Number Sample Matrix Sample Name CE118143.001 Soil BH1 1.0-1.2	CE118143.002 Soil BH2 2.0-2.2	CE118143.003 Soil BH3 0.6-0.8	CE118143.004 Soil BH3 1.3-1.5
Moisture Content Method: AN002 Tested: 9/11/2015						
% Moisture	%w/w	0.5	**11**	**9.2**	**6.7**	**6.3**
TAA (Titratable Actual Acidity) Method: AN219 Tested: 10/11/2015						
pH KCl	pH Units	-	**6.7**	**6.9**	**7.4**	**8.8**
Titratable Actual Acidity	kg H2SO4/T	0.25	<0.25	<0.25	<0.25	<0.25
Titratable Actual Acidity (TAA) moles H+/tonne	moles H+/T	5	<5	<5	<5	<5
Titratable Actual Acidity (TAA) S%w/w	%w/w S	0.01	<0.01	<0.01	<0.01	<0.01
Sulphur (SKCl)	%w/w	0.005	<0.005	<0.005	<0.005	**0.006**
Calcium (CaKCl)	%w/w	0.005	**0.039**	**0.046**	**0.13**	**0.22**
Magnesium (MgKCl)	%w/w	0.005	**0.10**	**0.009**	**0.077**	**0.079**
TPA (Titratable Peroxide Acidity) Method: AN218 Tested: 10/11/2015						
Peroxide pH (pH Ox)	pH Units	-	**8.4**	**6.8**	**7.8**	**8.7**
TPA as kg H_2SO_4/tonne	kg H2SO4/T	0.25	<0.25	<0.25	<0.25	<0.25
TPA as moles H+/tonne	moles H+/T	5	<5	<5	<5	<5
TPA as S % W/W	%w/w S	0.01	<0.01	<0.01	<0.01	<0.01
Titratable Sulfidic Acidity as moles H+/tonne	moles H+/T	5	<5	<5	<5	<5
Titratable Sulfidic Acidity as kg H_2SO_4/tonne	kg H2SO4/T	0.25	<0.25	<0.25	<0.25	<0.25
Titratable Sulfidic Acidity as S % W/W	%w/w S	0.01	<0.01	<0.01	<0.01	<0.01
ANCE as % $CaCO_3$	% CaCO3	0.01	**0.25**	**0.15**	**0.25**	**0.50**
ANCE as moles H+/tonne	moles H+/T	5	**50**	**30**	**50**	**100**
ANCE as S % W/W	%w/w S	0.01	**0.08**	**0.05**	**0.08**	**0.16**
Peroxide Oxidisable Sulphur (Spos)	%w/w	0.005	<0.005	<0.005	<0.005	**0.017**
Peroxide Oxidisable Sulphur as moles H+/tonne	moles H+/T	5	<5	<5	<5	**11**
Sulphur (Sp)	%w/w	0.005	<0.005	<0.005	**0.009**	**0.023**
Calcium (Cap)	%w/w	0.005	**0.053**	**0.056**	**0.15**	**0.56**
Reacted Calcium (CaA)	%w/w	0.005	**0.014**	**0.010**	**0.022**	**0.33**
Reacted Calcium (CaA)	moles H+/T	5	**7**	<5	**11**	**170**
Magnesium (Mgp)	%w/w	0.005	**0.10**	**0.013**	**0.076**	**0.084**
Reacted Magnesium (MgA)	%w/w	0.005	<0.005	<0.005	<0.005	<0.005
Reacted Magnesium (MgA)	moles H+/T	5	<5	<5	<5	<5
Net Acid Soluble Sulphur as % w/w	%w/w	0.005	-	-	-	-
Net Acid Soluble Sulphur as moles H+/tonne	moles H+/T	5	-	-	-	-
SPOCAS Net Acidity Calculations Method: AN220 Tested: -						
s-Net Acidity	%w/w S	0.01	<0.01	<0.01	<0.01	<0.01
a-Net Acidity	moles H+/T	5	<5	<5	<5	<5
Liming Rate	kg CaCO3/T	0.1	<0.1	<0.1	<0.1	<0.1
Verification s-Net Acidity	%w/w S	-20	**-0.05**	**-0.03**	**-0.05**	**-0.10**
a-Net Acidity without ANCE	moles H+/T	5	<5	<5	<5	**11**
Liming Rate without ANCE	kg CaCO3/T	0.1	<0.1	<0.1	<0.1	NA
Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 10/11/2015						
Chromium Reducible Sulphur (Scr)	%	0.005	<0.005	<0.005	**0.006**	**0.010**
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5	<5	<5	**6**

