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Job No: 13188/3
Our Ref: 13188/3-AA
3 August 2015

Nix Anderson Pty Ltd
17 Chuter Street
MCMAHONS POINT NSW 2060
Email: robert.mcguinness@nxa.com.au

Attention: Mr R McGuinness

Dear Sir

re: **Proposed Redevelopment**
160 Burwood Road, Concord
Additional Geotechnical Investigation

This report provides results of an additional geotechnical investigation at the above site. The investigation was commissioned by Mr R Ewing of Propertylink Holdings Pty Ltd through a subcontract agreement and was carried out in general accordance with Geotechnique Pty Ltd proposal Q6614-AC dated 12 June 2015.

Proposed Development

We understand that Nix Anderson has been retained by Propertylink to assist in carrying out feasibility review of the above site to assess the development potential on behalf of the site owners – Freshfood Australia Holdings Pty Ltd. It is also understood that the existing Robert Timms Factory (Bushell's) will be relocated prior to development and the site will be developed as an Urban Regeneration Project – an integrated Residential Community.

An additional geotechnical was required by drilling six boreholes in the north-east corner (pathway and seawall) of the site.

Background Information

Geotechnique Pty Ltd previously completed geotechnical and contamination assessments at the above site, which are detailed in our Reports 13188/1-AA dated 12 September 2014 and 13188/2-AA dated 11 September 2014. It is understood that additional boreholes are now required to be carried out in the area between the pathway and the seawall.

Regional Geology and Landscape

Reference to the Geological Map of Sydney indicates that the bedrock at the site is likely to be Hawkesbury Sandstone, comprising medium grained quartz sandstone.

Reference to the Soil Landscape Map of Sydney indicates that the landscape at the site belongs to the Gymea Group, which is characterised by undulating to rolling rises and low hills on Hawkesbury Sandstone. However, the site is likely to have been filled in the past to raise levels for development. The acid sulfate soil map indicates high probability of Acid Sulfate soils within nearby areas of the existing site.

Scope of Work
Field work for the additional investigation was carried out between 9 and 13 July 2015 and comprised of the following:

- Review services plans obtained from "Dial Before You Dig" to assess existing services across the site.
- Conduct an OH&S and walkover survey to assess existing site conditions.
- Scan proposed borehole locations for underground services. We engaged a specialist services locator for this purpose.
- Drill six (6) boreholes (BH11 to BH16) to depths of 10m, using a truck mounted drilling rig fully equipped for geotechnical investigation. Boreholes were drilled at the locations specified by the client. All boreholes were initially drilled to V-Bit or TC-Bit refusal in bedrock and then continued using rock coring. Approximate borehole locations are shown on the attached Drawing No 13188/3-AA1. Engineering logs detailing subsurface profiles encountered in boreholes and core photographs are also attached.
- Conduct Standard Penetration Testing (SPT) at regular depth intervals in the boreholes to assess strength characteristics of overburden soils.
- Recovery of representative soil and rock samples for visual assessment and laboratory testing (point load index on rock cores, acid sulfate and contamination testing on soil samples). Results of contamination testing are provided in a separate report.
- Measure depths to groundwater/seepage level in boreholes, where encountered.

Field work was supervised by a Geotechnical Engineer, responsible for sampling and preparation of borehole logs.

Surface and Sub-surface Conditions
The following observations were made during the field work:

- The site is occupied by the multistorey Robert Timms Factory (Bushell's), administration building and guard room etc. Open areas of the site are covered with asphalt/bitumen seal, grass and scattered trees.
- The site is bound to the south by Burwood Road, to the north by a Golf Course, to the east by residential building and Exile Bay, and to the west by residential buildings and Duke Avenue.
- The topography of the site gently slopes towards the north east direction towards Exile Bay at about 3 to 5 degrees.

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

Table 1 – Subsurface Conditions

BH	Top RL (m AHD)	Termination Depth (m)	Topsoil (m)	Fill (m)	Natural (m)	Bedrock (m)
11	3.5	10.2	NE	0.0 – 4.0*	4.0 – 4.5	4.5 –> 10.2
12	3.4	9.7	0.0 – 0.1	0.1 – 4.0	4.0 – 7.7	7.7 –> 9.7
13	3.4	10.0	0.0 – 0.1	0.1 – 2.5	2.5 – 3.5	3.5 –> 10.0
14	3.2	10.0	0.0 – 0.05	0.05 – 2.0	2.0 – 4.4	4.4 –> 10.0
15	3.2	1.3	0.0 – 0.1	0.1 –> 1.3	NE	NE
16	3.2	12.2	0.0 – 0.1	0.1 – 6.0	6.0 – 7.6	7.6 –> 12.2

** 50mm AC at ground surface*

Topsoil	Sandy Silt, low plasticity, dark brown with some roots
Fill	Sandy Gravel, coarse grained, yellow, brown Silty Sandy Clay, medium plasticity, red brown Silty Clayey Sand, fine to coarse grained, with some gravel Silty Clay, medium plasticity, grey, with some gravels
Natural	Silty Sand, fine to medium grained, brown, red, with some ironstone Silty Sandy Clay, medium plasticity, red, brown Silty Clayey Sand, fine to coarse grained, grey, brown, red
Bedrock	Sandstone, grey, brown, extremely weathered grading to slightly weathered to fresh with depth, low strength grading to high strength with depth

The six boreholes (BH11 to BH16) drilled at the location identified by the client, showed fill to depths ranging from 2m to 6m, overlying natural clays and overlying sandstone bedrock. It should be noted that the fill in BH15 and BH16 contained sandstone floaters/boulders. BH15 could not be continued beyond 1.3m due to refusal to drilling on sandstone floater or boulder.

Groundwater Measurement

Groundwater measured during auger boring was encountered at the following depths:

BH	Groundwater Depth (m)
11	4.0
12	1.8
13	2.5
14	3.0
16	3.0

The use of water for coring in the boreholes precluded measurement of groundwater level. It should be noted that fluctuations in the level of groundwater might occur due to variations in rainfall and/or other factors.

Acid Sulfate Soil Material

Laboratory tests were carried out to confirm the presence or otherwise of acid sulfate soils. Laboratory investigation consisted of testing representative soil samples to determine **pH_{KCl}, pH_{ox}, TPA** (Titratable Peroxide Acidity), **TAA** (Titratable Actual Acidity), **S_{POS}%** (Percent Peroxide Oxidisable Sulphur) and **S_{SCR}%** (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 Department of Natural Resources, Mines and Energy (Qld NRM&E) (Reference 1). The test results are attached and summary is presented below in Table 2.

