GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

APPROVED

Land and Environment Court of NSW

LEC No: 2021/00329677 DA20/1466

Date: 27/1/2023

GEOTECHNICAL INVESTIGATION

FOR

R & G CREATIONS

8 – 12 Princes Highway, Mollymook, New South Wales

Report No: 19/3255

Project No: 30090/3111D-G

November 2019

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1. INTRODUCTION

This report presents the results of a geotechnical investigation carried out by STS Geotechnics Pty Limited (STS) for a proposed new medium density residential development to be constructed at 8 – 12 Princes Highway, Mollymook. We have been informed the development comprises the demolition of existing structures on site prior to the construction of a five-storey residential unit type development including a lower ground level carpark. The finished floor level of the carpark is RL36.5 metres. Due to the ground surface slope across the site, construction of the lower ground car parking level will require excavating up to approximately 4.0 metres below the ground surface adjacent to the Princes Highway, with the depth of excavation decreasing towards the east. Further, we understand that it is proposed to dispose of excess stormwater via means of on-site infiltration.

The purpose of the investigation was to:

- assess the subsurface conditions over the site,
- provide a Site Classification to AS2870,
- provide recommendations regarding the appropriate foundation system for the site including design parameters,
- provide parameters for the temporary and permanent support of the excavation,
- provide recommendations regarding vibration control during rock excavation,
- comment on soil aggressiveness to buried steel and concrete, and
- assess the in-situ infiltration rate of near surface materials for the design of stormwater absorption systems.

The investigation was undertaken at the request of Emanuele Stefani of Edmiston Jones Pty Limited on behalf of R & G Creations.

Our scope of work did not include a contamination assessment.

2. NATURE OF THE INVESTIGATION

2.1. Fieldwork

The fieldwork consisted of drilling five (5) boreholes numbered BH1 to BH5, inclusive, at the locations shown on Drawing No. 19/3255. Restricted site access dictated the borehole locations. The boreholes were drilled using an Edson RP70 utility mounted drilling rig owned and operated by STS. Soils and weathered rock were drilled using rotary solid flight augers. Soil strengths were determined by undertaking Dynamic Cone Penetrometer (DCP) tests at each borehole location.

Drilling operations were undertaken by one of STS's senior geologists who also logged the subsurface conditions encountered.

The subsurface conditions observed are recorded on the borehole logs given in Appendix A. An explanation of the terms used on the logs is also given in Appendix A. Notes relating to geotechnical reports are also attached.

2.2. Laboratory Testing

In order to assess the soils for their aggressiveness selected representative soil samples were tested to determine the following:

- pH,
- Sulphate (S04) content,
- Chloride (Cl) content, and
- Electrical Conductivity (EC).

The detailed test reports are given in Appendix B.

3. GEOLOGY AND SITE CONDITIONS

The Ulladulla geological series sheet at a scale of 1:250,000 shows Tertiary Age basalt underlies the site.

The site is roughly rectangular in shape with a combined area of approximately 3,000 m^2. At the time of the fieldwork, the was operating as a motel and comprised a series of single level and split level two storey brick and cement rendered buildings with asphaltic concrete car parking, timber and brick retaining walls together with an in-ground swimming pool. Immediately to the east of the swimming pool is a fill embankment. The embankment has a height of approximately 2.5 to 3.0 metres and is retained in sections by a timber wall. The embankment has slope angles of up to 30°. Site vegetation comprised grass, trees and shrubs within the garden beds.

The ground surface falls approximately 9 metres to the south east.

To the south-west of the site is Princes Highway and to the other sides are residential properties. The existing structures on the adjacent properties to the north and south of the site are single storey clad residential dwellings located close to the site boundaries.

4. SUBSURFACE CONDITIONS

When assessing the subsurface conditions across a site from a limited number of boreholes, there is the possibility that variations may occur between test locations. The data derived from the site investigation programme are extrapolated across the site to form a geological model and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour regarding the proposed development. The actual condition at the site may differ from those inferred, since no subsurface exploration programme, no matter how comprehensive, can reveal all subsurface details and anomalies.

The subsurface conditions generally consist of topsoil, asphaltic concrete and fill overlying silty clays, gravelly silty clays and basalt bedrock. Topsoil was encountered in the boreholes drilled in the garden beds, being BH1, BH3, BH4 and BH5 to depths of 0.2 to 0.4 metres. The surface material in BH2 comprised asphaltic concrete and sandy gravel filling material to a depth of 0.2 metres. Fill materials were encountered across the site to depth of 0.5 – 1.8 metres, however fill was not encountered in BH3. The fill could not be penetrated in BH2. Natural silty clays and gravelly silty clays were encountered below the surface materials and fill to depths of 1.1 to 3.0 metres. The consistency of the clays varies from firm to stiff to very stiff. Weathered basalt bedrock underlies the site to the depth of auger refusal, 1.1 to 3.0 metres. Due to the method of drilling used, it was not possible to determine if the bedrock was in-situ, or comprises basalt core stone within a clay matrix.

Groundwater seepage was not observed during drilling of the boreholes.

5. DISCUSSION

5.1. Site Classification to AS2870

The classification has been prepared in accordance with the guidelines set out in the "Residential Slabs and Footings" Code, AS2870 – 2011.

Because there are buildings and trees present, abnormal moisture conditions (AMC) prevail at the site (Refer to Section 1.3.3 of AS2870).

Because of the AMC, and fill present, the site is classified *a problem site (P).*

5.2. Excavation Conditions and Support

Based on the subsurface conditions observed in the boreholes it is expected that excavations on the site to approximate depths of up to 4.0 m metres will encounter fill, clayey natural soils and possibly weathered basalt bedrock. Excavators without assistance should be able to remove the fill and natural soils.