Parameter	Units	LOR	Sample Number CE118143.005 Sample Matrix Soil Sample Name BH4 1.0-1.2
Moisture Content Method: AN002 Tested: 9/11/2015			
% Moisture	%w/w	0.5	**12**
TAA (Titratable Actual Acidity) Method: AN219 Tested: 10/11/2015			
pH KCl	pH Units	-	**8.8**
Titratable Actual Acidity	kg H2SO4/T	0.25	<0.25
Titratable Actual Acidity (TAA) moles H+/tonne	moles H+/T	5	<5
Titratable Actual Acidity (TAA) S%w/w	%w/w S	0.01	<0.01
Sulphur (SKCl)	%w/w	0.005	**0.006**
Calcium (CaKCl)	%w/w	0.005	**0.37**
Magnesium (MgKCl)	%w/w	0.005	**0.061**
TPA (Titratable Peroxide Acidity) Method: AN218 Tested: 10/11/2015			
Peroxide pH (pH Ox)	pH Units	-	**8.7**
TPA as kg H_2SO_4/tonne	kg H2SO4/T	0.25	<0.25
TPA as moles H+/tonne	moles H+/T	5	<5
TPA as S % W/W	%w/w S	0.01	<0.01
Titratable Sulfidic Acidity as moles H+/tonne	moles H+/T	5	<5
Titratable Sulfidic Acidity as kg H_2SO_4/tonne	kg H2SO4/T	0.25	<0.25
Titratable Sulfidic Acidity as S % W/W	%w/w S	0.01	<0.01
ANCE as % $CaCO_3$	% CaCO3	0.01	**0.90**
ANCE as moles H+/tonne	moles H+/T	5	**180**
ANCE as S % W/W	%w/w S	0.01	**0.29**
Peroxide Oxidisable Sulphur (Spos)	%w/w	0.005	**0.009**
Peroxide Oxidisable Sulphur as moles H+/tonne	moles H+/T	5	**6**
Sulphur (Sp)	%w/w	0.005	**0.015**
Calcium (Cap)	%w/w	0.005	**0.84**
Reacted Calcium (CaA)	%w/w	0.005	**0.47**
Reacted Calcium (CaA)	moles H+/T	5	**240**
Magnesium (Mgp)	%w/w	0.005	**0.046**
Reacted Magnesium (MgA)	%w/w	0.005	<0.005
Reacted Magnesium (MgA)	moles H+/T	5	<5
Net Acid Soluble Sulphur as % w/w	%w/w	0.005	-
Net Acid Soluble Sulphur as moles H+/tonne	moles H+/T	5	-

Parameter	Units	LOR	Sample Number: CE118143.005 Sample Matrix: Soil Sample Name: BH4 1.0-1.2
SPOCAS Net Acidity Calculations Method: AN220 Tested: -			
s-Net Acidity	%w/w S	0.01	<0.01
a-Net Acidity	moles H+/T	5	<5
Liming Rate	kg CaCO3/T	0.1	<0.1
Verification s-Net Acidity	%w/w S	-20	**-0.19**
a-Net Acidity without ANCE	moles H+/T	5	**6**
Liming Rate without ANCE	kg CaCO3/T	0.1	NA
Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 10/11/2015			
Chromium Reducible Sulphur (Scr)	%	0.005	**0.006**
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Chromium Reducible Sulphur (CRS) **Method: ME-(AU)-[ENV]AN217**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Chromium Reducible Sulphur (Scr)	LB031264	%	0.005	<0.005	0 - 3%	87%
Chromium Reducible Sulphur (Scr)	LB031264	moles H+/T	5	<5		