Table 2 – Acid Sulfate Tests Results

BH	**Depth (m)**	**Material Description**	**pH_{KCl} Unit**	**pH_{ox} Unit**	**TPA mole H^+/t**	**TAA mole H+/t**	**S_{POS} % w/w**	**S_{SCR} % w/w**
11	3.2-3.5	Silty Sandy Clay, red-brown	5.8	4.6	35	7	0.110	0.082
12	2.2-2.5	Silty Clay, grey with gravel	4.5	4.4	57	60	0.012	<0.005
13	0.5-0.8	Silty Clay, brown-orange	6.4	4.5	<5	<5	0.017	<0.005
13	2.2-2.5	Silty Clay, brown-grey	6.4	5.2	<5	<5	0.010	<0.005
14	2.5-2.8	Silty Sand, grey-brown	6.7	6.9	<5	<5	0.005	<0.005
15	0-0.3	Silty Sand, brown	8.9	7.4	<5	<5	<0.005	<0.005
Action Criteria adopted #					18	18	0.03	0.03

Notes

pH_{KCl} :	*pH in a 1:40 (W/V) suspension of soil in a solution of 1M K_{Cl} extract*
pH_{ox} :	*pH in a suspension of soil in a solution after peroxide digestion in SPOCAS method*
TPA:	*Titratable Peroxidel Acidity (moles H^+/tonne)*
TAA:	*Titratable Actual Acidity (moles H^+/tonne)*
S_{POS}:	*Peroxide Oxidisable Sulphur (% w/w)*
S_{SCR}:	*Chromium Reducible Sulphur (% w/w)*
#:	*Action Criteria adopted (Reference 2)*

Based on the consideration that the soil to be disturbed would be more than 1000 tonnes and of fine and coarse texture (sand/silty clay), the laboratory test results in the above table indicate the following:

- For soil samples, comprising silty clay, brown-orange in BH13 (0.5m-0.8m); silty clay, brown-grey in BH13 (2.2m-2.5m); silty sand, grey-brown in BH14 (2.5m-2.8m); and silty sand, brown in BH15 (0-0.15m); the TAA and TPA values were below the adopted “Action Criteria” of 18mol H+/tonne. The test results for oxidisable Sulphur SPos and S_{SCR} were also below the adopted “Action Criteria” of 0.03%. The soils at these depths are unlikely to be actual acid sulfate soil or potential acid sulfate soil. Based on the test results, no acid sulfate management plan is required for disturbance of soil at this depth.
- For soil samples, comprising silty sandy clay, red-brown in BH11 (3.2m-3.5m) the TPA value exceeded the adopted “Action Criteria” of 18 mol H+/tonne. The test results for oxidisable Sulphur (SPOs and SSCR) also exceeded the “Action Criteria” of 0.03%.
- For soil samples, comprising silty clay, grey in BH12 (2.2m-2.5m) the TPA and TAA values exceeded the adopted “Action Criteria” of 18 mol H+/tonne. However, the test results for oxidisable Sulphur (SPOs and SSCR) were below the “Action Criteria” of 0.03%. The lower peroxide oxidisable sulphur (Spos/SCR) test result indicated that the presence of pyritic sulphur (i.e. inorganic sulphur) is unlikely. The relatively higher values for TAA and TPA indicate that soils to be disturbed at this depth are acidic soil not acid sulfate soil. Based on these test results, it is considered that the soils in the samples analysed are unlikely to be acid sulfate soil (ASS) but are acidic soils (i.e. non-sulphuric and non-sulphidic) which are unlikely to produce significant amount of acid after being exposed to air due to disturbance or oxidation. The local environment is adapted to these soils in undisturbed condition. However, excavation and placement of these soils in conditions with increased rate of soil drainage could contribute for the release of acidic leachates and management of these acidic soils is required, if disturbed. The treatment of acidic soils (non-acid sulfate soils) should be carried out in accordance with processes described in NSW Acid Sulfate Soil Manual 1998 for acid sulfate management plan.

It should also be noted that during the previous geotechnical investigation in September 2015, in samples BH2 (1.5m-1.95m) which located in close proximity of BH12, the TAA and TPA values exceeded the adopted "Action Criteria" of 18 mol H+/tonne. The test results for oxidisable Sulphur (SPOs and SSCR) were below the "Action Criteria" of 0.03%. Based on the test results for BH2, it was considered that the soils in the sample BH2 (1.5m-1.95m) analysed were unlikely to be acid sulfate soil (ASS) but are acidic which are unlikely to produce significant amount of acid after being exposed to air due to disturbance or oxidation.

Point Load Strength Index

Rock cores obtained from the boreholes were photographed and tested at selected depths for determination of Point Load Strength Index (I_{s50}). The point load strength indices for the rock cores and the assessed rock strengths, in accordance with Australian Standard AS1726-1993 (Reference 3) are summarised in the following Table 3.

Table 3 – Point Load Strength Index Test Results

BH	Depth (m)	Diametral $I_{s(50)}$ (MPa)	Axial $I_{s(50)}$ (MPa)	Diametral Assessed Strength	Axial Assessed Strength
11	5.3	0.11	0.21	Low	Low
	6.1	0.45	0.34	Medium	Medium
	8.9	0.32	0.37	Medium	Medium
	9.3	1.24	1.19	High	High
13	6.5	0.18	0.26	Low	Low
	7.8	1.12	1.75	High	High
	8.8	1.33	1.71	High	High
	9.9	0.58	0.77	Medium	Medium
16	8.2	0.3	0.4	Medium	Medium
	9.8	0.71	1.46	Medium	High
	10.4	1.15	1.59	High	High
	11.5	0.97	1.67	Medium	High

The point load strength index tests results generally indicate the bedrock to be of low to very high strength. However, it should be noted that the tests could only be carried out on intact (stronger) portions of the rock cores. Therefore, strength assessments presented in Table 3 indicate the upper limits of rock strengths. Also it should be noted that some iron-hardened layers were not tested. These layers might show higher strength than the above values.

DISCUSSION AND RECOMMENDATIONS

Excavation Conditions

No information regarding cut and fill for the proposed development was available. It is our assessment that excavation of soils (including topsoil, fill and natural soils) and extremely weathered and very low strength sandstone can be achieved using conventional earthmoving equipment such as excavators and dozers. However, excavation in distinctly weathered to fresh and medium to high strength sandstone bedrock would be considerably difficult and may require larger equipment (such as a rock saw, Caterpillar D9 or equivalent). Although selection of rock cutting equipment is based on site access, desired smoothness of the excavated rock surface and acceptable ground vibration during rock excavation, we recommend the use of a rock saw for excavation into sandstone bedrock on the site boundaries, in order to minimise ground vibration.

Groundwater in BH11 to BH16 was encountered at depths ranging from 1.8m to 4m. The use of water for coring precluded further groundwater measurements in other boreholes. Depending on time of construction, groundwater might be at below or above this depth. If excavation extends below the groundwater level (most likely to be at RL 0) extensive dewatering may be required. We recommend that further groundwater monitoring be carried out if it is planned to excavate 3m depth. Installation of piezometers might be required to monitor long term groundwater conditions. Although minor groundwater inflow could be managed by a conventional sump and pump method, we do suggest that a specialist dewatering contractor be contacted if significant groundwater inflow is encountered during excavation. It should also be noted that trafficability problems could arise locally during wet weather or if water is allowed to pond at the site.

Fill Placement

We consider that the proposed development works would require only minor fill placement, if any. The following procedures are recommended for placement of controlled fill, where required.