If the basalt bedrock is in-situ, then excavators alone without assistance will not be able to remove any significant amount of rock below the depth of auger refusal as shown on the borehole logs. In-situ basalt bedrock may be very high strength, and therefore consideration needs to be given to the possible removal of high strength bedrock during the bulk excavation works. Hydraulic breakers mounted on an excavator or jack hammers will be required to break up the majority of the rock below these depths before it can be removed using an excavator.

Particular care will be required to ensure that buildings or other developments on adjacent properties are not damaged when excavating the rock. The adjacent buildings may be founded directly on the underlying bedrock. Buildings founded directly on rock can often be very susceptible to damage from vibrations.

Excavations methods should be adopted which limit ground vibrations at the adjoining developments to not more than 10 mm/sec. Vibration monitoring will be required to verify that this is achieved. However, if the contractor adopts methods and/or equipment in accordance with the recommendations in Table 5.1 for a ground vibration limit of 5 mm/sec, vibration monitoring may not be required.

Table 5.1 – Recommendations for Rock Breaking Equipment

Distance from adjoining structure (m)	**Maximum Peak Particle Velocity 5 mm/sec**		**Maximum Peak Particle Velocity 10 mm/sec**	
	Equipment	Operating Limit (% of Maximum Capacity)	Equipment	Operating Limit (% of Maximum Capacity)
1.5 to 2.5	Hand operated jackhammer only	100	300 kg rock hammer	50
2.5 to 5.0	300 kg rock hammer	50	300 kg rock hammer or 600 kg rock hammer	100 50
5.0 to 10.0	300 kg rock hammer or 600 kg rock hammer	100 50	600 kg rock hammer or 900 kg rock hammer	100 50

*Vibration monitoring is recommended for 10 mm/sec vibration limit.

The limits of 5 mm/sec and 10 mm/sec are expected to be achievable if rock breaker equipment or other excavation methods are restricted as indicated in Table 5.1.

At all times, the excavation equipment must be operated by experienced personnel, according to the manufacturer's instructions and in a manner consistent with minimising vibration effects.

Use of other techniques (e.g. grinding, rock sawing), although less productive, would reduce or possibly eliminate risks of damage to property through vibration effects transmitted via the ground. Such techniques may be considered if an alternative to rock breaking is required.

If rock sawing is carried out around excavation boundaries in not less than 1 metre deep lifts, a 900 kg rock hammer could be used at up to 100% maximum operating capacity with an assessed peak particle velocity not exceeding 5 mm/sec, subject to observation and confirmation by a geotechnical engineer at the commencement of excavation.

It should be noted that vibrations that are below threshold levels for building damage may be experienced at adjoining developments.

Saw cutting should be carried out before any rock breaking is commenced on the site. It would be appropriate before commencing excavation to undertake a dilapidation survey of any adjacent structures that may potentially be damaged. This will provide a reasonable basis for assessing any future claims of damage.

It is of course important that the onsite excavations are adequately supported at all times and do not endanger the adjacent properties.

Temporary slopes in the soils may be constructed at a maximum angle of 1 to 1. Where this is not possible it will be necessary to provide temporary support. Support is conventionally drilled and fixed into the materials below the base of the excavation.

When considering the design of the supports, it will be necessary to allow for the loading from structures in adjoining properties, any ground surface slope and the water table present. Where the structures in adjoining properties are within the zone of influence of the excavation, it will be necessary to adopt K_o conditions when designing the temporary support. Anchors or props can be used to provide the required support. If anchors extend into adjoining property, it will be necessary to obtain the permission of the property owners. Anchors should be installed into the weathered rock. When props or anchors are used for support, a rectangular earth pressure distribution should be adopted on the active side of the support. K_o should also be used to design the permanent support.

The following parameters are suggested for the design of the retaining wall system where there is a level ground surface:

Fill and Natural Soils / Boulders to the depth of auger refusal:

Active Earth Pressure Coefficient (K_a)	=	0.4
At Rest Pressure Coefficient (K_o)	=	0.55
Total (Bulk) Density	=	20 kN/m^3

In-situ Weathered rock below the depth of auger refusal:

Earth Pressure Coefficient	=	0.1 or 10 kPa (whichever is lesser)
Passive Earth Pressure Coefficient (K_p)	=	4.5 (weathered rock only)
Total (Bulk) Density	=	22 kN/m^3

Based on the observations during drilling, the lower ground level excavations are not expected to encounter the groundwater table. However, some minor perched water seepage may flow into the excavation from the soil rock interface. The inflow rates are likely to be minor and therefore a sump and a pump should be sufficient to control the anticipated seepage.

5.3. Foundation Design

The existing topsoil and fill materials are not suitable for foundation support. Footings that bear in firm to stiff natural clayey soils at a high level below any topsoil or fill may be proportioned using an allowable bearing pressure of 100 kPa. This value may be increased to 150 kPa when founding in stiff materials and 300 kPa when founding in very stiff natural materials.

On completion of bulk excavation works the exposed materials will likely comprise very stiff clays or weathered basalt along the western boundary adjacent to the Princess Highway, and fill materials towards the eastern edge of the building platform. Founding structures on a combination of bedrock/very clays and fill is likely to result in differential settlement of the foundations. We therefore recommend founding the structures uniformly across the building platform. In this regard, piles are likely to be required over the eastern half of the building to suspend the foundations.

Pad and or strip footings or piles founded in weathered basalt may be proportioned using an allowable bearing pressure of 700 kPa. For piles an allowable adhesion of 70 kPa may be adopted for the portion of the shaft within the weathered rock. When piles are founded in rock the adhesion in the overlying soils must be ignored.

