Acid Sulfate Soil Assessment

No. 62 Mactier Street, Narrabeen NSW 2101

Submitted To
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Document Revision History

Date	Rev	Author	Approved by	Comments
19-Aug-19	A	Nicholas Leong	Raj Singh	First Edition

List of Appendices

APPENDIX A: Site Plan and Borehole Logs

APPENDIX B: Site Photography

APPENDIX C: Laboratory Data

REFERENCED STANDARDS:

Standards Australia (1993), *Geotechnical site investigations*, AS 1726-1993, Standards Australia, Sydney, Retrieved from SAI Global.

Standards Australia (2011), *Residential slabs and footings*, AS 2870-2011, Standards Australia, Sydney, Retrieved from SAI Global.

ASSMAC, 1998: Acid Sulfate Soils Management Advisory Committee, 1998: Acid Sulfate Soil Manual

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1 Introduction

Intrax Consulting Engineers Pty Ltd (Intrax) was commissioned by Aleksandar Popovski to complete an Acid Sulfate Soil (ASS) assessment at No. 62 Mactier Street, Narrabeen NSW 2101 for the proposed development of a double storey residential dwelling and a above ground swimming pool.

The assessment is required by the Northern Beaches Council, as part of the planning process. This report outlines the findings of the site investigation carried out on 7th August 2019, and the results of additional laboratory testing.

The objective of this assessment is to determine the presence, or absence, of ASS within the vicinity of the proposed excavation, and determine whether the proposed development will extend below the water table, therefore having an impact on the groundwater beneath the site.

2 Project and Site Description

2.1 Project Description

The proposed development is a double storey residential dwelling and a swimming pool at the rear as outlined in the architectural drawings by Tullipan Homes Pty. Ltd., 7292-Wd3, 29/07/2019.

2.2 Site Description

No. 62 Mactier Street, Narrabeen NSW 2101 is a relatively level site with fall in the north direction towards Mactier Street. The site contained a residential dwelling at the time of investigation, with vegetation across the site consisting of grass cover and small sized trees.

Site conditions on the date of inspection are visible in the attached photography in Appendix B with the site features indicated in the site plan, refer Appendix A.

3 Method of Investigation

3.1 Fieldwork

The fieldwork consisted of drilling a total of four (4) boreholes (BH1 to BH4) to a maximum depth of 1.5 metres with 60mm dimeter post driver powered by a small motor. The approximate locations of the boreholes are shown on the attached site plan in Appendix A. The subsurface materials were visually classified in accordance with AS1726-2017: *Geotechnical Site Investigation*.

Soil samples for acid sulfate assessment were collected using a stainless-steel trowel from the auger. Sampling tools were decontaminated between each sample collection using water, DECON 90 and a scrubbing brush. All samples were placed in glass jars with plastic caps and Teflon seals with minimum headspace. Each sample was labelled with job number, the sample location and date. All samples were recorded on the Chain of Custody (COC) record stored in our office files.

On completion of fieldwork, the samples were delivered under cold storage conditions to SGS Alexandria, a NATA registered laboratory, for analysis under Standard COC procedures.

3.2 Laboratory Testing

Laboratory testing included the following:

- Thirteen samples for pH screening and two samples for complete chromium suite test to aid in assessment of acid sulfate soils.

Results of laboratory test are outlined in section 5 and detailed in Appendix C.

4 Results of Investigation

4.1 Desktop Assessment

A review of the 1:100 000 Sydney geological map for the area, indicates that the site is underlain by silty to peaty quartz sand, silt and clay; ferruginous and humic cementation in places; common shell layers. This is consistent with the natural soil encountered during the field investigation. An extract of the local geological map is provided below.

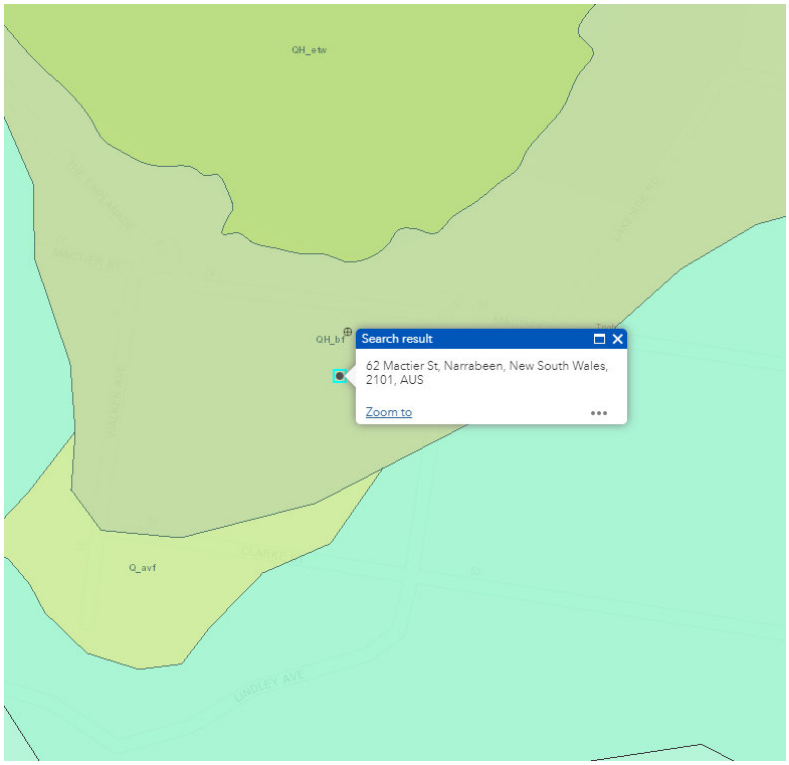


Figure 1: Extract of local geology, Intrax GIS database (NSW Geo Seamless)

4.2 Subsurface Conditions

The boreholes revealed the substrata typically consisted of the following soil profile. Variation from this profile existed across the site, refer to borehole logs in Appendix A for details.