- Strip existing topsoil and stockpile separately for possible future uses. Excess materials should be disposed off the site.
- Undertake proof rolling (using an 8 to 10 tonnes roller) of the exposed natural soils or fill to detect potentially weak spots (ground heave). Excavate areas of localised heaving to a depth of about 300mm and replace with granular fill, compacted as described below. Proof rolling will not be required if stripping of unsuitable materials exposes bedrock. Fill is generally assessed to be well compacted.
- Undertake proof rolling of soft spots backfilled with granular fill, as described above. If the backfilled area shows movement during proof rolling, this office should be contacted for further recommendations.
- Place suitable fill materials on proof rolled residual soils or bedrock. The fill should be placed in horizontal layers of 200mm to 250mm maximum loose thickness and compacted to a Minimum Dry Density Ratio (MDDR) of 98% Standard, at moisture content within 2% of Optimum Moisture Content (OMC). Controlled fill should preferably comprise non-reactive fill (e.g. crushed sandstone), with a maximum particle size not exceeding 75mm, or low plasticity clay. The natural soils and bedrock obtained from excavations within the site may be used in controlled fill after removal of unsuitable materials, if any, crushing to sizes finer than 75mm, proper mixing and moisture conditioning.
- Fill placement should be supervised to ensure that material quality, layer thickness, testing frequency and compaction criteria conform to the specifications. We recommend "Level 2" or better supervision, in accordance with AS3798-2007 – "Guidelines on Earthworks for Commercial and Residential Developments" (Reference 4). It should be noted that a Geotechnical Inspection and Testing Authority will generally provide certification on the quality of entire compacted fill only if Level 1 supervision and testing is carried out.

Batter Slopes and Retaining Structures

Cut and fill slopes during and after development works should be battered for stability or retained by engineered retaining structures. Recommend batter slopes for stability of cut and fill slopes are presented in Table 4.

Table 4 – Recommended Batter Slopes for Excavation Faces

Material	**Temporary (Horizontal : Vertical)**		**Permanent (Horizontal : Vertical)**	
	Exposed	**Protected**	**Exposed**	**Protected**
Controlled fill / natural soil	1.5:1.0	1.0:1.0	2.5:1.0	2.0:1.0
Extremely weathered and low strength sandstone	1.0:1.0	0.75:1.0	1.5:1.0	1.0:1.0
Distinctly weathered to fresh and medium to high strength sandstone	Sub-vertical	Sub-vertical	Sub-vertical	Sub-vertical

Surface protection of the slopes can be provided by shotcreting, which may be reinforced. It is also recommended that batter slopes are provided with adequate surface and sub-surface drainage.

Sub-vertical excavation in distinctly weathered and medium to high strength sandstone, where required, will have a very low risk of instability. However, some local rock bolting or shotcreting would be required, depending on the relative orientation of the rock discontinuities (bedding partings and joint systems) and cut faces. Therefore, the excavation faces should be inspected by a Geotechnical Engineer or an Engineering Geologist, as excavation progresses, at about every 1.5m depth interval, to assess localised rock bolting or shotcreting requirements.

Retaining structures, if required, could comprise a contiguous pier wall or secant pier walls installed prior to commencement of basement excavation. Secant pier wall will be required if excavation extends well below groundwater level. Earth pressure distribution on such retaining walls may be assumed to be triangular in shape and estimated as follows:

$$p_h = \gamma kH$$

Where,

p_h = Horizontal active pressure (kN/m^2)
γ = Total density of materials to be retained (kN/m^3)
k = Coefficient of earth pressure (k_a or k_o)
H = Retained height (m)

For design of flexible retaining structures where some lateral movement is acceptable, an active earth pressure coefficient (k_a) is recommended. If it is critical to limit the horizontal deformation of a retaining structure, use of an earth pressure coefficient at rest (k_0) is recommended. Recommended earth pressure coefficients for design of retaining structures are presented in the following Table 5.

Table 5 – Recommended Earth Pressure Parameters for Design of Retaining Structures

Retained Material	**Unit Weight (kN/m^3)**	**Active Earth Pressure Coefficient**	**Passive Earth Pressure (kPa)**	**At Rest Earth Pressure Coefficient**
Controlled fill / natural soil	18	0.40	Ignore	0.60
Extremely weathered and low strength sandstone	23	0.20	300	0.30
Distinctly weathered to fresh and medium to high strength sandstone	24	-	1000	-

The above coefficients are based on the assumption that ground level behind the retaining structure is horizontal and the retained material is effectively drained. Additional earth pressures resulting from surcharge load (buildings, infrastructures, etc) on retained materials and groundwater pressure, if any, should also be allowed for in design of retaining structures.

If the retaining structures are anchored or strutted the active earth pressure may be assumed to be rectangular and estimated as follows:

Active earth pressure $p_h = 0.8k\gamma H$

If basement excavation extends below groundwater level, then the design of retaining structures should allow for groundwater pressure.

The design of any retaining structures should also be checked for bearing capacity, overturning, sliding and overall stability of the slope.

Footings

Footings for the proposed development can consist of shallow (pad or strip) or deep footings (bored piers). The following recommended allowable bearing pressure values can be used for the design of footings.

Table 6 – Recommended Allowable Bearing Pressures

Founding Material	Allowable Bearing Pressure (kPa)	Allowable Shaft Adhesion (kPa)
Controlled fill	100	Ignore
Stiff / Medium dense natural soils	125	Ignore
Very low to low strength sandstone	750	50
Medium to high strength sandstone	5000	500

The recommended allowable shaft adhesions against uplift pressures are halves of the shaft adhesions for compressive loads presented in Table 6.

If footings are founded above and within the 1 Horizontal to 1 Vertical line projected from the base of excavations, the recommended allowable bearing pressures presented in Table 6 are not applicable and appropriate allowable bearing pressure will have to be determined by reassessment of materials exposed in the excavation face.

As depths to natural soils and bedrock with the recommended allowable bearing pressures could vary across the site, the founding depths of footings to be constructed will also vary. Therefore, an experienced Geotechnical Engineer, on the basis of assessment made during footing excavation or pier hole drilling, should confirm founding levels during construction. The engineer should ensure that the design strength of bedrock is achieved.

For footings founded in controlled fill and natural soils, the total settlements of footings under the recommended allowable bearing pressures are estimated to be in the range of 15mm to 20mm. However, for footings founded in bedrock total settlements under the recommended allowable bearing pressures are estimated to be about 1% of pier diameter or minimum footing dimension. Differential settlements are estimated to be about half the estimated total settlements.

Floor Slabs

Floor slabs could either be ground supported or suspended on footings. Floor slabs founded on controlled fill or natural soils could be designed for a modulus of subgrade reaction of 20kPa/mm.

Site Classification

Considering the presence of deep fill and existing structures, the site is classified as Class "P" (Problematic) as per AS2870-2011 "Residential slabs and footings".

Rock Anchors

It is likely that the retaining walls may require anchorage or tie-back, in order to resist lateral pressure. We suggest that all anchors are socketed in bedrock. The allowable grout to rock stress for use in rock anchorage design may be taken as 10% of the allowable bearing pressure given in Table 6. We also suggest that the anchors should have sufficient bond length outside the 1 Vertical to 1 Horizontal line drawn from the base of excavation.

