GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

GEOTECHNICAL INVESTIGATION & ACID SULFATE SOILS ASSESSMENT

FOR

NSW LAND & HOUSING CORPORATION

67 – 69 Pioneer Road & 28 – 30 Bramsen Street, Bellambi, New South Wales

Report No: 20/0652

Project No: 30282/3472D-G

March 2020

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1. INTRODUCTION

This report presents the results of a combined Geotechnical Investigation & Acid Sulfate Soils assessment carried out by STS Geotechnics Pty Limited (STS) for a proposed new residential development to be constructed at 67 – 69 Pioneer Road & 28 – 30 Bramsen Street, Bellambi. At the time of writing this report STS were not provided with architectural drawings for the project, however we understand the development will typically comprise the demolition of existing dwellings and construction of one to two level residential unit type buildings. The development will not include basement levels.

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,
- comment on soil aggressiveness to buried steel and concrete,
- undertake an Acid Sulfate Soils Assessment, and
- assess the requirement for an Acid Sulfate Soils Management Plan.

The investigation was undertaken at the request of Land and Housing Corporation NSW.

Our scope of work did not include a contamination assessment.

2. NATURE OF THE INVESTIGATION

2.1. Fieldwork

The fieldwork consisted of drilling six (6) boreholes numbered BH1 to BH6, at the locations shown on Drawing No. 20/0652. The boreholes were drilled using a track mounted Mini Christie drilling rig owned and operated by STS. Soils and weathered bedrock were drilled using rotary solid flight augers. Soil strengths were determined by undertaking Dynamic Cone Penetrometer (DCP) tests at each borehole location. In order to monitor groundwater levels PVC standpipe piezometers were installed in BH2 and BH6.

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 assist with determining the site classification, shrink swell index tests were carried out on representative samples retrieved from the site.

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

- pH,
- Sulphate content (SO_4),
- Chloride content (CL), and
- Electrical Conductivity (EC)

Based on field observations, six soil samples were also selected for laboratory analysis for the Acid Sulfate Soils assessment. The samples were dispatched to Australian Laboratory Services (ALS) for analysis using the Suspension Peroxide Oxidation Combined Acidity and Sulphate (SPOCAS) method. The method allows both a measure of the existing and potential acidity.

Detailed test reports are given in Appendix B.

3. GEOLOGY AND SITE CONDITIONS

The Wollongong geological series sheet at a scale of 1:50,000 indicates that the site is underlain by Permian Age bedrock of the Pheasants Nest Formation (Cumberland Subgroup). Bedrock within this formation comprise interbedded lithic sandstone, coal, claystone and siltstone.

The site is irregular in shape with a combined area of approximately 1,400 m^2. At the time of the fieldwork, the site was occupied by a series of single level fibro clad residential dwellings with strip concrete driveways and sheds. Site vegetation comprised grass, trees and shrubs.

The ground surface falls approximately 1.5 metre to the south-east.

To the south and west of the site are Bramsen Street and Pioneer Road respectively and to the remaining sides are single storey residential dwellings.

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 and fill overlying natural silty clays. Topsoil and fill materials were encountered to approximate depths of 0.2 – 0.5 metres. Natural silty clays were encountered below the topsoil and fill materials to the termination depth of 3.0 metres. The clays were assessed to be firm becoming stiff and very stiff with depth. The firm clays typically extend to depths of 0.8 to 1.5 metres.

Groundwater was not observed during auger drilling of the boreholes. Two weeks later the water level in the piezometer in BH6 was remeasured at a depth of 2.4 metres whist the piezometer in BH2 remained dry.

5. GEOTECHNICAL DISCUSSION

5.1. Site Classification to AS2870

In order to assist with determining the site classification, shrink swell index tests were carried out on representative samples retrieved from the site. The detailed test reports are attached and are summarised in Table 5.1 below:

Table 5.1 – Shrink Swell Summary Table

Location	Depth (m)	Material Description	Shrink/Swell Index (% per ΔpF)
BH2	0.6 – 0.8	Red brown with grey silty clay	3.7
BH4	0.5 – 0.8	Orange brown with red brown silty clay	2.2
BH4	1.0 – 1.2	Red brown with grey silty clay	3.4
BH6	0.6 – 0.8	Orange brown with red brown silty clay	4.3

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, the site is classified *a problem site (P).* However, provided the recommendations given below are adopted and the footings bear in the underlying natural soils, the site may be reclassified *Highly Reactive (H1).*

Foundation design and construction consistent with this classification shall be adopted as specified in the above referenced standard and in accordance with the following design details.

5.2. Foundation Design

The existing topsoil and fill materials should not be relied upon for foundation support. Footings that bear in the firm natural clayey soils below any topsoil, fill or soft clays may be proportioned using an allowable bearing pressure of 70 kPa. This value may be increased to 100 kPa in firm to stiff natural soils. The minimum depth of founding must comply with the requirements of AS2870-2011. The structural designer should be aware that the standard designs given in AS2870 assume a minimum allowable bearing pressure of 100 kPa.

In order to overcome the presence of trees, the foundations should be designed in accordance with the procedures given in Appendices H and CH of AS2870-2011. Tree information is attached.