Table 1: Subsurface Lithology encountered in BH1 to BH4

LAYER	Description	Depth to Base of Layer (m)
TOPSOIL	SAND, fine to medium grained, dark brown with grass roots	0.1
ALLUVIUM	SAND/Organic CLAY, medium plasticity, brown to orange brown/black	>1.5

4.2.1 Ground Water

Groundwater was not intersected at a maximum depth of 3.0 metres during borehole drilling.

It is pointed out that standing groundwater may fluctuate with seasonal variations, rainfall, temperature and other factors. Long term groundwater assessment has not been carried out.

5 Acid Sulfate Soil Assessment

5.1 Definition and Theoretical Background

ASS are naturally occurring sediments and soils containing iron sulphides (principally iron sulphide, iron disulphide or their precursors). Oxidation of these soils through exposure to the atmosphere or through lowering of groundwater levels results in the generation of sulfuric acid.

Most ASS are of Holocene age (<10000 years) and their formation requires the presence of iron-rich sediments, sulphate (usually from sea water), removal of reaction products such as bicarbonate, the presence of sulphate-reducing bacteria and an abundant supply of organic matter. These conditions generally exist in mangroves, salt marshes, inter-tidal areas and on the beds of coastal rivers and lakes.

ASS is further sub-divided into Actual Acid Sulfate Soils (AASS) and Potential Acid Sulphate Soil (PASS). AASS and PASS are generally found in the same soil profile with AASS overlying PASS.

AASS are soils that contain highly acidic soil horizons or layers resulting from the oxidation of iron sulphides. The oxidation produces hydrogen ions in excess of the buffering or neutralising capacity of the soil.

PASS are soils containing iron sulphides or sulfidic material (usually ferrous iron disulphide or pyrite) which are waterlogged soils, rich in pyrite, that have not been exposed to air and oxidised. Any disturbance that admits oxygen (such as excavation works) will lead to the development of actual acid sulphate soil layers, which may pose an environmental risk.

5.2 Indicators of AASS and PASS

The Indicators of PASS materials are as follows:

Screening tests: PASS indicators include significant negative pH shifts during screening tests and pH following oxidation (pH_{Fox}) below pH 3. Samples with pH_F < pH 4.0 indicate that in-situ conditions are already acidic. For pH_F approximately equal to 7 the soil is considered neutral.

Chromium Suite tests: Indicators of PASS materials include significant actual acidity (TAA greater than 18 Mole H^+/t) and Chromium Reducible Sulphur percentages S_{CR} greater than 0.03%. Samples with pH_{KCL} < 6.5 indicate that in-situ conditions are already somewhat acidic, but TAA greater than 18 mole H+/t is required for this to be significant (depending on scale of the job and nature of the soil).

5.3 Assessment Criteria

The ASSMAC (1998) action criteria for treatment of ASS based on the percentage of oxidisable sulphur or equivalent Titratable Actual Acidity (TAA) or Titratable Peroxide Acidity (TPA) for broad soil texture categories are presented in Table 3. When analysis results exceed the action criteria, a treatment regime and management plan for the materials is triggered. For disturbances of less than 1000 tonnes, the action criteria vary according to the texture of the material, however if more than 1000 tonnes is to be disturbed, all action criteria are the same: S% 0.03% and Acid 18 mole H^+/tonne. For the purposes of this assessment the criteria applicable for disturbing less than 1000 tonnes of soil disturbed has been adopted with a course texture.

The action criteria for ASS soil analysis are presented below.

Table 4.4. Action criteria based on ASS soil analysis for three broad texture categories

Type of Material		*Action Criteria 1-1000 tonnes disturbed*		*Action Criteria if more than 1000 tonnes disturbed*	
Texture range.McDonald et al. (1990)	*Approx. clay content (%<0.002 mm)*	*Sulfur trail % S oxidisable (oven-dry basis) eg SCRS or SPOS*	*Acid trail mol H^+/tonne (oven-dry basis) eg, TPA or TSA*	*Sulfur trail % S oxidisable (oven-dry basis) eg SCRS or SPOS*	*Acid trail mol H^+/tonne (oven-dry basis) eg, 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	0.1	62	0.03	18

Figure 2: Extract from Stone, Y, Ahern CR, and Blunden B (1998)

5.4 Laboratory Results

5.4.1 pH Screening Testing

Thirteen (13) samples were collected from BH1 to BH4 to test for pH screening tests to assess the actual and potential acidity of insitu samples.

A summary of pH screening test results is presented in Table 2 below:

Table 2.0 Field pH and Peroxide pH Test Results

Sample Location/Depth (m)	pH	Peroxide pH	pH Reduction	Reaction Rate
BH1-0.5m	6.6	5.6	1.0	x
BH1-1.0m	6.5	5.6	0.9	x
BH1-1.3m	5.6	2.2	3.4	xxxx
BH1-1.5m	5.7	2.9	2.8	xx
BH2-0.5m	6.2	5.5	0.7	xx
BH2-1.0m	6.7	5.7	1.0	xx
BH2-1.5m	5.9	2.8	3.2	xxx
BH3-0.5m	7.8	5.9	1.9	xx
BH3-1.0m	7.6	5.6	2.0	x
BH3-1.5m	6.6	5.8	0.9	x
BH4-0.5m	8.5	6.7	1.8	xx
BH4-1.0m	7.9	5.9	2.0	xxx
BH4-1.5m	6.7	4.1	2.7	xx