In order to ensure the bearing values given can be achieved, care should be taken to ensure that the base of excavations are free of all loose material prior to concreting. It is recommended that all footing excavations be protected with a layer of blinding concrete as soon as possible, preferably immediately after excavating, cleaning, inspection and approval. The possible presence of groundwater needs to be considered when drilling piers and pouring concrete.

5.4. Soil Aggressiveness

The aggressiveness or erosion potential of an environment in building materials, particularly concrete and steel is dependent on the levels of soil pH and the types of salts present, generally sulphates and chlorides. In order to determine the degree of aggressiveness, the test values obtained are compared to Tables 6.4.2 (C) and 6.5.2 (C) in AS2159 – 2009 Piling – Design and Installation and Tables 5.1 and 5.2 of AS2870-2011. In regards to the electrical conductivity, the laboratory test results have been multiplied by the appropriate factor to convert the results to EC_e. The test results are summarised in Table 5.2 below.

Table 5.2 – Soil Aggressiveness Summary Table

Sample No.	Location	Depth (m)	pH	Sulfate (mg/kg)	Chloride (mg/kg)	Electrical Conductivity (dS/m)	
						$EC_{1:5}$	EC_e
S1	BH1	0.4	5.9	20	40	0.035	0.3
S2	BH1	1.0	7.2	160	<200	0.086	0.6

The report results range between:

- pH - 5.9 and 7.2
- soluble SO_4 - 20 and 160 mg/kg (ppm)
- soluble Cl - 40 and <200 mg/kg (ppm)
- EC_e - 0.3 and 0.6 dS/m

The soils on the site consist of low permeability clays. Therefore, the soil conditions B are considered appropriate.

A review of the durability aspects indicates that:

- pH : minimum value of 5.9
- SO_4 : maximum value of 160 mg/kg (ppm) < 5000 ppm
- Cl : maximum value of <200 mg/kg (ppm) < 5000 ppm
- EC_e : maximum value of 0.6 dS/m

The exposure classification for the onsite soils is non-aggressive for both steel and concrete in accordance with AS2159-2009. The soils are classified as A1 in accordance with AS2870-2011.

Reference to DLWC (2002) "Site Investigations for Urban Salinity" indicates that EC_e values of 0.3 dS/m and 0.6 dS/m are consistent with the presence of non-saline soils.

5.5. Infiltration Testing

The infiltration rate of the onsite soils was assessed using the falling head test method. The tests were carried out using a PVC pipe installed into a preformed borehole that had been previously drilled. In order to create a saturated bulb in the testing zone, the casing was repeatedly filled with water and the drop in water level measured relative to time. This process was carried out until successive tests gave different readings by less than 5%. The last run has been used to determine the soil infiltration rate. The test was carried out in BH5, which was undertaken towards the toe of the fill embankment.

Results of the testing are summarised in Table 5.31 below.

Table 5.3 – Falling Head Test Summary Table:

Location	Depth of Test (m)	Design Infiltration Rate (litres/m^2/sec)
BH5	0.5	Nil

The test was undertaken at a depth of 0.5 metres, as the borehole could not penetrate below this depth. During the test, the water level did not fall during a 30-minute period.

The site geology comprises residual silty clays overlying weathered basalt bedrock. The lack of water infiltration recorded during the testing reflects the generally impermeable subsurface conditions present on site. The site is therefore not considered suitable for disposal of stormwater via means of soil infiltration.

6. FINAL COMMENTS

As noted in Sections 5.2 and 5.3, any in-situ bedrock is likely to be very high strength. Prior to finalising contracts for bulk earthworks or finalising the structural design it is recommended that a series of test pits be excavated across the site to expose the underlying basalt bedrock. The test pits will enable an assessment to be made as to whether the bedrock is in-situ, or represents basalt core stones within a clay matrix.

