

# GEOTECHNICAL INVESTIGATION

## FOR

# NSW LAND AND HOUSING CORPORATION

*17-27 Hardwicke Street, Riverwood, New South Wales (BGZLN)*

*Report No: 23/0234*

*Project No: 32062/7123D-G*

*February 2023*

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DRAWING NO. 23/0234 – BOREHOLE AND PENETROMETER LOCATIONS

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## 1. INTRODUCTION

This report presents the results of a Geotechnical Investigation carried out by STS Geotechnics Pty Limited (STS) for the proposed new residential development to be constructed at 17-27 Hardwicke Street, Riverwood, New South Wales. At the time of writing this report STS were not provided with architectural drawings for the project. The report has been prepared assuming site development will be limited to three storey residential buildings without basement excavation.

The purpose of the investigation was to provide information on:

- Site conditions and regional geology,
- Subsurface conditions
- Site Classification according to AS2870/AS2159 (soil reactivity),
- Maximum permissible temporary and permanent batter slopes and retaining wall design parameters,
- Foundation design parameters including foundation options, and
- Exposure classification/soil aggressiveness according to AS2870.

The investigation was undertaken in accordance with STS proposal P22-668A dated 16<sup>th</sup> November 2022.

Our scope of work did not include a contamination assessment.

## 2. NATURE OF THE INVESTIGATION

### 2.1. Fieldwork

The fieldwork consisted of drilling eight (8) boreholes numbered BH1 to BH8 (inclusive), at the locations shown on attached Drawing No. 23/0234. Restricted site access dictated the borehole locations. Boreholes were drilled using a utility mounted Christie Drilling rig, owned, and operated by STS. Soil strengths were assessed by carrying out a Dynamic Cone Penetrometer (DCP) test adjacent to each borehole location.

Drilling operations were undertaken by one of STS's senior technical officers who also logged the subsurface conditions encountered. Representative soil samples were collected from the boreholes for subsequent laboratory testing.

## 2.2. Laboratory Testing

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

- pH,
- Sulphate content ( $\text{SO}_4$ ),
- Chloride content (Cl) and
- Electrical Conductivity (EC).

To assist with determining the site classification, three Shrink Swell tests were carried out on representative samples retrieved from the site.

Detailed test reports are given in Appendix B.

## 3. GEOLOGY AND SITE CONDITIONS

The Sydney geological series map at a scale of 1:100,000 shows the site is underlain by Triassic Age Ashfield Shale of Wianamatta Group. Materials within this formation typically comprise black to dark grey shale and laminite.

At the time of the fieldwork, the site had existing dwellings with vegetation comprising grasses, shrubs, and trees. The ground surface falls approximately 4.0 metres to the west.

The site is bound by Hardwicke Street to the north, and residential dwellings in the adjoining properties.

## 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, particularly on a site such as this where there have been previous developments.

Except BH2, the subsurface conditions generally consist of fill and silty clays overlying weathered shale. In BH2, fill is present from surface to a depth of 0.1 metres. Firm to stiff becoming very stiff with increasing depths, natural silty clays underlie the site to the depths of 1.7 to 2.1 metres. Weathered shale underlies the natural silty clays to the depth of auger refusal, 1.8 to 2.3 metres.

Groundwater was not observed during drilling works.

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.

## 5. GEOTECHNICAL DISCUSSION

### 5.1. Site Classification (AS2870)

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

To assist with determining the site classification, three (3) shrink/swell tests were carried out on the representative samples retrieved from the site. The detailed test report is attached and summarised in Table 5.1.

Table 5.1 – Shrink Swell Test Summary

Location	Depth (m)	Material Description	Shrink/Swell Index (% per $\Delta pF$ )
BH1	0.9 – 1.1	SILTY CLAY: medium plasticity, orange, brown mottled grey and brown	2.6
BH4	1.0 – 1.2	SILTY CLAY: medium plasticity, orange, brown mottled grey	3.1
BH7	1.0 – 1.2	SILTY CLAY: low to medium plasticity, orange, brown mottled grey	1.4

Because there are existing dwellings 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)*. Provided the recommendations given below are adopted 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 design parameters provided below.

## 5.2. Temporary and Permanent Batter Slopes

STS have not been provided with architectural plans, however, the fall across the site suggests that either retaining walls and/or battered slopes will be required during development of the site.