Note: Reaction Rate means x – Slight; xx – Moderate; xxx – Strong; xxxx – Extreme/Vigorous

5.4.2 Chromium Suite Testing

Based on the pH screening test results presented in table 2, two samples BH1-1.3m and BH3-0.5m were selected to test for complete chromium suite. The recorded test results are presented in Table 3 below:

Table 3: Complete Chromium Suite Test Results

Sample Location/Depth (m)	pH	Peroxide pH	pH KCl	TAA (mole H+/t)	Scr (mole H+/t)	Net Acidity Chromium suite (mole H+/t)	Texture
BH1-1.3	5.6	2.2	4.6	195	44	240	Medium
BH3-0.5m	7.8	5.9	7.7	<5	<5	<0.1	Medium

6 Discussion

Based on the above pH screening test and chromium suite results, it is assessed that insitu soils encountered in BH1 to BH4 does not contain any Actual or Potential Acid Sulfate Soils to a depth of about 1.0m below the existing surface grade.

This project is expected to require excavation of minor soils to shallow depth to allow construction of an above ground swimming pool. The excavation would be within 1.0m below the existing surface grade.

Most likely, the foundation of existing house would be supported by the screw piles taken to a suitable stratum. A further advantage of screw piles is that no soils are brought to the surface and hence management of actual/potential acid sulfate soils may be avoided. Therefore, site does not require any Acid Sulfate Soils Management Plan (ASSMP) provided the depth of excavation is within 1.0m below the existing surface grade.

The soil below 1.0m has a potential to be acidic if exposed to the air during the construction of the proposed project. The total volume of the spoil to be generated during the excavation is not known. However, if any material is excavated below 1.0m depth then Intrax should be notified and an ASSMP would be required.

7 Limitations of Report

1. The recommendations in this report are based on the following:

    a. Information about the site & its history, proposed site treatment and building type conveyed to us by the client and or their agent

    b. Professional judgements and opinions using the most recent information in soil testing practice that is available to us.

    c. The location of our test sites and the information gained from this and other investigations.

    Should the client or their agent neglect to supply us with correct or relevant information, including information about previous buildings, trees or past activities on the site, or should changes be made to the building type, size and or/position, this report may be made obsolete, irrelevant or unsuitable. In such cases, Intrax will not accept any liability for the consequences and Intrax reserves the right to make an additional charge if more testing or a change to the report is necessary.

2. The recommendations made in this report may need to be reviewed should any site works disturb any soil 200mm below the proposed founding depth.

3. The descriptions of the soils encountered in the boreholes follow those outlined in AS1726-2017; Geotechnical Site Investigations. Colour descriptions can vary with soil moisture content and individual interpretation.

4. If the site conditions at the time of construction differ from those described in this report then Intrax must be contacted so a site inspection can be carried out prior to any footing being poured. The owner/builder will be responsible for any fees associated with this additional work.

5. This report assumes that the soil profile observed in the boreholes are representative of the entire site. If the soil profile and site conditions appear to differ substantially from those reported herein, then Intrax should be contacted immediately and this report may need to be reviewed and amended where appropriate. The owner/builder will be responsible for any fees associated with this additional work.

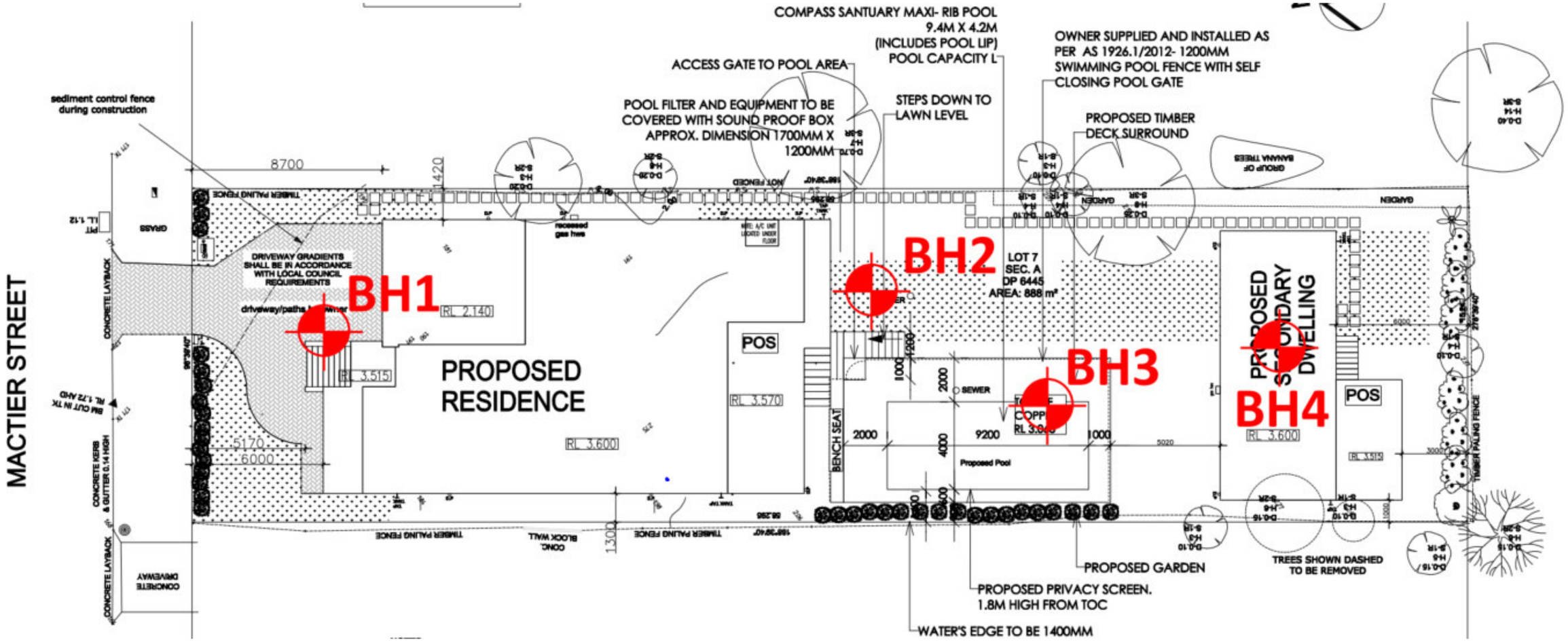
6. The user of this report must take into account the following limitations. Soil and drilling depths are given to a tolerance of +/- 200mm.