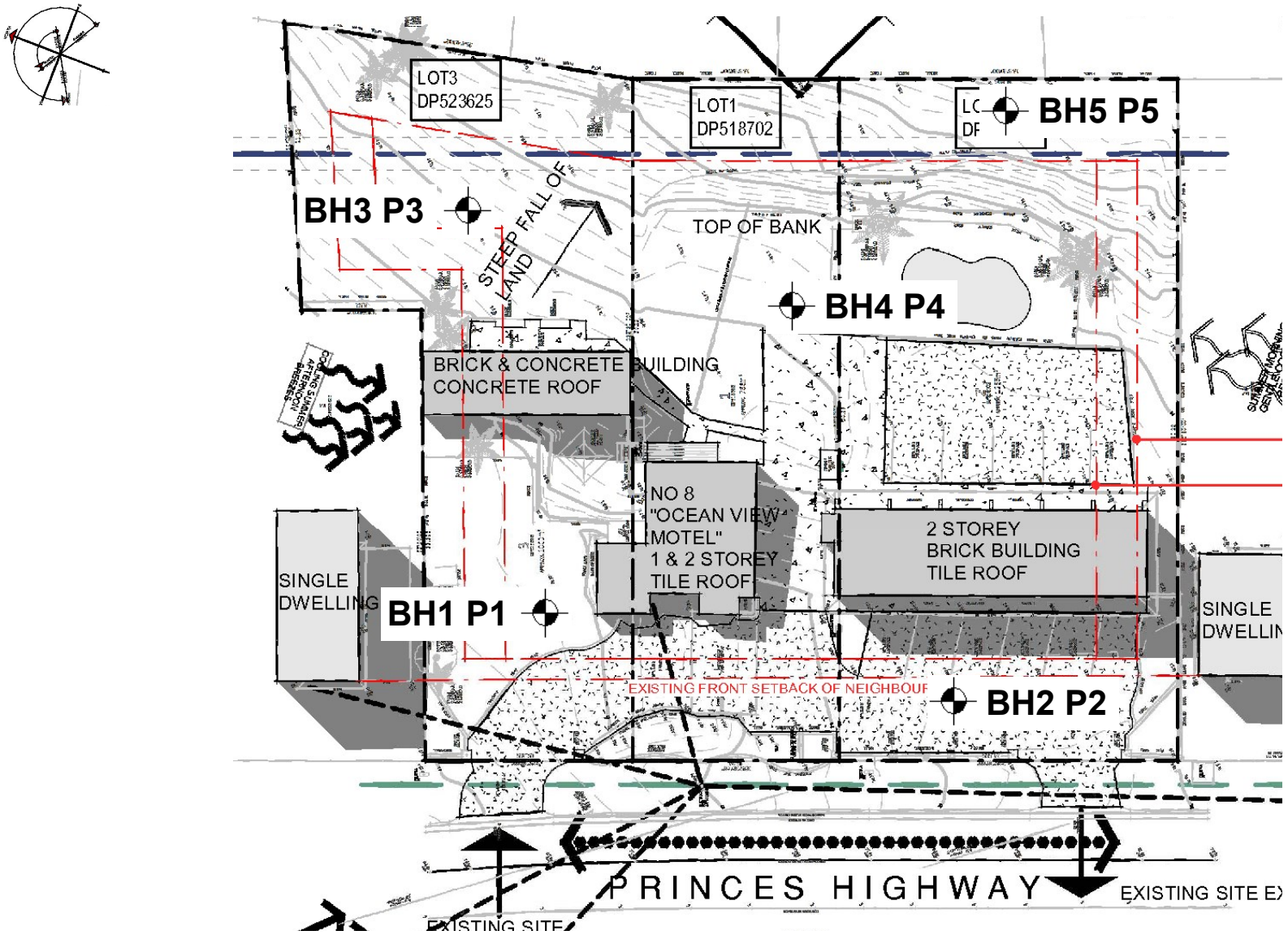
Further, the presence of very high strength in-situ bedrock may be problematic for the installation of conventional types of support, such as cantilevered solider pile retaining walls. Cantilevered walls rely on embedment below bulk excavation level to generate passive support. If the bedrock is very high strength, then the piling equipment may not be capable of penetrating the rock to the required depth.

During construction, should the subsurface conditions vary from those inferred above, we would be contacted to determine if any changes should be made to our recommendations.

The exposed bearing surfaces for footings should be inspected by a geotechnical engineer to ensure the allowable pressure given has been achieved.

Rasoul Machiani
Senior Geotechnical Engineer

Matthew Green
Principal Engineering Geologist



STS Geotechnics Pty. Ltd.	Scale: Unknown	Date: November 2019
Client: R & G CREATIONS		
GEOTECHNICAL INVESTIGATION **8-12 PRINCES HIGHWAY, MOLLYMOOK** **BOREHOLE AND PENETROMETER LOCATIONS**		Project No. 30090/3111D-G Drawing No: 19/3255

NOTES RELATING TO GEOTECHNICAL REPORTS

Introduction

These notes have been provided to outline the methodology and limitations inherent in geotechnical reporting. The issues discussed are not relevant to all reports and further advice should be sought if there are any queries regarding any advice or report.

When copies of reports are made, they should be reproduced in full.

Geotechnical Reports

Geotechnical reports are prepared by qualified personnel on the information supplied or obtained and are based on current engineering standards of interpretation and analysis.

Information may be gained from limited subsurface testing, surface observations, previous work and is supplemented by knowledge of the local geology and experience of the range of properties that may be exhibited by the materials present. For this reason, geotechnical reports should be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely.

Where the report has been prepared for a specific purpose (eg. design of a three-storey building), the information and interpretation may not be appropriate if the design is changed (eg. a twenty storey building). In such cases, the report and the sufficiency of the existing work should be reviewed by STS Geotechnics Pty Limited in the light of the new proposal.

Every care is taken with the report content, however, it is not always possible to anticipate or assume responsibility for the following conditions:

- Unexpected variations in ground conditions. The potential for this depends on the amount of investigative work undertaken.
- Changes in policy or interpretation by statutory authorities.
- The actions of contractors responding to commercial pressures.

If these occur, STS Geotechnics Pty Limited would be pleased to resolve the matter through further investigation, analysis or advice.

Unforeseen Conditions

Should conditions encountered on site differ markedly from those anticipated from the information contained in the report, STS Geotechnics Pty Limited should be notified immediately. Early identification of site anomalies generally results in any problems being more readily resolved and allows re-interpretation and assessment of the implications for future work.

Subsurface Information

Logs of a borehole, recovered core, test pit, excavated face or cone penetration test are an engineering and/or geological interpretation of the subsurface conditions. The reliability of the logged information depends on the drilling/testing method, sampling and/or observation spacings and the ground conditions. It is not always possible or economic to obtain continuous high quality data. It should also be recognised that the volume or material observed or tested is only a fraction of the total subsurface profile.

Interpretation of subsurface information and application to design and construction must take into consideration the spacing of the test locations, the frequency of observations and testing, and the possibility that geological boundaries may vary between observation points.

Groundwater observations and measurements outside of specially designed and constructed piezometers should be treated with care for the following reasons:

- In low permeability soils groundwater may not seep into an excavation or bore in the short time it is left open.
- A localised perched water table may not represent the true water table.
- Groundwater levels vary according to rainfall events or season.
- Some drilling and testing procedures mask or prevent groundwater inflow.

The installation of piezometers and long term monitoring of groundwater levels may be required to adequately identify groundwater conditions.