In the short term, dry cut soil slopes should remain stable at an angle of 1(H) to 1(V). In the long-term dry cut slopes formed at an angle of 2(H) to 1(V) should remain stable. Slopes cut at this angle would be subject to erosion unless protected by topsoil and diversion drains at the crest of the slopes. Dry cut slopes in the weathered shale should remain stable at an angle of 1(H) to 1(V). The above temporary batters should remain stable provided that all surcharge loads, including construction loads, are kept at a distance of at least 2h (where 'h' is the height of the batter in metres) from the crest of the batter. If steeper batters are to be used, then these must be supported by shotcrete and soil nail system designed by a suitable experienced structural or geotechnical engineer.

Where space for temporary batters is not available, a suitable retention system will be required for the support of the entire depth of excavation within soils or weathered shale materials.

Excavations on the subject site should not extend below the zone of influence of any adjacent structure footings, without first installing temporary support or discussing the works with a geotechnical engineer.

## 5.3. Retaining Wall Design Parameters

The parameters used to proportion retaining wall support depends on whether the walls can be permitted to deflect. For walls, which cannot be permitted to deflect, an at rest earth pressure coefficient ( $K_0$ ) of 0.6 should be adopted for the clays. For walls that can be allowed to deflect, an active earth pressure coefficient ( $K_a$ ) of 0.4 should be adopted for the clays. A passive earth pressure coefficient ( $K_p$ ) of 2.5 may be used for the clays and 4.5 for the weathered shale. A bulk density of 19 kN/m<sup>3</sup> may be used for the natural silty clays and 22 kN/m<sup>3</sup> for the weathered shale. As with all retaining walls, allowance must be made for ground surface slope, presence of groundwater and surcharge loads.

#### 5.4. Foundation Design Parameters

We do not recommend founding any structural loads within the fill.

High level pad and/or strip footings founded in the natural, firm and stiff silty clays may be proportioned using an allowable bearing pressure of 75 and 100 kPa respectively. The minimum depth of founding must comply with the requirements of AS2870.

Pad and/or strip footings founded in the natural very stiff silty clays may be proportioned using an allowable bearing pressure of 200 kPa.

Piers founded in very stiff silty clays may be proportioned using an allowable end bearing pressure of 300 kPa, provided their depth to diameter ratio exceeds a value of 4. An allowable adhesion value of 20 kPa may be adopted for the portion of the shaft below a depth of 0.5 metres.

If a higher load carrying capacity is required, piers founded in weathered shale may be proportioned using an allowable end bearing pressure of 700 kPa. An allowable adhesion value of 70 kPa may be adopted for the portion of the shaft in weathered shale. When piers are founded in weathered shale the adhesion within the overlying soils must be ignored.

To ensure the bearing values given can be achieved, care should be taken to ensure the base of the excavations is free of all loose material prior to concreting. To this end, it is recommended that all excavations be concreted as soon as possible, preferably immediately after excavating, cleaning, inspecting and approval. Pier excavations should not be left open overnight. The possibility of groundwater inflow needs to be considered when drilling the piers and pouring concrete.

During foundation construction, should the subsurface conditions vary to those inferred in this report, a suitably experienced geotechnical engineer should review the design and recommendations given above to determine if any alterations are required.

#### 5.5. 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 sulfates and chlorides. 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. The test results are summarised in Table 5.2.

Table 5.2 – Soil Aggressiveness Summary

Sample No.	Location	Depth (m)	pH	Sulfate (mg/kg)	Chloride (mg/kg)	Electrical Conductivity (dS/m)	
						EC <sub>1:5</sub>	EC <sub>e</sub>
S1	BH1	0.4	6.0	10	40	0.044	0.4
S2	BH4	0.5	5.4	30	<10	0.026	0.2
S3	BH6	0.5	5.2	50	20	0.040	0.4
S4	BH8	0.3	6.2	<10	10	0.020	0.2

The soils on the site are cohesive and above groundwater. Therefore, soil conditions B are considered appropriate (AS2159).

A review of the durability aspects indicates that:

- pH : minimum value of 5.2
- SO<sub>4</sub> : maximum value of 50 mg/kg (ppm) < 5000 ppm
- Cl : maximum value of 40 mg/kg (ppm) < 5000 ppm
- EC<sub>e</sub> : maximum value of 0.4 dS/m

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

Reference to DLWC (2002) “Site Investigations for Urban Salinity” indicates that EC<sub>e</sub> values of 0.2 to 0.4 dS/m are consistent with the presence of non-saline soils.