Acid Sulfate Soil Assessment

Based on the soil samples analysed for acid sulfate soil during the previous geotechnical investigation in September 2014 and this assessment, it is considered that:

- Soil material at depth (0-0.8m) is unlikely to be actual acid sulfate soil or potential acid sulfate soil. Based on the test results, no acid sulfate management plan is required for disturbance of soil at these depths.
- The soil samples analysed at depth (1.5m -2.5m) are unlikely to be acid sulfate soil (ASS) but are acidic soils (i.e. non-sulfuric and non-sulfidic). However, excavation and placement of these soils in conditions with increased rate of soil drainage could contribute for the release of acidic leachates and management of these acidic soils is required, if disturbed. The treatment of acidic soils (non-acid sulfate soils) should be carried out in accordance with processes described in NSW Acid Sulfate Soil Manual 1998 for acid sulfate management plan (Reference 2). The treatment method will include neutralising soils to prevent generation of acidic leachates. However, soil comprising silty clay, brown-orange in BH13 (2.2m-2.5m) is unlikely to be acid sulfate soil and acidic soil.
- The soil samples analysed at depths (3.2m-3.5m) are considered to potential acid sulfate, and likely to produce acid if disturbed. Acid sulfate soil management plan would be required, if the soils are to be disturbed.

Assessment

Based on the investigation results the site is suitable for the proposed residential development. It is important that the recommendations made in this report are followed. If it is planned to construct deep basements, we recommend that further groundwater measurement be carried out prior to excavation.

General

Assessments and recommendations presented in this report are based on site observation and information from only limited number of boreholes and samples analysed. Although we believe that the sub-surface profile presented in this report is indicative of the general profile across the site, it is possible that the sub-surface profile across the site could differ from that encountered in the boreholes. Likewise, comments on depth to groundwater level are based on observation during field work. We recommend that this company is contacted for further advice if actual site conditions encountered during basement excavation differ from those presented in this report.

If you have any questions, please contact the undersigned.

Yours faithfully
GEOTECHNIQUE PTY LTD

ZIAUDDIN AHMED
Senior Geotechnical Engineer

Attached	Drawing 13188/3-AA1 Engineering Borehole Logs, Core Photographs & Explanatory Notes Laboratory Test Results

References

1. Queensland, Department of Natural Resources, Mines and Energy, 2004 – Acid Sulphate Soils – Laboratory Methods Guidelines.
2. New South Wales, Acid Soil Management Advisory Committee, 1988 – Acid Sulphate Soil Manual
3. Australian Standard, Geotechnical Site Investigation, AS1726-1993.
4. Australian Standard AS3798-2007 - Guidelines on Earthworks for Commercial and Residential Developments, 2007.

LEGEND

- ● Borehole (August 2014)
- ● Borehole (July 2015)

Imagery ©2014 NearMap.com

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NOTES

1. Site features are indicative and are not to scale.
2. This drawing has been produced using a base plan provided by others to which additional information e.g test pits, borehole locations or notes have been added. Some or all of the plan may not be relevant at the time of producing this drawing

Nix Management Pty Ltd
Proposed Development
Robert Timms Factory Site (Bushell's)
160 Burwood Road, Concord

Borehole Locations

Drawing No: 13188/3-AA1
Job No: 13188/3
Drawn By: MH
Date: 30 July 2015
Checked By: ZA

File No: 13188-3
Layers: 0, AA1

engineering log - borehole

Client : Nix Anderson Pty Ltd
Project : Proposed Development
Location : 160 Burwood Road, Concord

Job No. : 13188/3
Borehole No. : 11
Date : 09/07/2015
Logged/Checked by: MT

drill model and mounting : Utility Mounted **slope :** **deg.** **R.L. surface :** ≅3.5

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

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
		GP				0			ASPHALT PAVEMENT				
									FILL: Sandy Gravel, course grained, brown				
		GP			N=12 9,7,5				FILL: Sandy Gravel, coarse grained, yellow				
		GP GP GP			N=5 3,2,3 N=5 3,2,3	1 2 3			FILL: Silty Sandy Clay, medium plasticity, red brown				
	▼	G				4		SM	Silty SAND, fine to medium grained, brown to red, with some ironstone	W	D		Groundwater at 4.0m
					N=40 11,20,20				SANDSTONE, grey-brown, low to medium strength, extremely weathered				Bedrock
						5			Refer to Cored Borehole				
						6							
						7							
						8							
						9							

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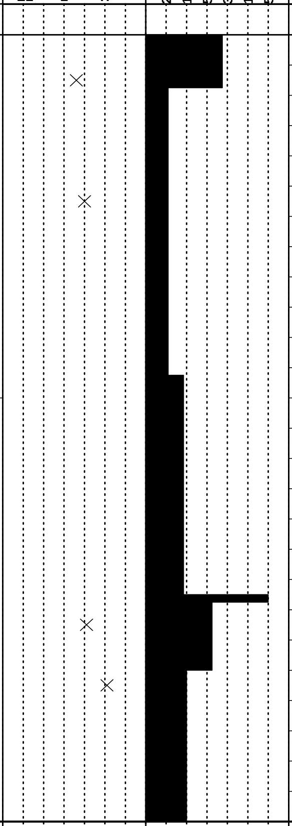
engineering log
cored borehole

Client : Nix Anderson Pty Ltd
Project : Proposed Development
Location : 160 Burwood Road, Concord

Job No. : 13188/3
Borehole No. : 11
Date : 09/07/2015
Logged/Checked by : MT

drill model and mounting : Utility Mounted
slope : **deg.**
R.L. surface : ≅3.5
core size: NMLC
bearing : **deg.**
datum : AHD

barrel lift	water loss/level	depth of R.L. in meters	graphic log	CORE DESCRIPTION rock type, grain characteristics, colour, structure, minor components.	weathering	strength	point load index strength $I_S(50)$ EL VL L M H VH	DEFECT DETAILS defect spacing (mm) 2000 1000 500 300 100 50	DEFECT DETAILS DESCRIPTION type, inclination, thickness, planarity, roughness, coating. Specific	General
				Coring Commenced at 5.0m						
		5		SANDSTONE, fine to coarse grained, grey to red-brown	DW-SW	L-M				
		6								
		7								
				SANDSTONE, fine to coarse grained, grey-brown	DW-SW	M-H				
		8								
		9								
		10								
				Borehole No. 11 terminated at 10.2m						
		11								
		12								
		13								
		14								