Supply of Geotechnical Information or Tendering Purposes

It is recommended tenderers are provided with as much geological and geotechnical information that is available and that where there are uncertainties regarding the ground conditions, prospective tenders should be provided with comments discussing the range of likely conditions in addition to the investigation data.

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CONSULTING GEOTECHNICAL ENGINEERS

APPENDIX A – BOREHOLE LOGS AND EXPLANATION SHEETS

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: R & G Creations	Project / STS No. 30090/3111D-G	**BOREHOLE NO.: BH 1**
Project: 8-12 Princes Highway, Mollymook	Date: November 18, 2019	
Location: Refer to Drawing No. 19/3255	Logged: JK Checked By: MG	Sheet 1 of 1

WATER TABLE	SAMPLES	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT (Soil type, colour, grain size, plasticity, minor components, observations)	SYMBOL	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	MOISTURE
			TOPSOIL: SILTY SANDY CLAY: dark brown, fine grained sand, low plasticity	CL	FIRM	D
	S1 @ 0.4 m	0.5	FILL: SILTY SANDY CLAY: orange brown, fine grained sand, low plasticity, trace of gravel	CL	STIFF	D-M
	S2 @ 1.0 m	1.0	SILTY CLAY: orange brown, medium to high plasticity	CL/CH	VERY STIFF	M
			WEATHERED BASALT: dark grey			
		1.5	AUGER REFUSAL AT 1.2 M ON WEATHERED BASALT / POSSIBLE FLOATER			
		2.0				
		2.5				

D - disturbed sample U - undisturbed tube sample B - bulk sample

WT - level of water table or free water N - Standard Penetration Test (SPT)

S - jar sample

NOTES: See explanation sheets for meaning of all descriptive terms and symbols

Contractor: STS

Equipment: EdsonRP70

Hole Diameter (mm): 100

Angle from Vertical (^{o}): 0

Drill Bit: Spiral

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: R & G Creations	Project / STS No. 30090/3111D-G	**BOREHOLE NO.: BH 2**
Project: 8-12 Princes Highway, Mollymook	Date: November 18, 2019	
Location: Refer to Drawing No. 19/3255	Logged: JK Checked By: MG	Sheet 1 of 1

WATER TABLE	SAMPLES	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT (Soil type, colour, grain size, plasticity, minor components, observations)	SYMBOL	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	MOISTURE
			FILL: ASPHALT/SANDY GRAVEL: dark grey, fine to medium grained	GW	DENSE	D
			FILL: GRAVELLY SANDY CLAY: dark brown, low plasticity, some gravel, cobbles	CL	STIFF	D
		0.5				
			AUGER REFUSAL AT 0.6 M IN FILL			
		1.0				
		1.5				
		2.0				
		2.5				

D - disturbed sample
U - undisturbed tube sample
B - bulk sample
WT - level of water table or free water
N - Standard Penetration Test (SPT)
S - jar sample

Contractor: STS
Equipment: EdsonRP70
Hole Diameter (mm): 100
Angle from Vertical (°): 0
Drill Bit: Spiral

NOTES: See explanation sheets for meaning of all descriptive terms and symbols

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: R & G Creations	Project / STS No. 30090/3111D-G	**BOREHOLE NO.: BH 3**
Project: 8-12 Princes Highway, Mollymook	Date: November 18, 2019	
Location: Refer to Drawing No. 19/3255	Logged: JK Checked By: MG	Sheet 1 of 1

WATER TABLE	SAMPLES	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT (Soil type, colour, grain size, plasticity, minor components, observations)	SYMBOL	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	MOISTURE
			TOPSOIL/FILL: SILTY CLAY: dark brown, medium plasticity, trace of gravel	CL	FIRM	M
		0.5	SILTY CLAY: orange brown/dark brown, medium to high plasticity, trace of basalt gravel	CL/CH	STIFF	M
		1.0	GRAVELLY SILTY CLAY: dark brown, medium plasticity, some basalt gravel, cobbles	CL	VERY STIFF	M-D
		1.5	AUGER REFUSAL AT 1.5 M ON WEATHERED BASALT / POSSIBLE FLOATER			
		2.0				
		2.5				

D - disturbed sample U - undisturbed tube sample B - bulk sample

WT - level of water table or free water N - Standard Penetration Test (SPT)

S - jar sample

NOTES: See explanation sheets for meaning of all descriptive terms and symbols

Contractor: STS

Equipment: EdsonRP70

Hole Diameter (mm): 100

Angle from Vertical (^{o}): 0

Drill Bit: Spiral

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: R & G Creations	Project / STS No. 30090/3111D-G	**BOREHOLE NO.: BH 4**
Project: 8-12 Princes Highway, Mollymook	Date: November 18, 2019	
Location: Refer to Drawing No. 19/3255	Logged: JK Checked By: MG	Sheet 1 of 2

WATER TABLE	SAMPLES	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT (Soil type, colour, grain size, plasticity, minor components, observations)	SYMBOL	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	MOISTURE
			FILL: SILTY SANDY CLAY: dark brown with light brown, fine grained sand, low plasticity	CL	SOFT	M
		0.5	FILL: SILTY CLAY: dark brown with orange brown and dark grey, medium to high plasticity	CL/CH	FIRM	M
		1.0			STIFF	
		1.5				
		2.0	SILTY CLAY: dark grey, medium to high plasticity	CL/CH	FIRM TO STIFF	M
		2.5	SILTY CLAY: orange brown/dark brown, medium to high plasticity, trace of basalt gravel	CL/CH	VERY STIFF	M
			WEATHERED BASALT: dark grey			