## 6. 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.

The above classification has been made assuming that all footings will bear in either natural ground or in controlled filling. Prior to the placement of any filling the existing surface should be stripped of all vegetation and topsoil.

If excavations for rainwater or detention tanks are to be made within 6 metres of the building foundations, advice should be sought regarding their effect on the foundations.



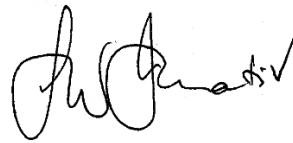
Placing absorption trenches on the high side of the property may create abnormal moisture conditions for the foundations (Refer to Section 1.3.3 of AS2870). This could have a negative effect on the foundation performance and more than likely alter the site classification provided above.

This report has been prepared assuming that no trees other than the vegetation noted will be present on the site. If future tree planting is planned, e.g., there is a landscaping plan, their effect on the foundation performance must be considered.

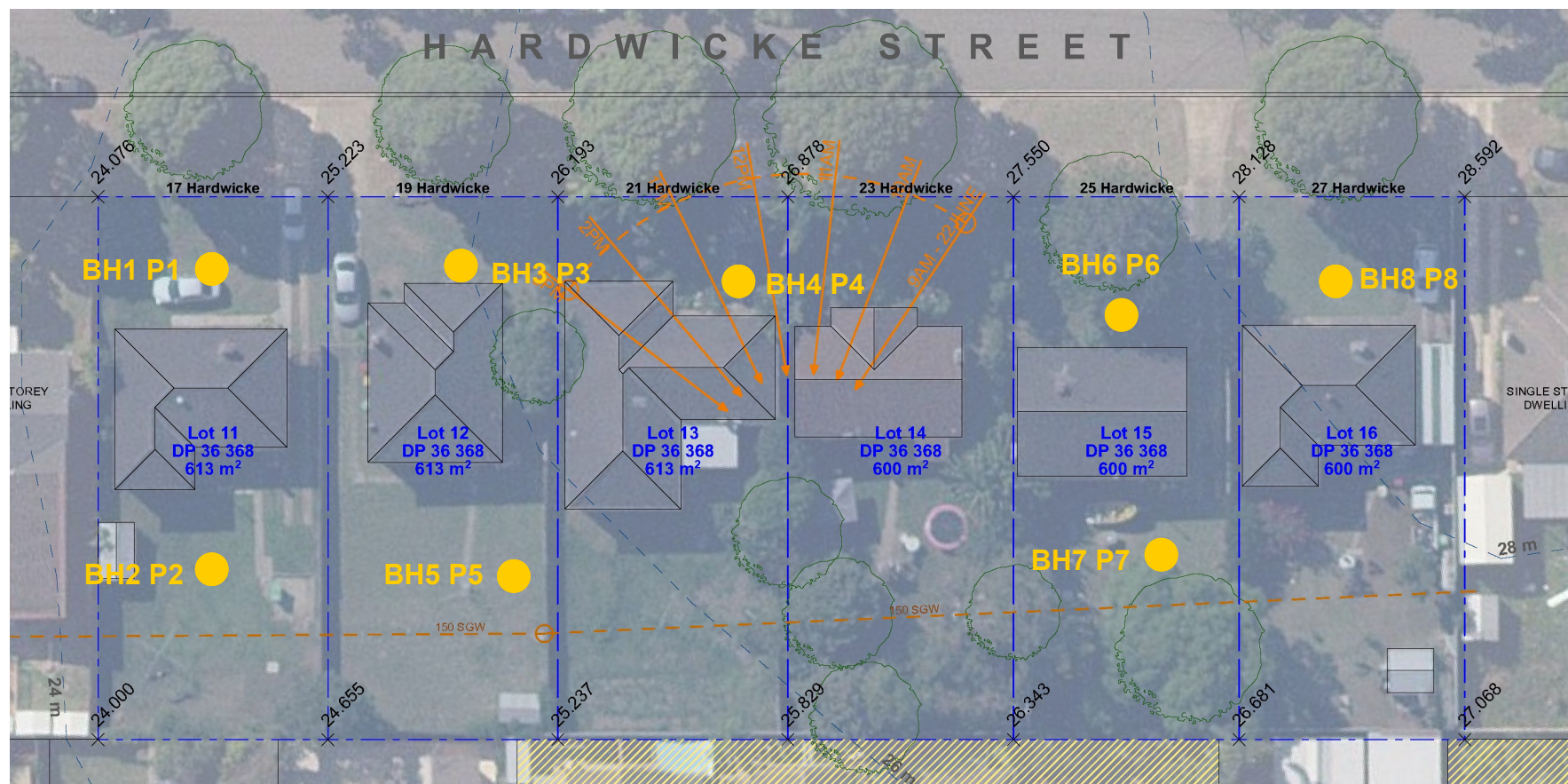
This report has been prepared assuming the site development will be limited to three storey residential buildings. The information and interpretation may not be relevant if the design proposal changes (e.g., to a five-storey building involving major cuts during the site preparation). If changes occur, we would be pleased to review the report and advise on the adequacy of the investigation.