Should a higher bearing pressure be required then piles can be used. Piles founded in very stiff clays may be proportioned using an allowable bearing pressure of 450 kPa, provided the depth to diameter ratio of the pile exceeds a value of 4. An allowable adhesion of 20 kPa may be adopted for the portion of the shaft within the natural soils.

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.

5.3. 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	5.8	110	160	0.030	0.2
S2	BH3	0.3	5.3	100	60	0.058	0.4

The report results range between:

- pH - 5.3 and 5.8
- soluble SO_4 - 100 and 110 mg/kg (ppm)
- soluble Cl - 60 and 160 mg/kg (ppm)
- EC_e - 0.2 and 0.4 dS/m

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

A review of the durability aspects indicates that:

- pH : minimum value of 5.3
- SO_4 : maximum value of 110 mg/kg (ppm) < 5000 ppm
- Cl : maximum value of 160 mg/kg (ppm) < 5000 ppm
- EC_e : maximum value of 0.4 dS/m

The exposure classification for the onsite soils is non-aggressive for steel and mildly aggressive to concrete in accordance with AS2159-2009. The soils are classified as A2 in accordance with AS2870-2011.

Reference to DLWC (2002) "Site Investigations for Urban Salinity" indicates that EC_e values of 0.2 dS/m to 0.4 dS/m are consistent with the presence of non-saline soils.

6. ACID SULFATE SOIL ASSESSMENT

6.1. Introduction

ASS are the common name given to sediments and soils containing iron sulfides which, when exposed to oxygen generate sulfuric acid. Natural processes formed the majority of acid sulfate sediments when certain conditions existed in the Holocene geological period (the last 10,000 years). Formation conditions require the presence of iron-rich sediments, sulfate (usually from seawater), removal of reaction products such as bicarbonate, the presence of sulfate reducing bacteria and a plentiful supply of organic matter. It should be noted that these conditions exist in mangroves, salt marsh vegetation or tidal areas, and at the bottom of coastal rivers and lakes.

The relatively specific conditions under which acid sulfate soils are formed usually limit their occurrence to low lying parts of coastal floodplains, rivers and creeks. This includes areas with saline or brackish water such as deltas, coastal flats, backswamps and seasonal or permanent freshwater swamps that were formerly brackish. Due to flooding and stormwater erosion, these sulfidic sediments may continue to be re-distributed through the sands and sediments of the estuarine floodplain region. Sulfidic sediment may be found at any depth in suitable coastal sediments – usually beneath the water table.

Any lowering in the water table that covers and protects potential ASS will result in their aeration and the exposure of iron sulfide sediments to oxygen. The lowering in the water table can occur naturally due to seasonal fluctuations and drought or any human intervention, when carrying out any excavations during site development. Potential ASS can also be the exposed to air during physical disturbance with the material at the disturbance face, as well as the extracted material, both potentially being oxidised. The oxidation of iron sulfide sediments in potential ASS results in ASS soils.

Successful management of areas with ASS is possible but must take into account the specific nature of the site and the environmental consequences of development. While it is preferable that sites exhibiting acid sulfate characteristics not be disturbed, management techniques have been devised to minimise and manage impacts in certain circumstances.

When works involving the disturbance of soil or the change of groundwater levels are proposed in coastal areas, a preliminary assessment should be undertaken to determine whether acid sulfate soils are present and if the proposed works are likely to disturb these soils.

6.2. Presence of ASS

Reference to the Bulli ASS Risk Map indicates the property is within an area designated as Disturbed Terrain. It should be noted that maps are a guide only.

The following geomorphic or site criteria are normally used to determine if acid sulfate soils are likely to be present:

- sediments of recent geological age (Holocene)
- soil horizons less than 5 in AHD
- marine or estuarine sediments and tidal lakes
- in coastal wetlands or back swamp areas

6.3. Assessment

Some of the site and geomorphic criteria noted above apply to the site.

In order to assess the significance of the ASS potential, the laboratory results carried out were compared to action criteria contained in ASSM (1998) summarised in Table 6.1. The action criteria trigger the need to prepare an ASSMP and are based on the percentage of oxidisable sulphur (or equivalent TPA and TSA) for broad categories of soil types. Works in soils that exceed these action criteria must prepare a management plan and obtain development consent.

As the soils encountered on the site primarily consisted of sands, the coarse texture grade criteria are the most appropriate and have been adopted for this assessment.

Table 6.1 – ASS Action Criteria

Type of material		Action Criteria if 1-1000 tonnes ASS disturbed		Action Criteria if more than 1000 tonnes ASS disturbed	
Texture Range (McDonald et al 1990)	**Approx. clay content (%<0.02mm)**	**Sulphur Trail %S oxidisable (oven dry basis) eg S_{TOS} or S_{POS}**	**Acid Trail Mol H^+/tonne (oven dry basis) eg TPA or TSA_S**	**Sulphur Trail %S oxidisable (oven dry basis) eg S_{TOS} or S_{POS}**	**Acid Trail Mol H^+/tonne (oven dry basis) eg TPA or TSA_S**
Coarse Texture (CT) Sands to loamy sands	≥5	0.03	18	0.03	18
Medium Texture (MT) Sandy loams to light clays	5-50	0.06	36	0.03	18
Fine Texture (FT) Medium to heavy clays and silty clays	≥40	0.1	62	0.03	18

The laboratory test results are summarised in relation to the action criteria in Table 6.2.