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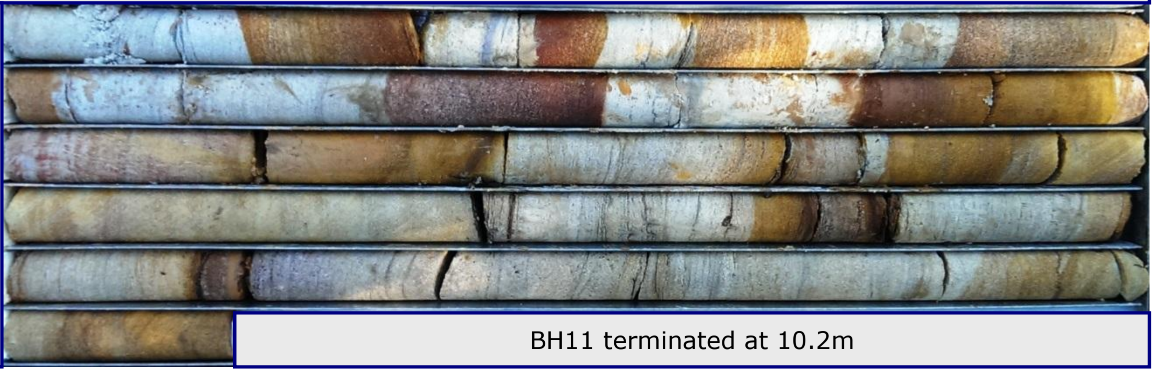
Job No 13188/3 BH11 Started Coring at 5m



BH11 terminated at 10.2m

engineering log - borehole

Client :	Nix Anderson Pty Ltd	**Job No. :**	13188/3
Project :	Proposed Development	**Borehole No. :**	12
Location :	160 Burwood Road, Concord	**Date :**	09/07/2015
		Logged/Checked by:	MT

drill model and mounting : Utility Mounted **slope :** deg. **R.L. surface :** ≅3.4

hole diameter : 125 mm **bearing :** deg. **datum :** AHD

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
		GP				0			TOPSOIL: Sandy Silt, low plasticity, dark brown, with some roots				
					N=7 3,3,4				FILL: Silty Clayey Sand, fine to coarse grained, with some gravel				
		GP							FILL: Silty Clay, medium plasticity, grey, with some gravel				
						1							
	▼	GP			N=8 4,3,5								Groundwater at 1.8m
						2							
		GP											
					N=5 1,2,3	3							
		GP											
		G											
						4		SC-SM	Silty Clayey SAND, fine to medium grained, black to dark brown, with some shell fragments	W			
					N=2 1,1,1			CI	Silty Sandy CLAY, medium plasticity, red to brown	M>PL	L		
						5							
					N=10 3,5,5	6							
						7							Becoming harder to drill
					N=R 12,16/ 100			SC-SM	Silty Clayey SAND, fine to coarse grained, grey-brown to red	W	MD		
									SANDSTONE, grey to red-brown, extremely weathered, low strength				Bedrock
						8							
						9							

engineering log - borehole

Client : Nix Anderson Pty Ltd
Project : Proposed Development
Location : 160 Burwood Road,
Concord

Job No. : 13188/3
Borehole No. : 12
Date : 09/07/2015
Logged/Checked by: MT

drill model and mounting : Utility Mounted
slope : **deg.**
R.L. surface : ≅3.4
hole diameter : 125 **mm**
bearing : **deg.**
datum : AHD

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
						10			Borehole No. 12 terminated at 9.7m due to TC-Bit refusal				
						11							
						12							
						13							
						14							
						15							
						16							
						17							
						18							
						19							

engineering log - borehole

Client : Nix Anderson Pty Ltd
Project : Proposed Development
Location : 160 Burwood Road, Concord

Job No. : 13188/3
Borehole No. : 13
Date : 10/07/2015
Logged/Checked by: MT

drill model and mounting : Utility Mounted
slope : **deg.**
R.L. surface : ≅3.4
hole diameter : 125 **mm**
bearing : **deg.**
datum : AHD

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
		GP				0			TOPSOIL: Silty Sand, fine to medium grained, dark brown, with some grass roots				
		GP			N=12 4,7,5	1			FILL: Silty Clay, medium plasticity, brown-orange, with some gravel				
		GP			N=6 3,3,3	2			FILL: Silty Clay, medium plasticity, brown-grey				
	▼	GP			N=8 3,4,4	3		SC-SM	Silty Clayey SAND, fine to medium grained, yellow, with some sandstone gravel	W	MD		Groundwater at 2.5m
						4		SM	Silty SAND, fine to coarse grained, grey	W	D		
					N=R 5,8,20/50	5			SANDSTONE, fine to coarse grained, grey-brown to yellow, extremely weathered, low strength				Bedrock
						6 7 8 9			Refer to Cored Borehole				

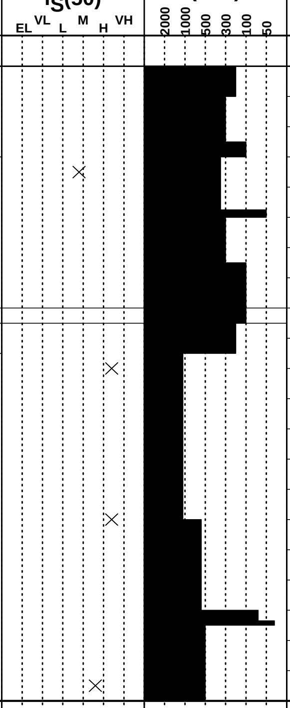
GEOTECHNIQUE
PTY LTD

engineering log
cored borehole

Client :	Nix Anderson Pty Ltd	**Job No. :**	13188/3
Project :	Proposed Development	**Borehole No. :**	13
Location :	160 Burwood Road, Concord	**Date :**	10/07/2015
		Logged/Checked by :	MT

drill model and mounting :	Utility Mounted	**slope :**		**deg.**	**R.L. surface :**	≅3.4
core size:	NMLC	**bearing :**		**deg.**	**datum :**	AHD

barrel lift	water loss/level	depth of R.L. in meters	graphic log	CORE DESCRIPTION rock type, grain characteristics, colour, structure, minor components.	weathering	strength	point load index strength $I_S(50)$ EL VL L M H VH	defect spacing (mm) 2000 1000 500 300 100 50	DEFECT DETAILS DESCRIPTION type, inclination, thickness, planarity, roughness, coating. Specific	General
				Coring Commenced at 5.8m						
		6	▨	SANDSTONE, fine to coarse grained, brown to red-grey	DW	L-M				
		7	▨	SANDSTONE, fine to coarse grained, grey to red-brown	DW	L-M				
				CORE LOSS: 7.4-7.5m					Core loss 100mm	
			▨	SANDSTONE, fine to coarse grained, grey to red-brown	DW	M				
		8 9	▨	SANDSTONE, fine to coarse grained, brown to grey	DW-SW	M-H				
		10 11 12 13 14 15		Borehole No. 13 terminated at 10.0m						



GEOTECHNIQUE
PTY LTD

Job No 13188/3 BH13 Started Coring at 5.8m

BH13 terminated at 10.0m

engineering log - borehole

Client : Nix Anderson Pty Ltd
Project : Proposed Development
Location : 160 Burwood Road,
Concord

Job No. : 13188/3
Borehole No. : 14
Date : 10/07/2015
Logged/Checked by: MT

drill model and mounting : Utility Mounted **slope :** **deg.** **R.L. surface :** ≅3.2