    It must be understood and a condition of acceptance of this report is that whilst every effort is made to identify fill material across the site, difficulties exist in determining fill material, in particular, for example, well compacted site or area derived fill, when utilising a small diameter auger. Consequently Intrax emphasises that we will not be responsible for any financial losses, consequential or otherwise, that may occur as a result of not accurately determining the fill profile across the site.

7. Finally, no responsibility will be taken for this report if it is altered in any way or is not reproduced in full.

Appendix A

Site Plan and Borehole Logs



Rev.	Remark/Comment	Date:	Appr.

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Client: Aleksandar Popovski

Project: Proposed Residential Dwelling
No 62 Mactier Street, Narrabeen, NSW 2101

Drawing: Site Plan

Designed:		Scale (A3):	AS NOTED
Drawn:	R.S	Date:	07.08.2019
Checked:		Sheets:	1 of 1
Project No.	124171	Drawing No.	1
			Rev.

Borehole Log: BH1 **Sheet:** 1 of 1
Client: Aleksander Popovski Drill Rig: Push Tube
Project: No. 62 Mactier Street, Narrabeen Logged: NL
Location: Refer to Plan Date: 7th August 2019

Method	Depth (metres)		Material Description	Soil Classification	Moisture	Consistency / Density	Structure, Origin, Water and Additional Observations	Sample or Field Test
		0.05	Topsoil - SAND, dark brown, poorly sorted fine grains		D		with grass roots	
PT	0.50		SAND, brown to orange brown, poorly sorted fine grains	SP	D	L		Soil Sample @ 0.50m
	1.00							Soil Sample @ 1.00m
		1.20						
		1.30	SAND with clay, dark brown, poorly sorted medium grains	SP	M	MD		
		1.40	Organic CLAY trace silt, black, moderate plasticity	OH	M	ST	with wood bark and plant roots	Soil Sample @ 1.30m
		1.50	SAND trace fines, grey dark brown, poorly sorted medium grains	SP	M-W	MD		
	1.50		Borehole Terminated at 1.50m					Soil Sample @ 1.50m
	2.00							
	2.50							
	3.00							
	3.50							
	4.00							
	4.50							
	5.00							

This borehole log is to be read in conjunction with the explanatory notes appended to the set of logs. This borehole log is not be reproduced without the full inclusion of all explanatory notes.

Borehole Log: BH2 **Sheet:** 1 of 1
Client: Aleksander Popovski Drill Rig: Push Tube
Project: No. 62 Mactier Street, Narrabeen Logged: NL
Location: Refer to Plan Date: 7th August 2019

Method	Depth (metres)		Material Description	Soil Classification	Moisture	Consistency / Density	Structure, Origin, Water and Additional Observations	Sample or Field Test
		0.05	Topsoil - SAND, dark brown, poorly sorted fine grains		D		with grass roots	
PT	0.50		SAND, brown to orange brown, poorly sorted fine grains	SP	D	L		Soil Sample @ 0.50m
	1.00							Soil Sample @ 1.00m
		1.30						
			SAND with clay, dark brown, poorly sorted medium grains	SP	M	MD		
		1.50						
	1.50	1.60	Organic CLAY trace silt, black, moderate plasticity	OH	M	ST	with wood bark and plant roots	Soil Sample @ 1.50m
			Borehole Terminated at 1.60m					
	2.00							
	2.50							
	3.00							
	3.50							
	4.00							
	4.50							
	5.00							

This borehole log is to be read in conjunction with the explanatory notes appended to the set of logs. This borehole log is not be reproduced without the full inclusion of all explanatory notes.

Borehole Log: BH3 **Sheet:** 1 of 1
Client: Aleksander Popovski Drill Rig: Push Tube
Project: No. 62 Mactier Street, Narrabeen Logged: NL
Location: Refer to Plan Date: 7th August 2019

Method	Depth (metres)		Material Description	Soil Classification	Moisture	Consistency / Density	Structure, Origin, Water and Additional Observations	Sample or Field Test
		0.05	Topsoil - SAND, dark brown, poorly sorted fine grains		D		with grass roots	
PT	0.50		SAND, brown to orange brown, poorly sorted fine grains	SP	D	L		Soil Sample @ 0.50m
	1.00							Soil Sample @ 1.00m
		1.20						
		1.30	Organic CLAY trace silt, black, moderate plasticity	OH	M	ST	with wood bark and plant roots	
		1.50	SAND trace fines, grey dark brown, poorly sorted medium grains	SP	M-W	MD		
	1.50		Borehole Terminated at 1.50m					Soil Sample @ 1.50m
	2.00							
	2.50							
	3.00							
	3.50							
	4.00							
	4.50							
	5.00							

This borehole log is to be read in conjunction with the explanatory notes appended to the set of logs. This borehole log is not be reproduced without the full inclusion of all explanatory notes.