Table 6.2 – SPOCAS TEST RESULTS SUMMARY

Analysis	Unit	LOR	ASS1	ASS2	ASS3	ASS4	ASS5	ASS6	Action Criteria[1] <1000 tonnes disturbed
pH After Oxidation	NA	0.1	4.4	4.4	4.7	4.9	4.1	4.7	<3 (high risk)
S (POS)	%	0.02	<0.02	<0.02	<0.02	<0.02	0.024	0.026	0.1
TPA	mole/tonne	2	174	188	149	62	187	134	62
TSA	Mole/tonne	2	76	38	22	42	50	26	62

1 = ASSMAC (1998)

= Action Criteria Exceeded

The results of the soil sample analyses are compared to the above criteria in Table 6.1 and the analytical laboratory reports for the testing performed are provided in Appendix B.

The results show that the peroxide oxidisable sulfur (POS) percentages are less than the action criteria value. The majority of the titratable peroxide acidity (TPA) and one of the titratable sulfidic acidity (TSA) concentrations measured in the samples are above the criterion of 62 mol H+/tonne. Because the peroxide oxidisable sulfur is below the detection limit, the "acid trail" recorded in these samples is due to something other than sulfur which means that ASS is not present.

Based on the above an ASS Management Plan will not be required provided onsite dewatering does not lower the groundwater level outside the site.

7. FINAL COMMENTS

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
STS Geotechnics Pty Limited

Matthew Green
Principal Engineering Geologist
STS Geotechnics Pty Limited

STS Geotechnics Pty. Ltd.	Scale: Unknown	Date: March 2020
Client: NSW LAND & HOUSING CORPORATION		
GEOTECHNICAL INVESTIGATION **67-69 PIONEER RD & 28-30 BRAMSEN ST, BELLAMBI** **BOREHOLE AND PENETROMETER LOCATIONS**	Project No. 30282/3472D-G Drawing No: 20/0652	

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.

APPENDIX A – BOREHOLE LOGS AND EXPLANATION SHEETS

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: NSW Land & Housing Corporation	Project / STS No. 30282/3472D-G	**BOREHOLE NO.: BH 1**
Project: 67-69 Pioneer Road and 28-30 Bramsen Street, Bellambi	Date: February 25, 2020	
Location: Refer to Drawing No. 20/0652	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 grey, medium plasticity, trace of gravel, (coal wash)	CL	SOFT	M
	S1 @ 0.4 m	0.5	SILTY CLAY: dark brown/orange brown, medium to high plasticity	CL/CH	FIRM	M
		1.0	SILTY CLAY: reds brown with light grey, high plasticity, trace of gravel	CH	FIRM	M
		1.5			FIRM TO STIFF	
		2.0			STIFF	
		2.5	SILTY CLAY: light grey with red brown and orange brown, high plasticity	CH	VERY STIFF	M
			BOREHOLE DISCONTINUED AT 3.0 M			

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: Mini Christie
Hole Diameter (mm): 100
Angle from Vertical (^{o}): 0
Drill Bit: Spiral

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: NSW Land & Housing Corporation	Project / STS No. 30282/3472D-G	**BOREHOLE NO.: BH 2**
Project: 67-69 Pioneer Road and 28-30 Bramsen Street, Bellambi	Date: February 25, 2020	
Location: Refer to Drawing No. 20/0652	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 CLAY: dark brown, medium plasticity	CL	SOFT	M
	ASS1 @ 0.5 m	0.5	SILTY CLAY: red brown/orange brown with light grey, medium to high plasticity	CL/CH	FIRM	M
	U50					
		1.0	SILTY CLAY: red brown with light grey, high plasticity	CH	FIRM	M
	ASS2 @ 1.5 m	1.5			FIRM TO STIFF	
					STIFF	
		2.0	SILTY CLAY: light grey with red brown, high plasticity	CH	VERY STIFF	M
	ASS3 @ 2.5 m	2.5	STANDPIPE PIEZOMETER INSTALLED			
			BOREHOLE DISCONTINUED AT 3.0 M			

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: Mini Christie
Hole Diameter (mm): 100
Angle from Vertical (^{o}): 0
Drill Bit: Spiral

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: NSW Land & Housing Corporation	Project / STS No. 30282/3472D-G	**BOREHOLE NO.: BH 3**
Project: 67-69 Pioneer Road and 28-30 Bramsen Street, Bellambi	Date: February 25, 2020	
Location: Refer to Drawing No. 20/0652	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
	S2 @ 0.3 m	0.5	TOPSOIL: SILTY CLAY: dark brown, medium plasticity	CL	SOFT	M
			SILTY CLAY: orange brown with red brown, medium to high plasticity	CL/CH	FIRM	M
		1.0	SILTY CLAY: red brown with light grey, high plasticity	CH	FIRM TO STIFF	M
		1.5			STIFF	
		2.0	SILTY CLAY: light grey with red brown and orange brown, high plasticity	CH	VERY STIFF	M
		2.5	BOREHOLE DISCONTINUED AT 3.0 M			

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: Mini Christie
Hole Diameter (mm): 100
Angle from Vertical (^{o}): 0
Drill Bit: Spiral