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

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, brown, with some grass roots				
		GP			N=6 1,2,4				FILL: Silty Clay, medium plasticity, grey-brown				
		GP			N=20 11,15,5	1			FILL: Silty Sand, fine to medium grained, brown, with trace of iron shards				
		GP				2			Silty SAND, fine to medium grained, grey-brown				
	▼				N=9 10,5,4	3		SM	Silty SAND, fine to coarse grained, grey-brown	W	MD		Groundwater at 3.0m
						4			Silty SAND, fine to medium grained, grey	W	MD		
					N=13 3,5,8	5		SC-SM	Silty Clayey SAND, fine to coarse grained, red-brown	W	MD		
					N=23 5,11,12	6		SM	Silty SAND, fine to coarse grained, red- brown, with some sandstone fragments	W	MD		
						7			SANDSTONE, red-brown to grey, extremely weathered, low strength				Bedrock
					N=R 25/50	8 9			SANDSTONE, grey to red, distinctly weathered, low to medium strength				

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : Nix Anderson Pty Ltd
Project : Proposed Development
Location : 160 Burwood Road,
Concord

Job No. : 13188/3
Borehole No. : 14
Date : 10/07/2015
Logged/Checked by: MT

drill model and mounting : Utility Mounted
slope : **deg.**
R.L. surface : ≅3.2
hole diameter : 125 **mm**
bearing : **deg.**
datum : AHD

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
							▨						
						10			Borehole No. 14 terminated at 10.0m				
						11							
						12							
						13							
						14							
						15							
						16							
						17							
						18							
						19							

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : Nix Anderson Pty Ltd
Project : Proposed Development
Location : 160 Burwood Road,
Concord

Job No. : 13188/3
Borehole No. : 15
Date : 13/07/2015
Logged/Checked by: MT

drill model and mounting : Utility Mounted **slope :** **deg.** **R.L. surface :** ≅3.2

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

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
		GP				0			TOPSOIL: Silty Sand, fine to medium grained, brown, with some grass				
		GP			N=R 3,5,25/50	1	▨		FILL: Silty Sandy Clay, medium plasticity, brown				
						2 3 4 5 6 7 8 9			Borehole No. 15 terminated at 1.3m due to refusal in possible sandstone boulder				

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : Nix Anderson Pty Ltd
Project : Proposed Development
Location : 160 Burwood Road,
Concord

Job No. : 13188/3
Borehole No. : 16
Date : 13/07/2015
Logged/Checked by: MT

drill model and mounting : Utility Mounted
slope : **deg.**
R.L. surface : ≅3.2
hole diameter : 125 **mm**
bearing : **deg.**
datum : AHD

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
		GP				0			TOPSOIL: Silty Sand, fine to medium grained, brown, with grass roots				
									FILL: Silty Clay, medium plasticity, grey-brown				
		GP			N=10 3,6,4								
						1			FILL: Silty Sand, fine to coarse grained, brown, with some gravel				
		GP			N=12 3,4,8								
						2							
					N=R 25/50	3			FILL: Silty Sand, fine grained, brown, with some boulders				
						4							
						5							
						6		SM	Silty SAND, fine to medium grained, dark brown, with some shell fragments	W			
						7							
									Refer to Cored Borehole				
						8							
						9							

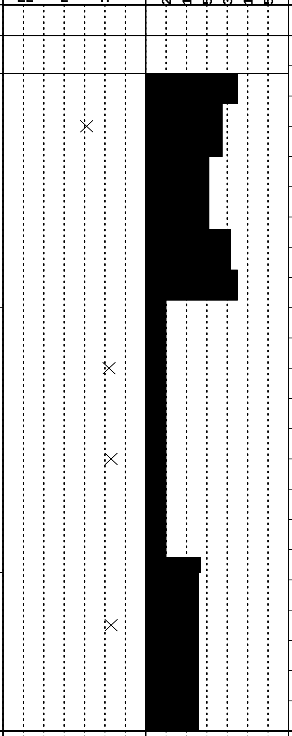
GEOTECHNIQUE
PTY LTD

engineering log
cored borehole

Client : Nix Anderson Pty Ltd
Project : Proposed Development
Location : 160 Burwood Road,
Concord

Job No. : 13188/3
Borehole No. : 16
Date : 13/07/2015
Logged/Checked by : MT

drill model and mounting : Utility Mounted
slope : deg.
R.L. surface : ≅3.2
core size: NMLC
bearing : deg.
datum : AHD



barrel lift	water loss/level	depth of R.L. in meters	graphic log	**CORE DESCRIPTION** rock type, grain characteristics, colour, structure, minor components.	weathering	strength	**DEFECT DETAILS DESCRIPTION** type, inclination, thickness, planarity, roughness, coating. Specific	General
				Coring Commenced at 7.6m				
				CORE LOSS: 7.6-7.85m			Core loss 250mm	
		8 9		SANDSTONE, fine to coarse grained, red-brown, grey	DW-SW	M		
		10 11		SANDSTONE, fine to coarse grained, red-brown	DW-SW	M-H		
		12		SANDSTONE, fine to coarse grained, grey	SW-FR	H-VH		
		13 14 15 16 17		Borehole No. 16 terminated at 12.2m				

GEOTECHNIQUE
PTY LTD

Job No 13188/3 BH16 Started Coring at 7.6m

KEY TO SYMBOLS

Symbol	Description
Strata symbols	
■	Pavement (Bitumen, Concrete Slab, etc)
▩	Fill
◫	Silty Sand
▦	Sandstone
✓	Topsoil
▨	Silty Clayey Sand
▧	Silty Sandy Clay medium plasticity
Misc. Symbols	
▼	Groundwater
Descriptions of various line types (solid, dotted, etc.)	
___	Profile change
_ _ _	Gradual profile change

Notes:

1. Exploratory borings were drilled between 13/07/2015 and 13/07/2015 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.

KEY TO SYMBOLS

Symbol	Description
Strata symbols	
▒	Sandstone
□	Core Loss
Misc. Symbols	
×	Point Load Strength
Descriptions of various line types (solid, dotted, etc.)	
____	Profile change
_ _ _	Gradual profile change

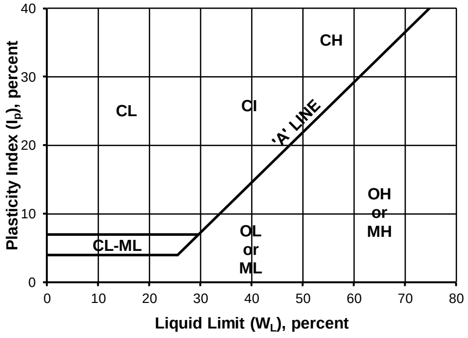
Notes:

1. Exploratory borings were drilled between 13/07/2015 and 13/07/2015 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	Standard Penetration Test (SPT) 'N' value. Individual numbers indicate blows per 150mm penetration.
	N=R 10,15/100	'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	M<PL M=PL M>PL	Moisture content less than Plastic Limit Moisture content equal to Plastic Limit Moisture content to be greater than Plastic Limit
Cohesionless soils	D M W	Dry - Runs freely through hand Moist - Tends to cohere Wet - Tends to cohere
Consistency Cohesive soils	 VS S F St VSt H	Term / Undrained shear strength, C_u (kPa) / Hand Penetrometer (Qu) Very Soft / ≤12 / <25 Soft / >12 ≤25 / 25 – 50 Firm / >25 ≤50 / 50 – 100 Stiff / >50 ≤100 / 100 – 200 Very Stiff / >100 ≤200 / 200 – 400 Hard / >200 / >400
Density Index Cohesionless soils	 VL L M D VD	Term / Density Index, I_D (%) / SPT 'N' (blows/300mm) Very Loose / ≤15 / ≤5 Loose / >15 ≤35 / >5 ≤10 Medium Dense / >35 ≤65 / >10 ≤30 Dense / >65 ≤85 / >30 ≤50 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