D - disturbed sample U - undisturbed tube sample B - bulk sample
WT - level of water table or free water N - Standard Penetration Test (SPT)
S - jar sample

NOTES: See explanation sheets for meaning of all descriptive terms and symbols

Contractor: STS
Equipment: EdsonRP70
Hole Diameter (mm): 100
Angle from Vertical (^{o}): 0
Drill Bit: Spiral

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: R & G Creations	Project / STS No. 30090/3111D-G	**BOREHOLE NO.: BH 4**
Project: 8-12 Princes Highway, Mollymook	Date: November 18, 2019	
Location: Refer to Drawing No. 19/3255	Logged: JK Checked By: MG	Sheet 2 of 2

WATER TABLE	SAMPLES	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT (Soil type, colour, grain size, plasticity, minor components, observations)	SYMBOL	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	MOISTURE
			WEATHERED BASALT: dark grey (possible floater)			
			AUGER REFUSAL AT 3.05 M ON WEATHERED BASALT / POSSIBLE FLOATER			
		3.5				
		4.0				
		4.5				
		5.0				
		5.5				

D - disturbed sample U - undisturbed tube sample B - bulk sample

WT - level of water table or free water N - Standard Penetration Test (SPT)

S - jar sample

NOTES: See explanation sheets for meaning of all descriptive terms and symbols

Contractor: STS

Equipment: EdsonRP70

Hole Diameter (mm): 100

Angle from Vertical (^{o}): 0

Drill Bit: Spiral

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: R & G Creations	Project / STS No. 30090/3111D-G	**BOREHOLE NO.: BH 5**
Project: 8-12 Princes Highway, Mollymook	Date: November 18, 2019	
Location: Refer to Drawing No. 19/3255	Logged: JK Checked By: MG	Sheet 1 of 1

WATER TABLE	SAMPLES	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT (Soil type, colour, grain size, plasticity, minor components, observations)	SYMBOL	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	MOISTURE
			FILL: SILTY CLAY: dark brown/orange brown, medium to high plasticity, trace of basalt gravel, cobbles	CL/CH	FIRM	M
		0.5	AUGER REFUSAL AT 0.5 M IN WEATHERED BASALT / POSSIBLE FLOATER			
		1.0				
		1.5				
		2.0				
		2.5				

D - disturbed sample U - undisturbed tube sample B - bulk sample
WT - level of water table or free water N - Standard Penetration Test (SPT)
S - jar sample

NOTES: See explanation sheets for meaning of all descriptive terms and symbols

Contractor: STS
Equipment: EdsonRP70
Hole Diameter (mm): 100
Angle from Vertical (^{o}): 0
Drill Bit: Spiral

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GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

Dynamic Cone Penetrometer Test Report

Project: 8-12 PRINCES HIGHWAY, MOLLYMOOK
Client: R & G CREATIONS
Address: 92 North Street, Nowra
Test Method: AS 1289.6.3.2

Project No.: 30090/3111D-G
Report No.: 19/3255
Report Date: 21/11/2019
Page: 1 of 1

NATA
Accredited for compliance with ISO/IEC 17025 - Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards
NATA Accreditation Number 2750

Site No.	P1	P2	P3	P4	P5	
Location	Refer to Drawing No. 19/3255	Refer to Drawing No. 19/3255	Refer to Drawing No. 19/3255	Refer to Drawing No. 19/3255	Refer to Drawing No. 19/3255	
Date Tested	18/11/2019	18/11/2019	18/11/2019	18/11/2019	18/11/2019	
Starting Level	Surface Level	Surface Level	Surface Level	Surface Level	Surface Level	
Depth (m)	Penetration Resistance (blows / 150mm)					
0.00 - 0.15	2	*	2	1	2	
0.15 - 0.30	8	*	3	2	4	
0.30 - 0.45	4	6	3	2	2	
0.45 - 0.60	4	13	4	3	10	
0.60 - 0.75	7	22	4	3	22	
0.75 - 0.90	6	Refusal	9	4	Refusal	
0.90 - 1.05	10		12	5		
1.05 - 1.20	22		22	4		
1.20 - 1.35	Refusal		Refusal	4		
1.35 - 1.50				5		
1.50 - 1.65				4		
1.65 - 1.80				3		
1.80 - 1.95				3		
1.95 - 2.10				3		
2.10 - 2.25				4		
2.25 - 2.40				7		
2.40 - 2.55				10		
2.55 - 2.70				22		
2.70 - 2.85				Refusal		
2.85 - 3.00						
3.00 - 3.15						
3.15 - 3.30						
3.30 - 3.45						
3.45 - 3.60						
3.60 - 3.75						

Remarks: * Pre drilled prior to testing

Approved Signatory.....
Technician: JK
Orlando Mendoza - Laboratory Manager

E1. CLASSIFICATION OF SOILS

E1.1 Soil Classification and the Unified System

An assessment of the site conditions usually includes an appraisal of the data available by combining values of engineering properties obtained by the site investigation with descriptions, from visual observation of the materials present on site.

The system used by SMEC in the identification of soil is the Unified Soil Classification system (USC) which was developed by the US Army Corps of Engineers during World War II and has since gained international acceptance and has been adopted in its metricated form by the Standards Association of Australia.

The Australian Site Investigation Code (AS1726-1981, Appendix D) recommends that the description of a soil includes the USC group symbols which are an integral component of the system.

The soil description should contain the following information in order:

Soil composition

- SOIL NAME and USC classification symbol (IN BLOCK LETTERS)
- plasticity or particle characteristics
- colour
- secondary and minor constituents (name estimated proportion, plasticity or particle characteristics, colour

Soil condition

- moisture condition
- consistency or density index

Soil structure

- structure (zoning, defects, cementing)

Soil origin

interpretation based on observation eg FILL, TOPSOIL, RESIDUAL, ALLUVIUM.