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: NSW Land & Housing Corporation	Project / STS No. 30282/3472D-G	**BOREHOLE NO.: BH 4**
Project: 67-69 Pioneer Road and 28-30 Bramsen Street, Bellambi	Date: February 25, 2020	
Location: Refer to Drawing No. 20/0652	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 CLAY: dark brown, medium plasticity	CL	SOFT TO FIRM	M
	S3 @ 0.5 m	0.5	SILTY CLAY: orange brown with red brown and light grey, medium to high plasticity	CL/CH	FIRM	M
	U50					
		1.0	SILTY CLAY: red brown with light grey, high plasticity	CH	FIRM	M
	U50					
					FIRM TO STIFF	
		1.5			STIFF	
		2.0				
		2.5	SILTY CLAY: light grey with red brown and orange brown, high plasticity	CH	VERY STIFF	M
			BOREHOLE DISCONTINUED AT 3.0 M			

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: Mini Christie
Hole Diameter (mm): 100
Angle from Vertical (^{o}): 0
Drill Bit: Spiral

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: NSW Land & Housing Corporation	Project / STS No. 30282/3472D-G	**BOREHOLE NO.:**	**BH 5**
Project: 67-69 Pioneer Road and 28-30 Bramsen Street, Bellambi	Date: February 25, 2020		
Location: Refer to Drawing No. 20/0652	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: GRAVELLY SILTY CLAY: dark brown with dark grey, medium plasticity, some gravel, (coal wash)	CL	SOFT	M
		0.5	SILTY CLAY: orange brown, medium to high plasticity	CL/CH	FIRM	M
					FIRM TO STIFF	
		1.0	SILTY CLAY: red brown with light grey, high plasticity	CH	FIRM TO STIFF	M
		1.5			STIFF	
			SILTY CLAY: light grey with red brown and orange brown, high plasticity	CH	VERY STIFF	M
		2.0				
		2.5				
			BOREHOLE DISCONTINUED AT 3.0 M			

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: Mini Christie
Hole Diameter (mm): 100
Angle from Vertical (^{o}): 0
Drill Bit: Spiral

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: NSW Land & Housing Corporation	Project / STS No. 30282/3472D-G	**BOREHOLE NO.: BH 6**
Project: 67-69 Pioneer Road and 28-30 Bramsen Street, Bellambi	Date: February 25, 2020	
Location: Refer to Drawing No. 20/0652	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
	ASS4/S4 @ 0.4 m	0.5	TOPSOIL: SILTY CLAY: dark grey, medium plasticity, trace of fine grained sand	CL	SOFT TO FIRM	M
	U50	1.0	SILTY CLAY: orange brown with red brown and light grey, medium to high plasticity	CL/CH	FIRM FIRM TO STIFF	M
	ASS5 @ 1.2 m	1.5	SILTY CLAY: red brown with light grey, high plasticity	CH	STIFF VERY STIFF	M
	ASS6 @ 2.5 m	2.0 2.5	SILTY CLAY: light grey with red brown, high plasticity STANDPIPE PIEZOMETER INSTALLED BOREHOLE DISCONTINUED AT 3.0 M	CH	VERY STIFF	M

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: Mini Christie
Hole Diameter (mm): 100
Angle from Vertical (°): 0
Drill Bit: Spiral

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GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

Dynamic Cone Penetrometer Test Report

Project: 67-69 PIONEER ROAD & 28-30 BRAMSEN STREET, BELLAMBI
Client: NSW LAND & HOUSING CORPORATION
Address: 31-39 Macquarie Street, Parramatta
Test Method: AS 1289.6.3.2

Project No.: 30282/3472D
Report No.: 20/0652
Report Date: 28/2/20202
Page: 1 of 1

NATA
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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	P6
Location	Refer to Drawing No. 20/0652	Refer to Drawing No. 20/0652	Refer to Drawing No. 20/0652	Refer to Drawing No. 20/0652	Refer to Drawing No. 20/0652	Refer to Drawing No. 20/0652
Date Tested	25/2/2020	25/2/2020	25/2/2020	25/2/2020	25/2/2020	25/2/2020
Starting Level	Surface Level	Surface Level	Surface Level	Surface Level	Surface Level	Surface Level
Depth (m)	Penetration Resistance (blows / 150mm)					
0.00 - 0.15	1	1	1	1	1	1
0.15 - 0.30	2	1	2	2	2	2
0.30 - 0.45	2	2	1	2	1	2
0.45 - 0.60	3	2	2	2	2	3
0.60 - 0.75	3	2	2	3	2	2
0.75 - 0.90	2	3	3	2	3	3
0.90 - 1.05	3	2	2	3	4	3
1.05 - 1.20	2	3	3	2	3	4
1.20 - 1.35	3	2	3	3	3	3
1.35 - 1.50	2	2	4	3	4	5
1.50 - 1.65	3	3	6	4	5	6
1.65 - 1.80	3	3	6	7	7	8
1.80 - 1.95	4	4	5	6	7	12
1.95 - 2.10	6	4	6	7	8	15
2.10 - 2.25	6	7	7	6	10	15
2.25 - 2.40	12	8	9	8	10	18
2.40 - 2.55	16	8	9	10	13	22
2.55 - 2.70	18	10	12	13	16	Refusal
2.70 - 2.85	22	11	13	15	22	
2.85 - 3.00	Refusal	13	15	15	Refusal	
3.00 - 3.15		Discontinued	Discontinued	Discontinued		
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