TAA (Titratable Actual Acidity) **Method: ME-(AU)-[ENV]AN219**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
pH KCl	LB031263	pH Units	-	5.7	0 - 3%	98%
Titratable Actual Acidity	LB031263	kg H2SO4/T	0.25	<0.25	0 - 20%	NA
Titratable Actual Acidity (TAA) moles H+/tonne	LB031263	moles H+/T	5	<5	0 - 22%	92%
Titratable Actual Acidity (TAA) S%w/w	LB031263	%w/w S	0.01	<0.01	0%	92%
Sulphur (SKCl)	LB031263	%w/w	0.005	<0.005	0 - 9%	90%
Calcium (CaKCl)	LB031263	%w/w	0.005	<0.005	1 - 8%	98%
Magnesium (MgKCl)	LB031263	%w/w	0.005	<0.005	0 - 5%	99%

TPA (Titratable Peroxide Acidity) **Method: ME-(AU)-[ENV]AN218**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Peroxide pH (pH Ox)	LB031262	pH Units	-	6.4	0 - 2%	96%
TPA as kg H_2SO_4/tonne	LB031262	kg H2SO4/T	0.25	<0.25	0%	108%
TPA as moles H+/tonne	LB031262	moles H+/T	5	<5	0%	108%
TPA as S % W/W	LB031262	%w/w S	0.01	<0.01	0%	108%
ANCE as % $CaCO_3$	LB031262	% CaCO3	0.01	<0.01	0%	
ANCE as moles H+/tonne	LB031262	moles H+/T	5	<5	0%	
ANCE as S % W/W	LB031262	%w/w S	0.01	<0.01	0%	
Sulphur (Sp)	LB031262	%w/w	0.005	<0.005	0 - 3%	99%
Calcium (Cap)	LB031262	%w/w	0.005	<0.005	1 - 9%	97%
Magnesium (Mgp)	LB031262	%w/w	0.005	<0.005	1 - 22%	104%

METHOD SUMMARY

METHOD	METHODOLOGY SUMMARY
AN002	The test is carried out by drying (at either 40°C or 105°C) a known mass of sample in a weighed evaporating basin. After fully dry the sample is re-weighed. Samples such as sludge and sediment having high percentages of moisture will take some time in a drying oven for complete removal of water.
AN004	Soils, sediments and sludges are pulverised using an LM2 ring mill. The dry sample is pulverised to a particle size of >90% passing through a -75µm sieve.
AN217	Dried pulped sample is mixed with acid and chromium metal in a rapid distillation unit to produce hydrogen sulfide (H2S) which is collected and titrated with iodine (I2(aq)) to measure SCR.
AN218	Soil samples are subjected to extreme oxidising conditions using hydrogen peroxide. Continuous application of heat and peroxide ensure all sulfide is converted to sulfuric acid. Excess peroxide is broken down by a copper catalyst prior to titration for acidity. Calcium, magnesium, and sulfur are determined by ICP-OES. Also included is a carbonate modification step which, depending on pH after the initial oxidation, gives a measure of ANC.
AN219	Dried pulped sample is extracted for 4 hours in a 1 M KCl solution. The ratio of sample to solution is 1:40. The extract is titrated for acidity. Calcium, magnesium, and sulfur are determined by ICP-AES.
AN220	SPOCAS Suite: Scheme for the calculation of net acidities and liming rates using a Fineness Factor of 1.5.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
**	Indicative data, theoretical holding time exceeded.	QFL	QC result is below the lower tolerance
		-	The sample was not analysed for this analyte
		NVL	Not Validated

Samples analysed as received.
Solid samples expressed on a dry weight basis.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: http://www.sgs.com.au/~/media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf

COC received 5/11/15 @ 4:50 pm

GEOTECHNIQUE PTY LTD

Laboratory Test Request / Chain of Custody Record

Lemko Place
PENRITH NSW 2750

P O Box 880
PENRITH NSW 2751

Tel: (02) 4722 2700
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email: info@geotech.com.au