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STS Geotechnics Pty. Ltd.

Scale: Unknown

Date: February 2023

Client: NSW LAND & HOUSING CORPORATION

GEOTECHNICAL INVESTIGATION  
17-27 HARDWICKE STREET, RIVERWOOD  
BOREHOLE AND PENETROMETER LOCATIONS

Project No.  
32062/7123D-G

Drawing No: 23/0234

## 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

Form: I1-2

Client: NSW Land & Housing Corporation				Project / STS No. 32062/7123D-G		BOREHOLE NO.: BH 2				
Project: 17-27 Hardwicke Street, Riverwood				Date: January 31, 2023						
Location: Refer to Drawing No. 23/0234				Logged: MB Checked By: KS		Sheet 1 of 1				
W A T T E R L E	S A M P L E S	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT		S Y M B O L	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	M O I S T U R E			
			Soil Name, grain size /plasticity, colour; secondary constituents (Inc. Description) , minor constituents including other remarks							
			FILL: SILTY CLAY: low plasticity, brown, trace of gravel					CL	-	<PL
			SILTY CLAY: low plasticity, brown					CL	STIFF	<PL
			SILTY CLAY: medium plasticity, orange brown mottled grey					CI	STIFF	=PL
									VERY STIFF	
			SILTY CLAY: medium plasticity, grey mottled brown					CI	VERY STIFF	<PL
			WEATHERED SHALE: brown						EXTREMELY LOW STRENGTH	D
			AUGER REFUSAL AT 2.2 M ON WEATHERED SHALE							
D - disturbed sample U - undisturbed tube sample B - bulk sample Contractor: STS WT - level of water table or free water N - Standard Penetration Test (SPT) Equipment: Christie S - jar sample Hole Diameter (mm): 100					Angle from Vertical (°): 0					
NOTES: See explanation sheets for meaning of all descriptive terms and symbols					Drill Bit: Spiral					

Client: NSW Land & Housing Corporation		Project / STS No. 32062/7123D-G		BOREHOLE NO.: BH 3		
Project: 17-27 Hardwicke Street, Riverwood		Date: January 31, 2023		Sheet 1 of 1		
Location: Refer to Drawing No. 23/0234		Logged: MB Checked By: KS				
W A T T A E B R L E	S A M P L E S	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT  Soil Name, grain size /plasticity, colour; secondary constituents (Inc. Description) , minor constituents including other remarks	S Y M B O L	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)  M O I S T U R E	
		0.5	SILTY CLAY: low plasticity, brown	CL	STIFF  VERY STIFF	<PL
		1.0	SILTY CLAY: low to medium plasticity, orange brown mottled grey	CL/CI	VERY STIFF	<PL
		1.5	SILTY CLAY: low to medium plasticity, grey	CL/CI	VERY STIFF	<PL
		2.0	WEATHERED SHALE: brown		EXTREMELY LOW STRENGTH	D
		2.5	AUGER REFUSAL AT 2.1 M ON WEATHERED SHALE			
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: Christie Hole Diameter (mm): 100 Angle from Vertical (°): 0 Drill Bit: Spiral		
NOTES: See explanation sheets for meaning of all descriptive terms and symbols						