STS Geotechnics Pty Ltd
14/1 Cowpasture Place, Wetherill Park NSW 2164
Phone: (02)9756 2166 | Email: enquiries@stsgeo.com.au

GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

Tree Heights and Type

Project: 67-69 Pioneer Road & 28-30 Bramsen Street, Bellambi — Project No. / STS No.: 30282/3472D-G

Client: McDonald Jones Homes — Technician: JK

Tree No.	Canopy Radius (m)	Distance from Tree Along Ground (m)	Uphill / Level / Downhill	Height of Tree (m)	Native (Y / N)	Growing/Mature
T1-T5	5 - 6		L	8 - 10	Y	G
T6-T10	4 - 8		L-D	14 - 25	N	G-M
T11	4		L	9	Y	M
T12	3		U	5	Y	M
T13	3		U	7	Y	M

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 STS Geotechnics Pty Ltd (STS) 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.

APPENDIX B – LABORATORY TEST RESULTS

STS Geotechnics Pty Ltd
14/1 Cowpasture Place, Wetherill Park NSW 2164
Phone: (02)9756 2166 | Email: enquiries@stsgeo.com.au

GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

Shrink Swell Index Report

Project: 67 - 69 PIONEER ROAD & 28 - 30 BRAMSEN STREET, BELLAMBI
Client: LAND & HOUSING CORPORATION
Address: LEVEL 2, 31 - 39, MAQUARIE STREET, PARRAMATTA, 2150
Test Method: AS 1289 7.1.1

Project No.: 30282/3472D-L
Report No.: 20/0666
Report Date: 2/03/2020
Page: 1 OF 1

Sampling Procedure: AS 1289.1.3.1 Clause 3.1.3.2 - Thin Walled Sampler

STS / Sample No.		3472/1	3472/2	3472/3	3472/4		
Sample Location		Borehole 2 Refer to Drawing	Borehole 4 Refer to Drawing	Borehole 4 Refer to Drawing	Borehole 6 Refer to Drawing		
Material Description		Silty Clay, brown, red	Silty Clay, brown	Silty Clay, red, grey, trace of gravel	Silty Clay, brown, yellow		
Depth (m)		0.6 - 0.85	0.5 - 0.8	1.0 - 1.25	0.6 - 0.8		
Sample Date		25/02/2020	25/02/2020	25/02/2020	25/02/2020		
Shrink	Moisture Content (%)	40.5	39.6	33.9	39.1		
	Soil Crumbling	Nil	Nil	Nil	Nil		
	Extent of Cracking	Open Cracks	Open Cracks	Fine Cracks	Fine Cracks		
	Strain (%)	6.6	4.0	4.8	7.5		
Swell	Moisture Content Initial (%)	39.1	41.0	33.4	38.5		
	Moisture Content Final (%)	40.9	44.8	36.9	39.6		
	Strain (%)	0.0	0.0	0.0	0.0		
Inert Inclusions (%)		<5	<5	<5	<5		
Shrink Swell Index (%)		**3.7**	**2.2**	**2.7**	**4.2**		

Remarks:

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

Approved Signatory.....

Technician: DH

Orlando Mendoza - Laboratory Manager

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2006628**	Page	: 1 of 6
Amendment	: **1**		
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	: 30055/30315/30282	Date Samples Received	: 26-Feb-2020 12:15
Order number	: E-2020-0064	Date Analysis Commenced	: 27-Feb-2020
C-O-C number	: ----	Issue Date	: 02-Mar-2020 16:57
Sampler	: ----		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 16		
No. of samples analysed	: 16		

Accreditation No. 825
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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.