E1.2 Soil Composition

(a) Soil Name and Classification Symbol

The USC system is summarised in Figure E1.2.1. The primary division separates soil types on the basis of particle size into:

- Coarse grained soils - more than 50% of the material less than 60 mm is larger than 0.06 mm (60 µm).
- Fine grained soils - more than 50% of the material less than 60 mm is smaller than 0.06 mm (60 µm).

Initial classification is by particle size as shown in Table E1.2.1. Further classification of fine grained soils is based on plasticity.

TABLE E1.2.1 - CLASSIFICATION BY PARTICLE SIZE

NAME	SUB-DIVISION	SIZE
Clay (1)		< 2 µm
Silt (2)		2 µm to 60 µm
Sand	Fine Medium Coarse	60 µm to 200 µm 200 µm to 600 µm 600 µm to 2 mm
Gravel (3)	Fine Medium Coarse	2 mm to 6 mm 6 mm to 20 mm 20 mm to 60 mm
Cobbles (3)		60 mm to 200 mm
Boulders (3)		> 200 mm

Where a soil contains an appropriate amount of secondary material, the name includes each of the secondary components (greater than 12%) in increasing order of significance, eg sandy silty clay.

Minor components of a soil are included in the description by means of the terms “some” and “trace” as defined in Table E1.2.2.

TABLE E1.2.2 - MINOR SOIL COMPONENTS

TERM	DESCRIPTION	APPROXIMATE PROPORTION (%)
Trace	presence just detectable, little or no influence on soil properties	0-5
Some	presence easily detectable, little influence on soil properties	5-12

The USC group symbols should be included with each soil description as shown in Table E1.2.3

TABLE E1.2.3 - SOIL GROUP SYMBOLS

SOIL TYPE	PREFIX
Gravel	G
Sand	S
Silt	M
Clay	C
Organic	O
Peat	Pt

The group symbols are combined with qualifiers which indicate grading, plasticity or secondary components as shown on Table E1.2.4

TABLE E1.2.4 - SOIL GROUP QUALIFIERS

SUBGROUP	SUFFIX
Well graded	W
Poorly Graded	P
Silty	M
Clayey	C
Liquid Limit <50% - low to medium plasticity	L
Liquid Limit >50% - medium to high plasticity	H

(b) Grading

"Well graded" Good representation of all particle sizes from the largest to the smallest.

"Poorly graded" One or more intermediate sizes poorly represented

"Gap graded" One or more intermediate sizes absent

"Uniformly graded" Essentially single size material.

(c) Particle shape and texture

The shape and surface texture of the coarse grained particles should be described.

Angularity may be expressed as "rounded", "sub-rounded", "sub-angular" or "angular".

Particle **form** can be "equidimensional", "flat" or elongate".

Surface texture can be "glassy", "smooth", "rough", pitted" or striated".

(d) Colour

The colour of the soil should be described in the moist condition using simple terms such as:

Black White Grey Red
Brown Orange Yellow Green
Blue

These may be modified as necessary by "light" or "dark". Borderline colours may be described as a combination of two colours, eg red-brown.

For soils that contain more than one colour terms such as:

- Speckled Very small (<10 mm dia) patches
- Mottled Irregular
- Blotched Large irregular (>75 mm dia)
- Streaked Randomly oriented streaks

(e) Minor Components

Secondary and minor components should be individually described in a similar manner to the dominant component.

E1.3 ***S****oil Condition*

(a) Moisture

Soil moisture condition is described as "dry", "moist" or "wet".

The moisture categories are defined as:
Dry (D) - Little or no moisture evident. Soils are running.
Moist (M) - Darkened in colour with cool feel. Granular soil particles tend to adhere. No free water evident upon remoulding of cohesive soils.

In addition the moisture content of cohesive soils can be estimated in relation to their liquid or plastic limit.

(b) Consistency

Estimates of the consistency of a clay or silt soil may be made from manual examination, hand penetrometer test, SPT results or from laboratory tests to determine undrained shear or unconfined compressive strengths. The classification of consistency is defined in Table E1.3.1.

TABLE E1.3.1 - CONSISTENCY OF FINE-GRAINED SOILS

TERM	UNCONFINED STRENGTH (kPa)	FIELD IDENTIFICATION
Very Soft	<25	Easily penetrated by fist. Sample exudes between fingers when squeezed in the fist.
Soft	25 - 50	Easily moulded in fingers. Easily penetrated 50 mm by thumb.
Firm	50 - 100	Can be moulded by strong pressure in the fingers. Penetrated only with great effort.
Stiff	100 - 200	Cannot be moulded in fingers. Indented by thumb but penetrated only with great effort.
Very Stiff	200 - 400	Very tough. Difficult to cut with knife. Readily indented with thumb nail.
Hard	>400	Brittle, can just be scratched with thumb nail. Tends to break into fragments.

Unconfined compressive strength as derived by a hand penetrometer can be taken as approximately double the undrained shear strength ($q_u = 2\ c_u$).

(c) Density Index

The insitu density index of granular soils can be assessed from the results of SPT or cone penetrometer tests. Density index should not be estimated visually.

TABLE E1.3.2 - DENSITY OF GRANULAR SOILS

TERM	SPT N VALUE	STATIC CONE VALUE q_c (MPa)	DENSITY INDEX (%)
Very Loose	0 - 3	0 - 2	0 - 15
Loose	3 - 8	2 - 5	15 - 35
Medium Dense	8 - 25	5 - 15	35 - 65
Dense	25 - 42	15 - 20	65 - 85
Very Dense	>42	>20	>85

E1.4 Soil Structure

(a) Zoning

A sample may consist of several zones differing in colour, grain size or other properties. Terms to classify these zones are:

Layer - continuous across exposure or sample
Lens - discontinuous with lenticular shape
Pocket - irregular inclusion
Each zone should be described, their distinguishing features, and the nature of the interzone boundaries.