AS1726 – Unified Soil Classification System

Major Divisions		Particle size (mm)	Group Symbol	Typical Names	Field Identifications Sand and Gravels			Laboratory classification					
									% (2) < 0.075mm	Plasticity of Fine Fraction	$C_u = D_{60}/D_{10}$	$C_c = (D_{30})^2/(D_{10}D_{60})$	Notes
COARSE GRAINED SOILS (more than half of material less 63mm is larger than 0.075mm)	BOULDERS	200						Use the gradation of material passing 63mm for classification of fractions according to the criteria given in 'Major Divisions'					
	COBBLES	63											
	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
			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	-	-	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
		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		
			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	-	-	
		Fine 0.075	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)	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	**Dry Strength**	**Dilatancy**	**Toughness**						
					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				

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		
	cn	clean		
Coating or infilling	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 Breccia Irregular rock fragments in a finer matrix		LIMESTONE and DOLOMITE (undifferentiated)		Calcirudite		Fragments of volcanic ejecta in a finer matrix Rounded grains AGGLOMERATE Angular grains VOLCANIC BRECCIA	SALINE ROCKS Halite Anhydrite
	2										
	0.6	ARENACEOUS	Coarse	SANDSTONE Angular or rounded grains, commonly cemented by clay, calcite or iron minerals Quartzite Quartz grains and siliceous cement Arkose Many feldspar grains Greywacke Many rock chips				Calcarenite		Cemented volcanic ash TUFF	Gypsum
	0.2		Medium								
	0.06		Fine								
	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		MARBLE QUARTZITE Granulite HORNFELS Amphibolite Serpentine	Grain size description	Pegmatite		GABBRO	Pyrosenite	More than 20 20
COARSE	GNEISS Well developed but often widely spaced foliation sometimes with schistose bands Migmatite Irregularly foliated: mixed schists and gneisses		COARSE	GRANITE	Diorite		Peridorite	6
				These rocks are sometimes phorphyritic and are then described, for example, as porphyritic granite				2
MEDIUM	SCHIST Well developed undulose foliation; generally much mica		MEDIUM	Micorgranite	Microdiorite	Dolerite		0.6
				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

CLIENT DETAILS

Contact	Danda Sapkota	Manager	Jon Dicker
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Project	**13188-4 Concord**	SGS Reference	**CE116272 R0**
Order Number	**SE141506**	Report Number	0000026795
Samples	7	Date Reported	24 Jul 2015
Date Started	21 Jul 2015	Date Received	20 Jul 2015

COMMENTS

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

SIGNATORIES

Anthony Nilsson
Operations Manager

		Sample Number	CE116272.001	CE116272.002	CE116272.003	CE116272.004
		Sample Matrix	Soil	Soil	Soil	Soil
		Sample Date	09 Jul 2015	09 Jul 2015	09 Jul 2015	09 Jul 2015
		Sample Name	BH11 3.2-3.5	BH12 2.2-2.5	BH13 0.5-0.8	BH13 2.2-2.5
Parameter	Units	LOR				

Moisture Content Method: AN002 Tested: 20/7/2015

% Moisture	%w/w	0.5	**17**	**19**	**15**	**14**

TAA (Titratable Actual Acidity) Method: AN219 Tested: 22/7/2015

pH KCl	pH Units	-	**5.8**	**4.5**	**6.4**	**6.4**
Titratable Actual Acidity	kg H2SO4/T	0.25	**0.37**	**2.9**	<0.25	<0.25
Titratable Actual Acidity (TAA) moles H+/tonne	moles H+/T	5	**7**	**60**	<5	<5
Titratable Actual Acidity (TAA) S%w/w	%w/w S	0.01	**0.01**	**0.10**	<0.01	<0.01
Sulphur (SKCl)	%w/w	0.005	**0.016**	**0.016**	**0.009**	**0.011**
Calcium (CaKCl)	%w/w	0.005	**0.056**	**0.039**	**0.30**	**0.11**
Magnesium (MgKCl)	%w/w	0.005	**0.050**	**0.045**	**0.045**	**0.037**

TPA (Titratable Peroxide Acidity) Method: AN218 Tested: 22/7/2015

Peroxide pH (pH Ox)	pH Units	-	**4.6**	**4.4**	**4.5**	**5.2**
TPA as kg H_2SO_4/tonne	kg H2SO4/T	0.25	**1.7**	**2.8**	<0.25	<0.25
TPA as moles H+/tonne	moles H+/T	5	**35**	**57**	<5	<5
TPA as S % W/W	%w/w S	0.01	**0.06**	**0.09**	<0.01	<0.01
Titratable Sulfidic Acidity as moles H+/tonne	moles H+/T	5	**27**	<5	<5	<5
Titratable Sulfidic Acidity as kg H_2SO_4/tonne	kg H2SO4/T	0.25	**1.3**	<0.25	<0.25	<0.25
Titratable Sulfidic Acidity as S % W/W	%w/w S	0.01	**0.04**	<0.01	<0.01	<0.01
ANCE as % $CaCO_3$	% CaCO3	0.01	<0.01	<0.01	<0.01	<0.01
ANCE as moles H+/tonne	moles H+/T	5	<5	<5	<5	<5
ANCE as S % W/W	%w/w S	0.01	<0.01	<0.01	<0.01	<0.01
Peroxide Oxidisable Sulphur (Spos)	%w/w	0.005	**0.11**	**0.012**	**0.017**	**0.010**
Peroxide Oxidisable Sulphur as moles H+/tonne	moles H+/T	5	**67**	**7**	**11**	**6**
Sulphur (Sp)	%w/w	0.005	**0.12**	**0.027**	**0.027**	**0.021**
Calcium (Cap)	%w/w	0.005	**0.10**	**0.038**	**0.32**	**0.12**
Reacted Calcium (CaA)	%w/w	0.005	**0.045**	<0.005	**0.016**	<0.005
Reacted Calcium (CaA)	moles H+/T	5	**23**	<5	**8**	<5
Magnesium (Mgp)	%w/w	0.005	**0.060**	**0.042**	**0.044**	**0.041**
Reacted Magnesium (MgA)	%w/w	0.005	**0.011**	<0.005	<0.005	<0.005
Reacted Magnesium (MgA)	moles H+/T	5	**9**	<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	-	-	-	-

Parameter	Units	LOR	Sample Number Sample Matrix Sample Date Sample Name: CE116272.001 Soil 09 Jul 2015 BH11 3.2-3.5	CE116272.002 Soil 09 Jul 2015 BH12 2.2-2.5	CE116272.003 Soil 09 Jul 2015 BH13 0.5-0.8	CE116272.004 Soil 09 Jul 2015 BH13 2.2-2.5