- Amendment (02/03/2020): This report has been amended following changes to the analytical data reported. The quality system is being utilised to resolve this issue. The specific data affected includes ED040S results.
- ED045G: LOR raised for Chloride on sample 11 due to sample matrix.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	30055/6296	30055/6303	30055/6304	30055/6307	30055/6308
				Client sampling date / time	25-Feb-2020 00:00	25-Feb-2020 00:00	25-Feb-2020 00:00	25-Feb-2020 00:00	25-Feb-2020 00:00
Compound	CAS Number	LOR	Unit		ES2006628-001	ES2006628-002	ES2006628-003	ES2006628-004	ES2006628-005
					Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)									
pH Value	----	0.1	pH Unit		**8.0**	**7.4**	**8.2**	**5.9**	**5.8**
EA010: Conductivity (1:5)									
Electrical Conductivity @ 25°C	----	1	µS/cm		**473**	**24**	**359**	**26**	**360**
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	0.1	%		**11.1**	**8.9**	**10.9**	**11.5**	**17.4**
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**260**	**20**	**90**	**50**	**300**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	30055/6310	30055/6311	30055/6314	30055/6318	30055/6326
				Client sampling date / time	25-Feb-2020 00:00	25-Feb-2020 00:00	25-Feb-2020 00:00	25-Feb-2020 00:00	25-Feb-2020 00:00
Compound	CAS Number	LOR	Unit		ES2006628-006	ES2006628-007	ES2006628-008	ES2006628-009	ES2006628-010
					Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)									
pH Value	----	0.1	pH Unit		**5.9**	**6.2**	**5.8**	**5.6**	**5.8**
EA010: Conductivity (1:5)									
Electrical Conductivity @ 25°C	----	1	µS/cm		**282**	**100**	**22**	**27**	**37**
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	0.1	%		**13.8**	**8.8**	**20.4**	**11.8**	**11.6**
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**150**	**60**	**50**	**40**	**50**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	30315/S1	30315/S2	30282/S1	30282/S2	30282/S3
				Client sampling date / time	25-Feb-2020 00:00	25-Feb-2020 00:00	25-Feb-2020 00:00	25-Feb-2020 00:00	25-Feb-2020 00:00
Compound	CAS Number	LOR	Unit		ES2006628-011	ES2006628-012	ES2006628-013	ES2006628-014	ES2006628-015
					Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)									
pH Value	----	0.1	pH Unit		**5.9**	**5.2**	**5.8**	**5.3**	**5.6**
EA010: Conductivity (1:5)									
Electrical Conductivity @ 25°C	----	1	µS/cm		**18**	**47**	**35**	**58**	**39**
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	0.1	%		**26.9**	**26.2**	**26.5**	**25.1**	**28.6**
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg		**120**	**90**	**110**	**100**	**110**
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg		<500	**20**	**160**	**60**	**120**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	30282/S4	----	----	----	----
				Client sampling date / time	25-Feb-2020 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	ES2006628-016	--------	--------	--------	--------	
				Result	----	----	----	----	
EA002: pH 1:5 (Soils)									
pH Value	----	0.1	pH Unit	**6.4**	----	----	----	----	
EA010: Conductivity (1:5)									
Electrical Conductivity @ 25°C	----	1	µS/cm	**24**	----	----	----	----	
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	0.1	%	**23.5**	----	----	----	----	
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**80**	----	----	----	----	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg	**200**	----	----	----	----	

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2008007**	Page	: 1 of 8
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	: 30282, 30055, 30060	Date Samples Received	: 09-Mar-2020 10:15
Order number	: E-2020-0077	Date Analysis Commenced	: 12-Mar-2020
C-O-C number	: ----	Issue Date	: 12-Mar-2020 17:22
Sampler	: ----		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 13		
No. of samples analysed	: 13		

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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*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

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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.

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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.

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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.

- ASS: EA029 (SPOCAS): Laboratory determinations of ANC needs to be corroborated by effectiveness of the measured ANC in relation to incubation ANC. Unless corroborated, the results of ANC testing should be discounted when determining Net Acidity for comparison with action criteria, or for the determination of the acidity hazard and required liming amounts.
- ASS: EA029 (SPOCAS): Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime ($CaCO_3$) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from kg/t dry weight to kg/m3 in-situ soil, multiply reported results x wet bulk density of soil in t/m3.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	30282/ASS1	30282/ASS2	30282/ASS3	30282/ASS4	30282/ASS5
			Client sampling date / time	06-Mar-2020 00:00	06-Mar-2020 00:00	06-Mar-2020 00:00	06-Mar-2020 00:00	06-Mar-2020 00:00
Compound	CAS Number	LOR	Unit	ES2008007-001	ES2008007-002	ES2008007-003	ES2008007-004	ES2008007-005
				Result	Result	Result	Result	Result
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	4.5	4.3	4.2	5.4	4.2
pH OX (23B)	----	0.1	pH Unit	4.4	4.4	4.7	4.9	4.1
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	97	150	127	20	137
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	174	188	149	62	187
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	76	38	22	42	50
sulfidic - Titratable Actual Acidity (s-23F)	----	0.020	% pyrite S	0.156	0.241	0.203	0.032	0.220
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.020	% pyrite S	0.278	0.302	0.239	0.099	0.299
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.020	% pyrite S	0.122	0.060	0.035	0.067	0.080
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.020	% S	0.023	0.066	0.038	<0.020	0.057
Peroxide Sulfur (23De)	----	0.020	% S	0.040	0.080	0.045	0.024	0.083
Peroxide Oxidisable Sulfur (23E)	----	0.020	% S	<0.020	<0.020	<0.020	0.024	0.026
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	10	mole H+ / t	10	<10	<10	15	16
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.020	% Ca	0.048	<0.020	<0.020	0.303	0.020
Peroxide Calcium (23Wh)	----	0.020	% Ca	0.053	<0.020	<0.020	0.315	0.020
Acid Reacted Calcium (23X)	----	0.020	% Ca	<0.020	<0.020	<0.020	<0.020	<0.020
acidity - Acid Reacted Calcium (a-23X)	----	10	mole H+ / t	<10	<10	<10	<10	<10
sulfidic - Acid Reacted Calcium (s-23X)	----	0.020	% S	<0.020	<0.020	<0.020	<0.020	<0.020
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	----	0.020	% Mg	0.048	0.074	0.100	0.052	0.048
Peroxide Magnesium (23Tm)	----	0.020	% Mg	0.052	0.074	0.100	0.053	0.050
Acid Reacted Magnesium (23U)	----	0.020	% Mg	<0.020	<0.020	<0.020	<0.020	<0.020
Acidity - Acid Reacted Magnesium (a-23U)	----	10	mole H+ / t	<10	<10	<10	<10	<10
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.020	% S	<0.020	<0.020	<0.020	<0.020	<0.020
EA029-G: Retained Acidity								
HCl Extractable Sulfur (20Be)	----	0.020	% S	----	0.085	0.056	----	0.076
Net Acid Soluble Sulfur (20Je)	----	0.020	% S	----	<0.020	<0.020	----	<0.020
acidity - Net Acid Soluble Sulfur (a-20J)	----	10	mole H+ / t	----	<10	<10	----	<10
sulfidic - Net Acid Soluble Sulfur (s-20J)	----	0.020	% pyrite S	----	<0.020	<0.020	----	<0.020