Borehole Log: BH4 **Sheet:** 1 of 1

Client: Aleksander Popovski Drill Rig: Push Tube

Project: No. 62 Mactier Street, Narrabeen Logged: NL

Location: Refer to Plan Date: 7th August 2019

Method	Depth (metres)		Material Description	Soil Classification	Moisture	Consistency / Density	Structure, Origin, Water and Additional Observations	Sample or Field Test
		0.05	Topsoil - SAND, dark brown, poorly sorted fine grains		D		with grass roots	
	0.50		SAND, brown to orange brown, poorly sorted fine grains	SP	D	L		Soil Sample @ 0.50m
PT		0.80	Organic CLAY trace silt, black, moderate plasticity	OH	M	ST	with wood bark and plant roots	
	1.00	1.10						Soil Sample @ 1.00m
			SAND trace fines, grey dark brown, poorly sorted medium grains	SP	M-W	MD		
		1.50						
	1.50		Borehole Terminated at 1.50m					Soil Sample @ 1.50m
	2.00							
	2.50							
	3.00							
	3.50							
	4.00							
	4.50							
	5.00							

This borehole log is to be read in conjunction with the explanatory notes appended to the set of logs. This borehole log is not be reproduced without the full inclusion of all explanatory notes.

EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT LOGS

DRILLING/EXCAVATION METHOD

HA	Hand Auger	W	Washbore	PT	Push Tube
MA-	Mechanical Auger Drilling	HQ	Diamond Core - 63 mm	EX	Excavator
-V	V-Bit	NMLC	Diamond Core - 52 mm	HAD	Hollow Auger Drilling
-TC	TC-Bit, e.g. ADT	NQ	Diamond Core - 47 mm		

PENETRATION/EXCAVATION RESISTANCE

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

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

WATER

∇	Water level at date shown	$\Leftarrow$	Partial water loss
$\Rightarrow$	Water inflow	$\|\Leftarrow\|$	Complete water loss

NO	Ground Water Not Observed: Ground water obersvation not possible. Ground water may or may not be present
NE	Ground Water Not Encountered: Ground water was not evident during excavation or a short time after completion. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period.

SAMPLING AND TESTING

SPT	Standard Penetration Test to AS1289.6.3.1 - 2004
3,6,9 N=15	3,6,9 = blows per 150mm. N = blows per final 300mm penetration
30/80mm	Practical refusal, with blows and depth of penetration before refusal occurred
RW	Penetration caused under rod weight only
HW	Penetration caused under hammer and rod weight only
HB	Hammer bounce without penetration
R	Refusal to test
DCP	Dynamic Cone Penetrometer Test to AS1289.6.3.2 - 1997
DCP (p)	Dynamic Cone Penetrometer Test to AS1289.6.3.3 - 1997 Perth Sand Penetrometer
6	6 = blows per 100mm of penetration

DS	Disturbed sample
BDS	Bulk disturbed sample
U63	Undisturbed thin wall push tube sample, nominal sample diameter denoted in millimetres
W	Water sample
G	Gas sample
V	pilcon shear vane (kPa)
PP	Pocket penetrometer (kPa)
FP	Field permeability test over section noted
ES	Environmental sample
PI	Plastic Index (%)
PL	Plastic Limit (%)
LL	Liquid Limit (%)
MC	Moisture Content (%)
CBR	Californian Bearing Ration (%)

ROCK CORE RECOVERY

TCR = Total Core Recovery (%)

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

RQD = Rock Quality Designation (%)

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

EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT LOGS - SOIL DESCRIPTION (AS1726 - 2017)

SOIL CLASSIFICATION SYSTEM

Coarse Grained Soil

GW	Well graded gravels, gravel-sand mixtures, little or no fines
GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines, uniform gravels
GM	Silty gravels, gravel-sand-silt mixtures
GC	Clayey gravels, gravel-sand-clay mixtures
SW	Well-graded sands, gravelly sands, little or no fines
SP	Poorly-graded sands, gravelly sand, little or no fines
SM	Silty sands, sand-silt mixtures
SC	Clayey sands, sand-clay mixtures

Fine Grained Soils

ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or silts with low plasticity
CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays
OL	Organic silts and organic silty clays of low plasticity
MH	Inorganic silts, micaceous or diatomaceous fine sand for silty soils
CH	Inorganic clays of high plasticity
OH	Organic clays of medium to high plasticity, organic silts
PT	Peat, humus, swamp soils with high organic contents

First Letter: G = Gravel, S = Sand, M = Silt, C = Clay; Second Letter: W = Well-graded, P = Poorly-graded, M = Mixture, O = Organic, L = Low plasticity, H = High plasticity

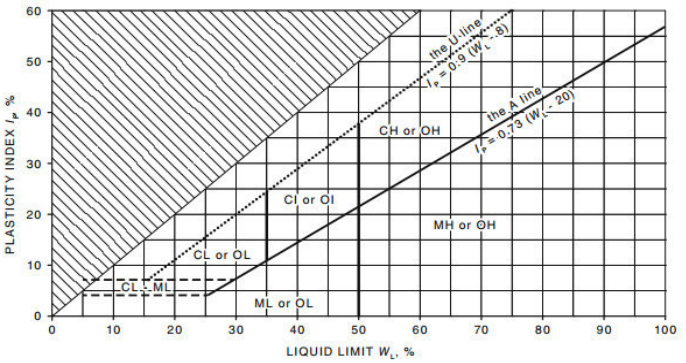
Soils may be a combination of multiple soil classifications where borderline