SPOCAS Net Acidity Calculations Method: AN220 Tested: -

s-Net Acidity	%w/w S	0.01	**0.05**	**0.10**	<0.01	<0.01
a-Net Acidity	moles H+/T	5	**30**	**62**	<5	<5
Liming Rate	kg CaCO3/T	0.1	**2.2**	**4.7**	<0.1	<0.1
Verification s-Net Acidity	%w/w S	-20	**0.04**	NA	NA	NA
a-Net Acidity without ANCE	moles H+/T	5	**75**	**67**	**12**	**7**
Liming Rate without ANCE	kg CaCO3/T	0.1	**5.6**	**5.0**	NA	NA

Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 21/7/2015

Chromium Reducible Sulphur (Scr)	%	0.005	**0.082**	<0.005	<0.005	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5	**51**	<5	<5	<5

Parameter	Units	LOR	Sample Number Sample Matrix Sample Date Sample Name	CE116272.005 Soil 09 Jul 2015 BH14 2.5-2.8	CE116272.006 Soil 09 Jul 2015 BH15 0-0.3	CE116272.007 Soil 09 Jul 2015 BH16 0.5-0.8

Moisture Content Method: AN002 Tested: 20/7/2015

Parameter	Units	LOR	CE116272.005	CE116272.006	CE116272.007
% Moisture	%w/w	0.5	**14**	**6.9**	**18**

TAA (Titratable Actual Acidity) Method: AN219 Tested: 22/7/2015

Parameter	Units	LOR	CE116272.005	CE116272.006	CE116272.007
pH KCl	pH Units	-	**6.7**	**8.9**	**6.3**
Titratable Actual Acidity	kg H2SO4/T	0.25	<0.25	<0.25	<0.25
Titratable Actual Acidity (TAA) moles H+/tonne	moles H+/T	5	<5	<5	<5
Titratable Actual Acidity (TAA) S%w/w	%w/w S	0.01	<0.01	<0.01	<0.01
Sulphur (SKCl)	%w/w	0.005	**0.011**	<0.005	<0.005
Calcium (CaKCl)	%w/w	0.005	**0.027**	**0.13**	**0.22**
Magnesium (MgKCl)	%w/w	0.005	**0.038**	**0.017**	**0.032**

TPA (Titratable Peroxide Acidity) Method: AN218 Tested: 22/7/2015

Parameter	Units	LOR	CE116272.005	CE116272.006	CE116272.007
Peroxide pH (pH Ox)	pH Units	-	**6.9**	**7.4**	**4.3**
TPA as kg H_2SO_4/tonne	kg H2SO4/T	0.25	<0.25	<0.25	<0.25
TPA as moles H+/tonne	moles H+/T	5	<5	<5	<5
TPA as S % W/W	%w/w S	0.01	<0.01	<0.01	<0.01
Titratable Sulfidic Acidity as moles H+/tonne	moles H+/T	5	<5	<5	<5
Titratable Sulfidic Acidity as kg H_2SO_4/tonne	kg H2SO4/T	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
ANCE as % $CaCO_3$	% CaCO3	0.01	**0.15**	**0.25**	<0.01
ANCE as moles H+/tonne	moles H+/T	5	**30**	**50**	<5
ANCE as S % W/W	%w/w S	0.01	**0.05**	**0.08**	<0.01
Peroxide Oxidisable Sulphur (Spos)	%w/w	0.005	**0.005**	<0.005	**0.018**
Peroxide Oxidisable Sulphur as moles H+/tonne	moles H+/T	5	<5	<5	**11**
Sulphur (Sp)	%w/w	0.005	**0.017**	**0.007**	**0.019**
Calcium (Cap)	%w/w	0.005	**0.034**	**0.14**	**0.22**
Reacted Calcium (CaA)	%w/w	0.005	**0.007**	<0.005	<0.005
Reacted Calcium (CaA)	moles H+/T	5	<5	<5	<5
Magnesium (Mgp)	%w/w	0.005	**0.048**	**0.022**	**0.032**
Reacted Magnesium (MgA)	%w/w	0.005	**0.009**	<0.005	<0.005
Reacted Magnesium (MgA)	moles H+/T	5	**8**	<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	-	-	-

		Sample Number	CE116272.005	CE116272.006	CE116272.007
		Sample Matrix	Soil	Soil	Soil
		Sample Date	09 Jul 2015	09 Jul 2015	09 Jul 2015
		Sample Name	BH14 2.5-2.8	BH15 0-0.3	BH16 0.5-0.8
Parameter	**Units**	**LOR**			

SPOCAS Net Acidity Calculations Method: AN220 Tested: -

s-Net Acidity	%w/w S	0.01	<0.01	<0.01	<0.01
a-Net Acidity	moles H+/T	5	<5	<5	<5
Liming Rate	kg CaCO3/T	0.1	<0.1	<0.1	<0.1
Verification s-Net Acidity	%w/w S	-20	NA	NA	NA
a-Net Acidity without ANCE	moles H+/T	5	<5	<5	**12**
Liming Rate without ANCE	kg CaCO3/T	0.1	<0.1	<0.1	NA

Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 21/7/2015

Chromium Reducible Sulphur (Scr)	%	0.005	<0.005	<0.005	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5	<5	<5

QC SUMMARY

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)	LB028096	%	0.005	<0.005	0%	93%
Chromium Reducible Sulphur (Scr)	LB028096	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	LB028108	pH Units	-	6.0	0%	98%
Titratable Actual Acidity	LB028108	kg H2SO4/T	0.25	<0.25	0%	NA
Titratable Actual Acidity (TAA) moles H+/tonne	LB028108	moles H+/T	5	<5	0%	92%
Titratable Actual Acidity (TAA) S%w/w	LB028108	%w/w S	0.01	<0.01	0%	92%
Sulphur (SKCl)	LB028108	%w/w	0.005	<0.005	7%	112%
Calcium (CaKCl)	LB028108	%w/w	0.005	<0.005	9%	
Magnesium (MgKCl)	LB028108	%w/w	0.005	<0.005	1%	

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

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Peroxide pH (pH Ox)	LB028109	pH Units	-	6.4	0%	100%
TPA as kg H_2SO_4/tonne	LB028109	kg H2SO4/T	0.25	<0.25	0%	107%
TPA as moles H+/tonne	LB028109	moles H+/T	5	<5	0%	107%
TPA as S % W/W	LB028109	%w/w S	0.01	<0.01	0%	107%
ANCE as % $CaCO_3$	LB028109	% CaCO3	0.01	<0.01	0%	
ANCE as moles H+/tonne	LB028109	moles H+/T	5	<5	0%	
ANCE as S % W/W	LB028109	%w/w S	0.01	<0.01	0%	
Sulphur (Sp)	LB028109	%w/w	0.005	<0.005	19%	
Calcium (Cap)	LB028109	%w/w	0.005	<0.005	17%	
Magnesium (Mgp)	LB028109	%w/w	0.005	<0.005	14%	

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
		QFL	QC result is below the lower tolerance
**	Indicative data, theoretical holding time exceeded.	-	The sample was not analysed for this analyte
^	Performed by outside laboratory.	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