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	30282/ASS1	30282/ASS2	30282/ASS3	30282/ASS4	30282/ASS5
				Client sampling date / time	06-Mar-2020 00:00	06-Mar-2020 00:00	06-Mar-2020 00:00	06-Mar-2020 00:00	06-Mar-2020 00:00
Compound	CAS Number	LOR	Unit		ES2008007-001	ES2008007-002	ES2008007-003	ES2008007-004	ES2008007-005
					Result	Result	Result	Result	Result
EA029-H: Acid Base Accounting									
ANC Fineness Factor	----	0.5	-		**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S		**0.17**	**0.27**	**0.22**	**0.06**	**0.26**
Net Acidity (acidity units)	----	10	mole H+ / t		**108**	**168**	**139**	**35**	**162**
Liming Rate	----	1	kg CaCO3/t		**8**	**13**	**10**	**3**	**12**
Net Acidity excluding ANC (sulfur units)	----	0.02	% S		**0.17**	**0.27**	**0.22**	**0.06**	**0.26**
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t		**108**	**168**	**139**	**35**	**162**
Liming Rate excluding ANC	----	1	kg CaCO3/t		**8**	**13**	**10**	**3**	**12**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	30282/ASS6	30055/6342	30055/6343	30055/6351	30055/6355
			Client sampling date / time	06-Mar-2020 00:00	06-Mar-2020 00:00	06-Mar-2020 00:00	06-Mar-2020 00:00	06-Mar-2020 00:00
Compound	CAS Number	LOR	Unit	ES2008007-006	ES2008007-007	ES2008007-008	ES2008007-009	ES2008007-010
				Result	Result	Result	Result	Result
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	**4.1**	**4.2**	**5.5**	**5.5**	**6.3**
pH OX (23B)	----	0.1	pH Unit	**4.7**	**4.9**	**5.0**	**5.0**	**5.8**
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	**108**	**87**	**8**	**9**	<2
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	**134**	**122**	**16**	<2	<2
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	**26**	**34**	**8**	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.020	% pyrite S	**0.172**	**0.140**	<0.020	<0.020	<0.020
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.020	% pyrite S	**0.215**	**0.195**	**0.026**	<0.020	<0.020
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.020	% pyrite S	**0.042**	**0.055**	<0.020	<0.020	<0.020
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.020	% S	**0.037**	**0.036**	<0.020	<0.020	<0.020
Peroxide Sulfur (23De)	----	0.020	% S	**0.040**	**0.046**	<0.020	<0.020	<0.020
Peroxide Oxidisable Sulfur (23E)	----	0.020	% S	<0.020	<0.020	<0.020	<0.020	<0.020
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	10	mole H+ / t	<10	<10	<10	<10	<10
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.020	% Ca	<0.020	**0.033**	**0.129**	**0.121**	**0.215**
Peroxide Calcium (23Wh)	----	0.020	% Ca	<0.020	**0.033**	**0.129**	**0.127**	**0.225**
Acid Reacted Calcium (23X)	----	0.020	% Ca	<0.020	<0.020	<0.020	<0.020	<0.020
acidity - Acid Reacted Calcium (a-23X)	----	10	mole H+ / t	<10	<10	<10	<10	<10
sulfidic - Acid Reacted Calcium (s-23X)	----	0.020	% S	<0.020	<0.020	<0.020	<0.020	<0.020
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	----	0.020	% Mg	**0.090**	**0.148**	**0.026**	**0.074**	**0.024**
Peroxide Magnesium (23Tm)	----	0.020	% Mg	**0.090**	**0.148**	**0.026**	**0.074**	**0.024**
Acid Reacted Magnesium (23U)	----	0.020	% Mg	<0.020	<0.020	<0.020	<0.020	<0.020
Acidity - Acid Reacted Magnesium (a-23U)	----	10	mole H+ / t	<10	<10	<10	<10	<10
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.020	% S	<0.020	<0.020	<0.020	<0.020	<0.020
EA029-G: Retained Acidity								
HCl Extractable Sulfur (20Be)	----	0.020	% S	**0.044**	**0.055**	----	----	----
Net Acid Soluble Sulfur (20Je)	----	0.020	% S	<0.020	<0.020	----	----	----
acidity - Net Acid Soluble Sulfur (a-20J)	----	10	mole H+ / t	<10	<10	----	----	----
sulfidic - Net Acid Soluble Sulfur (s-20J)	----	0.020	% pyrite S	<0.020	<0.020	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	30282/ASS6	30055/6342	30055/6343	30055/6351	30055/6355
				Client sampling date / time	06-Mar-2020 00:00	06-Mar-2020 00:00	06-Mar-2020 00:00	06-Mar-2020 00:00	06-Mar-2020 00:00
Compound	CAS Number	LOR	Unit		ES2008007-006	ES2008007-007	ES2008007-008	ES2008007-009	ES2008007-010
					Result	Result	Result	Result	Result
EA029-H: Acid Base Accounting									
ANC Fineness Factor	----	0.5	-		**1.5**	**1.5**	**1.5**	**1.5**	**1.5**
Net Acidity (sulfur units)	----	0.02	% S		**0.18**	**0.16**	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t		**112**	**102**	<10	<10	<10