PARTICLE SIZE

Soil	Major Division	Sub-Division	Particle Size (mm)
Coarse	Boulders		>200
	Cobbles		63 - 200
	Gravel	Coarse	20 - 63
		Medium	6 - 20
		Fine	2.36 - 6
	Sand	Coarse	0.6 - 2.36
		Medium	0.2 - 0.6
		Fine	0.075 - 0.2
Fine	Silt		0.002 - 0.075
	Clay		< 0.002

0.075mm is the approximate minimum particle size discernible by eye

PLASTICITY CHART



MOISTURE CONDITION

Coarse	D	Dry	Sands and gravels are free flowing.
	M	Moist	Soils are darker than in the dry condition and may feel cool. Sands and gravels tend to cohere.
	W	Wet	Soils exude free water. Sands and gravels tend to cohere.
Fine	PL	Plastic Limit	Moisture content of fine grain soils are described; as below plastic limit (<PL), near to plastic limit (=PL), above plastic limit (>PL), near to the liquid limit (=LL), or above the liquid limit (>LL)
	LL	Liquid Limit	

CONSISTENCY AND DENSITY

Fine Grained Soils

			Pocket Pentrometer Reading (kPa)
VS	Very Soft	Exudes between fingers when squeezed	<25
S	Soft	Can be moulded by light finger pressure	20 - 50
F	Firm	Can be moulded by strong finger pressure	50 - 100
St	Stiff	Cannot be moulded by fingers. Can be indented by thumb	100 - 200
VSt	Very Stiff	Can be indented by thumb nail	200 - 400
H	Hard	Can be indented by thumb nail with difficulty	>400

Coarse Grained Soil

		Density Index %	'N' Value
VL	Very Loose	≤15	0 - 4
L	Loose	15 - 35	4 - 10
MD	Medium Dense	35 - 65	10 - 30
D	Dense	65 - 85	30 - 50
VD	Very Dense	>85	>50

SECONDARY OR MINOR SOIL COMPONENTS

Designation of components	In coarse grained soils				In fine grained soils	
	%Fines	Terminology	%Accessory Coarse Fraction	Terminology	%Sand/gravel	Terminology
Minor	≤5	'trace' clay/silt	≤15	'trace' sand/gravel	≤15	'trace' sand/gravel
	5 - 12	'with' clay/silt	15 - 30	'with' sand/gravel	15 - 30	'with' sand/gravel
Secondary	> 15	Prefix silty or clayey	>30	Prefix sandy or gravelly	>30	Prefix sandy or gravelly

EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT LOGS - ROCK DESCRIPTION (AS1726 - 2017)

STRENGTH OF INTACT ROCK

Symbol	Term	Point Load Index, (I_{s50}) MPa	Field Guide to Strength
VL	Very Low	$0.03 \le I_{s50} < 0.1$	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; pieces up to 30mm thick can be broken by finger pressure
L	Low	$0.1 \le I_{s50} < 0.3$	Easily scored with knife; indentations 1mm to 3mm after firm blow with pick point; core 150mm long and 50mm diameter can be broken by hand; sharp edges of core friable
M	Medium	$0.3 \le I_{s50} < 1.0$	Readily scored with knife; core 150mm long and 50mm diameter can be broken by hand with difficulty
H	High	$1.0 \le I_{s50} < 3$	Core 150mm long and 50mm diameter cannot be broken by hand but can be broken by single firm blow of pick; rock rings under hammer
VH	Very High	$3 \le I_{s50} < 10$	Hand held specimen breaks with pick after more than one blow; rock rings under hammer
EH	Extremely High	$10 \le I_{s50}$	Specimen requires many pick blows to break intact rock, rock rings under hammer

Material with rock strength less than 'Very Low' are described using soil properties

DEGREE OF ROCK WEATHERING

Term		Symbol		Definition
Residual Soil		RS		Soil derived from the weathering of rock; the mass structure and material fabric are no longer evident the soil has not been significantly transported.
Extremely Weathered		XW		Material is weathered to such an extent that it has soil properties, i.e. it either disintegrates or can be remoulded, in water. Fabric of original rock still visible.
Highly Weathered	Distinctly Weathered	HW	DW	Rock strength is changed by weathering. The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognizable. Some minerals are decomposed to clay minerals. Porosity may be increased by leach, or may be decreased due to deposition of weathering products in pores.
Moderately Weathered		MW		The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable, but shows little or no change of strength from fresh rock.
Slightly Weathered		SW		Rock is slightly discoloured but shows little or no change of strength from fresh rock
Fresh		FR		Rock shows no sign of decomposition or staining

Distinctly Weathered is to be used when it is not possible to differentiate between highly and moderately weathered.

Extremely Weathered material is to be described using soil properties

ROCK MASS PROPERTIES

Term	Separation of Stratification Planes
Thinly laminated	< 6mm
Laminated	6mm to 20 mm
Very thinly bedded	20mm to 60mm
Thinly bedded	60mm to 200mm
Medium bedded	0.2m to 0.6m
Thickly bedded	0.6m to 2.0m
Massive	< 2m

Term	Description
Fragmented	Primarily fragments < 20mm length and mostly of width < core diameter
Highly fractured	Core lengths generally less than 20mm to 40mm with occasional fragments
Fractured	Core lengths mainly 30mm to 100mm with occasional shorter and longer pieces
Slightly fractured	Core lengths generally 0.3m to 1.0m with occasional longer and shorter sections
Unbroken	Core has no fractures