(b) Defects

Defects which are present in the sample can include:

- fissures
- roots (containing organic matter)
- tubes (hollow)
- casts (infilled)

Defects should be described giving details of dimensions and frequency. Fissure orientation, planarity, surface condition and infilling should be noted. If there is a tendency to break into blocks, block dimensions should be recorded

E1.5 Soil Origin

Information which may be interpretative but which may contribute to the usefulness of the material description should be included. The most common interpreted feature is the origin of the soil. The assessment of the probable origin is based on the soil material description, soil structure and its relationship to other soil and rock materials.

Common terms used are:

“Residual Soil” - Material which appears to have been derived by weathering from the underlying rock. There is no evidence of transport.

“Colluvium” - Material which appears to have been transported from its original location. The method of movement is usually the combination of gravity and erosion.

“Landslide Debris” - An extreme form of colluvium where the soil has been transported by mass movement. The material is obviously distributed and contains distinct defects related to the slope failure.

“Alluvium” - Material which has been transported essentially by water. usually associated with former stream activity.

“Fill” - Material which has been transported and placed by man. This can range from natural soils which have been placed in a controlled manner in engineering construction to dumped waste material. A description of the constituents should include an assessment of the method of placement.

E1.6 Fine Grained Soils

The physical properties of fine grained soils are dominated by silts and clays.

The definition of clay and silt soils is governed by their Atterberg Limits. Clay soils are characterised by the properties of cohesion and plasticity with cohesion defines as the ability to deform without rupture. Silts exhibit cohesion but have low plasticity or are non-plastic.

The field characteristics of clay soils include:

- dry lumps have appreciable dry strength and cannot be powdered
- volume changes occur with moisture content variation
- feels smooth when moist with a greasy appearance when cut.

The field characteristics of silt soils include:

- dry lumps have negligible dry strength and can be powdered easily
- dilatancy - an increase in volume due to shearing - is indicted by the presence of a shiny film of water after a hand sample is shaken. The water disappears upon remoulding. Very fine grained sands may also exhibit dilatancy.
- low plasticity index
- feels gritty to the teeth

E1.7 Organic Soils

Organic soils are distinguished from other soils by their appreciable content of vegetable matter, usually derived from plant remains.

The soil usually has a distinctive smell and low bulk density.

The USC system uses the symbol Pt for partly decomposed organic material. The O symbol is combined with suffixes “O” or “H” depending on plasticity.

Where roots or root fibres are present their frequency and the depth to which they are encountered should be recorded. The presence of roots or root fibres does not necessarily mean the material is an “organic material” by classification.

Coal and lignite should be described as such and not simply as organic matter.

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APPENDIX B – LABORATORY TEST RESULTS

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES1938108**	Page	: 1 of 5
Client	: **STS Geotechnics**	Laboratory	: Environmental Division Sydney
Contact	: Enquiries	Contact	: Customer Services ES
Address	: Unit 14/1 Cowpasture Place Wetherill Park 2164	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: ----	Telephone	: +61-2-8784 8555
Project	: 30055/30084/30090/30125/30060	Date Samples Received	: 19-Nov-2019 10:30
Order number	: E-2019-1045	Date Analysis Commenced	: 21-Nov-2019
C-O-C number	: ----	Issue Date	: 22-Nov-2019 17:23
Sampler	: ----		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 11		
No. of samples analysed	: 11		

Accreditation No. 825
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ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ED045G: LOR raised for Chloride on various samples due to sample matrix.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	30055/6034	30055/6041	30055/6042	30055/6043	30084/S1
				Client sampling date / time	18-Nov-2019 00:00	18-Nov-2019 00:00	18-Nov-2019 00:00	18-Nov-2019 00:00	18-Nov-2019 00:00
Compound	CAS Number	LOR	Unit		ES1938108-001	ES1938108-002	ES1938108-003	ES1938108-004	ES1938108-005
					Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)									
pH Value	----	0.1	pH Unit		**6.9**	**7.4**	**5.2**	**6.4**	**6.0**
EA010: Conductivity (1:5)									
Electrical Conductivity @ 25°C	----	1	µS/cm		**61**	**273**	**74**	**91**	**39**
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	0.1	%		**7.3**	**11.3**	**17.4**	**6.1**	**18.6**
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**10**	**280**	**10**	**50**	**110**
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg		**----**	**----**	**----**	**----**	<200

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	30090/S1	30090/S2	30125/S1	30125/S2	30060/1006
			Client sampling date / time	18-Nov-2019 00:00	18-Nov-2019 00:00	18-Nov-2019 00:00	18-Nov-2019 00:00	18-Nov-2019 00:00
Compound	CAS Number	LOR	Unit	ES1938108-006	ES1938108-007	ES1938108-008	ES1938108-009	ES1938108-010
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**5.9**	**7.2**	**5.7**	**5.4**	**6.0**
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**35**	**86**	**83**	**77**	**28**
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**6.2**	**27.1**	**16.0**	**16.9**	**13.7**
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**20**	**160**	**70**	**70**	**10**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	**40**	<200	<10	**20**	**----**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	30060/1010	----	----	----	----
			Client sampling date / time	18-Nov-2019 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	ES1938108-011	--------	--------	--------	--------
				Result	----	----	----	----
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**7.6**	----	----	----	----
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**420**	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**8.9**	----	----	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**180**	----	----	----	----