Liming Rate	----	1	kg CaCO3/t		**8**	**8**	<1	<1	<1
Net Acidity excluding ANC (sulfur units)	----	0.02	% S		**0.18**	**0.16**	<0.02	<0.02	<0.02
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t		**112**	**102**	<10	<10	<10
Liming Rate excluding ANC	----	1	kg CaCO3/t		**8**	**8**	<1	<1	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	30055/6368	30055/6365	30060/1098	----	----
			Client sampling date / time	06-Mar-2020 00:00	06-Mar-2020 00:00	06-Mar-2020 00:00	----	----
Compound	CAS Number	LOR	Unit	ES2008007-011	ES2008007-012	ES2008007-013	--------	--------
				Result	Result	Result	----	----
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	**5.6**	**8.2**	**4.4**	----	----
pH OX (23B)	----	0.1	pH Unit	**4.2**	**8.0**	**4.8**	----	----
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	**7**	<2	**72**	----	----
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	**75**	<2	**105**	----	----
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	**68**	<2	**33**	----	----
sulfidic - Titratable Actual Acidity (s-23F)	----	0.020	% pyrite S	<0.020	<0.020	**0.115**	----	----
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.020	% pyrite S	**0.120**	<0.020	**0.168**	----	----
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.020	% pyrite S	**0.110**	<0.020	**0.053**	----	----
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.020	% S	<0.020	**0.020**	**0.020**	----	----
Peroxide Sulfur (23De)	----	0.020	% S	<0.020	**0.023**	**0.026**	----	----
Peroxide Oxidisable Sulfur (23E)	----	0.020	% S	<0.020	<0.020	<0.020	----	----
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	10	mole H+ / t	<10	<10	<10	----	----
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.020	% Ca	**0.094**	**0.466**	**0.075**	----	----
Peroxide Calcium (23Wh)	----	0.020	% Ca	**0.095**	**0.886**	**0.075**	----	----
Acid Reacted Calcium (23X)	----	0.020	% Ca	<0.020	**0.420**	<0.020	----	----
acidity - Acid Reacted Calcium (a-23X)	----	10	mole H+ / t	<10	**209**	<10	----	----
sulfidic - Acid Reacted Calcium (s-23X)	----	0.020	% S	<0.020	**0.336**	<0.020	----	----
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	----	0.020	% Mg	**0.034**	**0.106**	**0.125**	----	----
Peroxide Magnesium (23Tm)	----	0.020	% Mg	**0.035**	**0.109**	**0.125**	----	----
Acid Reacted Magnesium (23U)	----	0.020	% Mg	<0.020	<0.020	<0.020	----	----
Acidity - Acid Reacted Magnesium (a-23U)	----	10	mole H+ / t	<10	<10	<10	----	----
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.020	% S	<0.020	<0.020	<0.020	----	----
EA029-F: Excess Acid Neutralising Capacity								
Excess Acid Neutralising Capacity (23Q)	----	0.020	% CaCO3	----	**1.74**	----	----	----
acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t	----	**347**	----	----	----
sulfidic - Excess Acid Neutralising Capacity (s-23Q)	----	0.020	% S	----	**0.556**	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	30055/6368	30055/6365	30060/1098	----	----
				Client sampling date / time	06-Mar-2020 00:00	06-Mar-2020 00:00	06-Mar-2020 00:00	----	----
Compound	CAS Number	LOR	Unit		ES2008007-011	ES2008007-012	ES2008007-013	--------	--------
					Result	Result	Result	----	----
EA029-F: Excess Acid Neutralising Capacity - Continued									
EA029-G: Retained Acidity									
HCl Extractable Sulfur (20Be)	----	0.020	% S		**----**	**----**	**0.028**	**----**	**----**
Net Acid Soluble Sulfur (20Je)	----	0.020	% S		**----**	**----**	<0.020	**----**	**----**
acidity - Net Acid Soluble Sulfur (a-20J)	----	10	mole H+ / t		**----**	**----**	<10	**----**	**----**
sulfidic - Net Acid Soluble Sulfur (s-20J)	----	0.020	% pyrite S		**----**	**----**	<0.020	**----**	**----**
EA029-H: Acid Base Accounting									
ANC Fineness Factor	----	0.5	-		**1.5**	**1.5**	**1.5**	**----**	**----**
Net Acidity (sulfur units)	----	0.02	% S		<0.02	<0.02	**0.13**	**----**	**----**
Net Acidity (acidity units)	----	10	mole H+ / t		<10	<10	**79**	**----**	**----**
Liming Rate	----	1	kg CaCO3/t		<1	<1	**6**	**----**	**----**
Net Acidity excluding ANC (sulfur units)	----	0.02	% S		<0.02	<0.02	**0.13**	**----**	**----**
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t		<10	<10	**79**	**----**	**----**
Liming Rate excluding ANC	----	1	kg CaCO3/t		<1	<1	**6**	**----**	**----**