DEFECT TYPES AND DESCRIPTIONS

Defect Type		Defect Shape		Surface Roughness		Defect Coatings	
BR	Bedding parting	PL	Planar	VR	Very rough	CL	Clean
JT	Joint	ST	Stepped	RO	Rough	ST	Stained
SR	Sheared surface	CR	Curved	SM	Smooth	VN	Veneer
SZ	Sheared zone	IR	Irregular	PO	Polished	CT	Coating
SS	Sheared seam	UN	Undulating	SL	Slickenside		
CS	Crushed seam						
IS	Infill seam						
XS	Extremely Weathered Seam						

Vertical Boreholes - The dip of the defect is given from the horizontal

Inclined Boreholes - The angle of the defect is given from the core axis

Appendix B

Site Photography

Appendix C

Laboratory Data

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS

Contact	Raj Singh
Client	INTRAX CONSULTING ENGINEERS PTY LTD
Address	C 207 22-36 MOUNTAIN STREET ULTIMO NSW 2007
Telephone	61 2 48695666
Facsimile	(Not specified)
Email	raj.singh@intrax.com.au
Project	**S#124171**
Order Number	(Not specified)
Samples	13

LABORATORY DETAILS

Manager	Huong Crawford
Laboratory	SGS Alexandria Environmental
Address	Unit 16, 33 Maddox St Alexandria NSW 2015
Telephone	+61 2 8594 0400
Facsimile	+61 2 8594 0499
Email	au.environmental.sydney@sgs.com
SGS Reference	**SE196226 R0**
Date Received	08 Aug 2019
Date Reported	09 Aug 2019

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(4354).

SIGNATORIES

Shane McDermott
Inorganic/Metals Chemist

Parameter	Units	LOR	Sample Number: SE196226.001 Sample Matrix: Soil Sample Date: 07 Aug 2019 Sample Name: BH1-0.50m (S#124171)	SE196226.002 Soil 07 Aug 2019 BH1-1.00m (S#124171)	SE196226.003 Soil 07 Aug 2019 BH1-1.30m (S#124171)	SE196226.004 Soil 07 Aug 2019 BH1-1.50m (S#124171)
Field pH for Acid Sulphate Soil Method: AN104 Tested: 9/8/2019						
pHf	pH Units	-	**6.6**	**6.5**	**5.6**	**5.7**
pHfox	pH Units	-	**5.6**	**5.6**	**2.2**	**2.9**
Reaction*	No unit	-	X	X	XXXX	XX
pH Difference*	pH Units	-10	**1.0**	**0.9**	**3.4**	**2.8**

Parameter	Units	LOR	Sample Number: SE196226.005 Sample Matrix: Soil Sample Date: 07 Aug 2019 Sample Name: BH2-0.50m (S#124171)	SE196226.006 Soil 07 Aug 2019 BH2-1.00m (S#124171)	SE196226.007 Soil 07 Aug 2019 BH2-1.50m (S#124171)	SE196226.008 Soil 07 Aug 2019 BH3-0.50m (S#124171)
Field pH for Acid Sulphate Soil Method: AN104 Tested: 9/8/2019						
pHf	pH Units	-	**6.2**	**6.7**	**5.9**	**7.8**
pHfox	pH Units	-	**5.5**	**5.7**	**2.8**	**5.9**
Reaction*	No unit	-	XX	XX	XXX	XX
pH Difference*	pH Units	-10	**0.7**	**1.0**	**3.2**	**1.9**

Parameter	Units	LOR	Sample Number: SE196226.009 Sample Matrix: Soil Sample Date: 07 Aug 2019 Sample Name: BH3-1.00m (S#124171)	SE196226.010 Soil 07 Aug 2019 BH3-1.50m (S#124171)	SE196226.011 Soil 07 Aug 2019 BH4-0.50m (S#124171)	SE196226.012 Soil 07 Aug 2019 BH4-1.00m (S#124171)
Field pH for Acid Sulphate Soil Method: AN104 Tested: 9/8/2019						
pHf	pH Units	-	**7.6**	**6.6**	**8.5**	**7.9**
pHfox	pH Units	-	**5.6**	**5.8**	**6.7**	**5.9**
Reaction*	No unit	-	X	X	XX	XXX
pH Difference*	pH Units	-10	**2.0**	**0.9**	**1.8**	**2.0**

Parameter	Units	LOR	Sample Number: SE196226.013 Sample Matrix: Soil Sample Date: 07 Aug 2019 Sample Name: BH4-1.50m (S#124171)
Field pH for Acid Sulphate Soil Method: AN104 Tested: 9/8/2019			
pHf	pH Units	-	**6.7**
pHfox	pH Units	-	**4.1**
Reaction*	No unit	-	XX
pH Difference*	pH Units	-10	**2.7**

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.

Field pH for Acid Sulphate Soil **Method: ME-(AU)-[ENV]AN104**

Parameter	QC Reference	Units	LOR	DUP %RPD	LCS %Recovery
pHf	LB180540	pH Units	-	2%	NA
pHfox	LB180540	pH Units	-	2%	NA

METHOD SUMMARY

METHOD	METHODOLOGY SUMMARY
AN104	pHF is determined on an extract of approximately 2g of as received sample in approximately 10 mL of deionised water with pH determined after standing 30 minutes.
AN104	pHFox is determined on an extract of approximately 2g of as received sample with a few mLs of 30% hydrogen peroxide (adjusted to pH 4.5 to 5.5) with the extract reaction being rated from slight to extreme, with pH determined after reaction is complete and extract has cooled. Referenced to ASS Laboratory Methods Guidelines, method 23Af-Bf, 2004. X Slight Reaction XX Moderate Reaction XXX Strong/High Reaction XXXX Extreme/Vigorous Reaction (gas evolution and heat generation)

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
		NVL	Not Validated

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Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

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

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au.pv.sgsvr/en-gb/environment.