Page

TO:	SGS ENVIRONMENTAL SERVICES UNIT 16 33 MADDOX STREET ALEXANDRIA NSW 2015	**Sampling By:** AI	**Job No:** 13603/2
			Project:
PH:	02 8594 0400	**FAX:** 02 8594 0499	
ATTN:	Ms Emily Yin	**Project Manager:** IJ	**Location:**

Sampling details — **Results required by:** Wed - 11/11

	Location	Depth	Soil	Water	sPOCAS	CRS							Notes	Keep Sample
1	BH1	1.0-1.2	DSP		✓	✓							sPOCAS test includes	
	BH1	2.0-2.2	DSP										pH(kcl), pH(ox), TPA, TAA, TSA	
	BH2	1.0-1.2	DSP											
2	BH2	2.0-2.2	DSP		✓	✓							CRS=Chromium Reducible Sulphur	
3	BH3	0.6-0.8	DSP		✓	✓								
4	BH3	1.3-1.5	DSP		✓	✓								
	BH4	0.3-0.5	DSP											
5	BH4	1.0-1.2	DSP		✓	✓								

SGS Alexandria Environmental
SE145719 COC
Received: 06 – Nov – 2015

Relinquished by			Received by		
Name	Signature	Date	Name	Signature	
Indra Jworchan		5/11/2015	Tommy	Tommy P.	6/11/15 1:45p.m

Legend:

WG	USG	Undisturbed soil sample (glass	DSP	Disturbed soil sample (small plastic bag)	* Purge & Trap
WP	DSG	Disturbed soil sample (glass ja	✓	Test required	# Geotechnique Screen

Form No 4.7F2-5 SGS

SAMPLE RECEIPT ADVICE

SE145719

CLIENT DETAILS

Contact	Indra Jworchan
Client	Geotechnique
Address	P.O. Box 880 NSW 2751
Telephone	02 4722 2700
Facsimile	02 4722 6161
Email	indra.jworchan@geotech.com.au
Project	**13603-2**
Order Number	(Not specified)
Samples	5

LABORATORY DETAILS

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Laboratory	SGS Alexandria Environmental
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Facsimile	+61 2 8594 0499
Email	au.environmental.sydney@sgs.com
Samples Received	Fri 6/11/2015
Report Due	Wed 11/11/2015
SGS Reference	**SE145719**

SUBMISSION DETAILS

This is to confirm that 5 samples were received on Friday 6/11/2015. Results are expected to be ready by Wednesday 11/11/2015. Please quote SGS reference SE145719 when making enquiries. Refer below for details relating to sample integrity upon receipt.

Sample counts by matrix	5 Soils	Type of documentation received	COC
Date documentation received	6/11/2015	Samples received in good order	Yes
Samples received without headspace	N/A	Sample temperature upon receipt	18°C
Sample container provider	Client	Turnaround time requested	Three Days
Samples received in correct containers	Yes	Sufficient sample for analysis	Yes
Sample cooling method	Ice Bricks	Samples clearly labelled	Yes
Complete documentation received	Yes		

Samples will be held for one month for water samples and two months for soil samples from date of report, unless otherwise instructed.

COMMENTS

SPOCAS and CRS subcontracted to SGS Cairns, 2/58 Comport St, Portsmith QLD 4870, NATA Accreditation Number: 2562, Site Number: 3146.
Sampling date was not provided. It is assumed to be as date samples were relinquished.
3 soil samples unmarked for analyses on the COC have been placed on hold.

SAMPLE RECEIPT ADVICE

SE145719

CLIENT DETAILS

Client Geotechnique

Project 13603-2

SUMMARY OF ANALYSIS

No.	Sample ID	Sample Subcontracted
001	BH1 1.0-1.2	1
002	BH2 2.0-2.2	1
003	BH3 0.6-0.8	1
004	BH3 1.3-1.5	1
005	BH4 1.0-1.2	1

The above table represents SGS Environmental Services' interpretation of the client-supplied Chain Of Custody document.
The numbers shown in the table indicate the number of results requested in each package.
Please indicate as soon as possible should your request differ from these details .
Testing as per this table shall commence immediately unless the client intervenes with a correction .