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS		LABORATORY DETAILS	
Contact	Raj Singh	Manager	Anthony Nilsson
Client	INTRAX CONSULTING ENGINEERS PTY LTD	Laboratory	SGS Cairns Environmental
Address	C 207 22-36 MOUNTAIN STREET ULTIMO NSW 2007	Address	Unit 2, 58 Comport St Portsmith QLD 4870
Telephone	61 2 48695666	Telephone	+61 07 4035 5111
Facsimile	02 8594 0499	Facsimile	+61 07 4035 5122
Email	au.environmental.sydney@sgs.com	Email	AU.Environmental.Cairns@sgs.com
Project	**S#124171- Additional**	SGS Reference	**CE141285A R0**
Order Number	**SE196226A**	Date Received	13 Aug 2019
Samples	1	Date Reported	14 Aug 2019

COMMENTS

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

SIGNATORIES

Anthony Nilsson
Operations Manager

Jon Dicker
Manager Northern QLD

Parameter	Units	LOR	Sample Number: CE141285A.001 Sample Matrix: Soil Sample Date: 07 Aug 2019 Sample Name: BH1-1.30m (S#124171)
Moisture Content Method: AN002 Tested: 13/8/2019			
% Moisture	%w/w	0.5	**64**
TAA (Titratable Actual Acidity) Method: AN219 Tested: 14/8/2019			
pH KCl	pH Units	-	**4.6**
Titratable Actual Acidity	kg H2SO4/T	0.25	**9.6**
Titratable Actual Acidity (TAA) moles H+/tonne	moles H+/T	5	**195**
Titratable Actual Acidity (TAA) S%w/w	%w/w S	0.01	**0.31**
Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 14/8/2019			
Chromium Reducible Sulphur (Scr)	%	0.005	**0.070**
Chromium Reducible Sulphur (Scr)	moles H+/T	5	**44**
Chromium Suite Net Acidity Calculations Method: AN220 Tested: 14/8/2019			
s-Net Acidity	%w/w S	0.005	**0.38**
s-Net Acidity without ANC	%w/w S	0.005	**0.38**
a-Net Acidity	moles H+/T	5	**240**
Liming Rate	kg CaCO3/T	0.1	**18**
Verification s-Net Acidity	%w/w S	-20	**0.07**
a-Net Acidity without ANCBT	moles H+/T	5	**240**
Liming Rate without ANCBT	kg CaCO3/T	0.1	**18**

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)	LB070478	%	0.005	<0.005	0 - 2%	92%
Chromium Reducible Sulphur (Scr)	LB070478	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	LB070477	pH Units	-	5.9	0 - 1%	98%
Titratable Actual Acidity	LB070477	kg H2SO4/T	0.25	<0.25	0 - 1%	NA
Titratable Actual Acidity (TAA) moles H+/tonne	LB070477	moles H+/T	5	<5	0 - 1%	92%
Titratable Actual Acidity (TAA) S%w/w	LB070477	%w/w S	0.01	<0.01	0 - 1%	92%

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.
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.
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	Chromium 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
		NVL	Not Validated

Unless it is reported that sampling has been performed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

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

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

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ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS		LABORATORY DETAILS	
Contact	Raj Singh	Manager	Anthony Nilsson
Client	INTRAX CONSULTING ENGINEERS PTY LTD	Laboratory	SGS Cairns Environmental
Address	C 207 22-36 MOUNTAIN STREET ULTIMO NSW 2007	Address	Unit 2, 58 Comport St Portsmith QLD 4870
Telephone	61 2 48695666	Telephone	+61 07 4035 5111
Facsimile	02 8594 0499	Facsimile	+61 07 4035 5122
Email	au.environmental.sydney@sgs.com	Email	AU.Environmental.Cairns@sgs.com
Project	**S#124171- Additional**	SGS Reference	**CE141285 R0**
Order Number	**SE196226A**	Date Received	12 Aug 2019
Samples	1	Date Reported	13 Aug 2019

COMMENTS

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

SIGNATORIES

Anthony Nilsson
Operations Manager

Jon Dicker
Manager Northern QLD

Parameter	Units	LOR	Sample Number: CE141285.001 Sample Matrix: Soil Sample Date: 07 Aug 2019 Sample Name: BH3-0.50m (S#124171)
Moisture Content Method: AN002 Tested: 12/8/2019			
% Moisture	%w/w	0.5	**2.2**
TAA (Titratable Actual Acidity) Method: AN219 Tested: 13/8/2019			
pH KCl	pH Units	-	**7.7**
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
Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 13/8/2019			
Chromium Reducible Sulphur (Scr)	%	0.005	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5
Chromium Suite Net Acidity Calculations Method: AN220 Tested: 13/8/2019			
s-Net Acidity	%w/w S	0.005	<0.005
s-Net Acidity without ANC	%w/w S	0.005	<0.005
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	**0.00**
a-Net Acidity without ANCBT	moles H+/T	5	<5
Liming Rate without ANCBT	kg CaCO3/T	0.1	<0.1

QC SUMMARY

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

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Chromium Reducible Sulphur (Scr)	LB070434	%	0.005	<0.005	0%	95%
Chromium Reducible Sulphur (Scr)	LB070434	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	LB070432	pH Units	-	5.7	0%	101%
Titratable Actual Acidity	LB070432	kg H2SO4/T	0.25	<0.25	0%	NA
Titratable Actual Acidity (TAA) moles H+/tonne	LB070432	moles H+/T	5	<5	0%	92%
Titratable Actual Acidity (TAA) S%w/w	LB070432	%w/w S	0.01	<0.01	0%	92%

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.
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AN220	Chromium Suite: Scheme for the calculation of net acidities and liming rates using a Fineness Factor of 1.5.

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