Client: NSW Land & Housing Corporation			Project / STS No. 32062/7123D-G		BOREHOLE NO.: BH 4	
Project: 17-27 Hardwicke Street, Riverwood			Date: January 31, 2023			
Location: Refer to Drawing No. 23/0234			Logged: MB Checked By: KS		Sheet 1 of 1	
W A T T E R L E	S A M P L E S	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT  Soil Name, grain size /plasticity, colour; secondary constituents (Inc. Description) , minor constituents including other remarks	S Y M B O L	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	M O I S T U R E
	S2 @ 0.5 m		SILTY CLAY: low plasticity, brown	CL	FIRM	<PL
			SILTY CLAY: medium plasticity, orange brown mottled grey	CL/CI	VERY STIFF	=PL
	U50	0.5	SILTY CLAY: low to medium plasticity, grey mottled brown	CL/CI	VERY STIFF	=PL
		1.0	WEATHERED SHALE: brown		EXTREMELY LOW STRENGTH	D
1.5	AUGER REFUSAL AT 2.2 M ON WEATHERED SHALE					
2.0						



Client: NSW Land & Housing Corporation			Project / STS No. 32062/7123D-G		BOREHOLE NO.: BH 5		
Project: 17-27 Hardwicke Street, Riverwood			Date: January 31, 2023				
Location: Refer to Drawing No. 23/0234			Logged: MB Checked By: KS		Sheet 1 of 1		
W A T T E R L E	S A M P L E S	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT  Soil Name, grain size /plasticity, colour; secondary constituents (Inc. Description) , minor constituents including other remarks		S Y M B O L	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	M O I S T U R E
		0.5	SILTY CLAY: low plasticity, brown		CL	STIFF	<PL
			SILTY CLAY: medium plasticity, orange brown mottled grey		CL/CI	STIFF	=PL
						VERY STIFF	
		1.0					
		1.5					
			SILTY CLAY: low to medium plasticity, grey mottled brown		CL/CI	VERY STIFF	<PL
			WEATHERED SHALE: brown			EXTREMELY LOW STRENGTH	D
			AUGER REFUSAL AT 1.8 M ON WEATHERED SHALE				
		2.0					
		2.5					
D - disturbed sample WT - level of water table or free water S - jar sample  U - undisturbed tube sample B - bulk sample N - Standard Penetration Test (SPT)					Contractor: STS Equipment: Christie Hole Diameter (mm): 100		
NOTES: See explanation sheets for meaning of all descriptive terms and symbols					Angle from Vertical (°): 0 Drill Bit: Spiral		

Client: NSW Land & Housing Corporation		Project / STS No. 32062/7123D-G		BOREHOLE NO.: BH 6		
Project: 17-27 Hardwicke Street, Riverwood		Date: January 31, 2023		Sheet 1 of 1		
Location: Refer to Drawing No. 23/0234		Logged: MB Checked By: KS				
W A T T A E B R L E	S A M P L E S	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT  Soil Name, grain size /plasticity, colour; secondary constituents (Inc. Description) , minor constituents including other remarks	S Y M B O L	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	M O I S T U R E
	S3 @ 0.5 m	0.5	SILTY CLAY: low plasticity, brown	CL	FIRM	<PL
			SILTY CLAY: low to medium plasticity, orange brown mottled grey	CL/CI	STIFF	<PL
					VERY STIFF	
		1.0				
		1.5	SILTY CLAY: low plasticity, grey mottled brown	CL	VERY STIFF	<PL
			WEATHERED SHALE: brown		EXTREMELY LOW STRENGTH	D
		2.0	AUGER REFUSAL AT 1.9 M ON WEATHERED SHALE			
		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: Christie Hole Diameter (mm): 100		
NOTES: See explanation sheets for meaning of all descriptive terms and symbols				Angle from Vertical (°): 0 Drill Bit: Spiral		

Client: NSW Land & Housing Corporation			Project / STS No. 32062/7123D-G		BOREHOLE NO.: BH 7	
Project: 17-27 Hardwicke Street, Riverwood			Date: January 31, 2023			
Location: Refer to Drawing No. 23/0234			Logged: MB Checked By: KS		Sheet 1 of 1	
W A T T E R L E	S A M P L E S	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT  Soil Name, grain size /plasticity, colour; secondary constituents (Inc. Description) , minor constituents including other remarks	S Y M B O L	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	M O I S T U R E
	U50	0.0	SILTY CLAY: low plasticity, brown	CL	FIRM	<PL
		0.1	SILTY CLAY: low to medium plasticity, orange brown mottled grey	CL/CI	VERY STIFF	<PL
		0.2				
		0.3				
		0.4				
		0.5				
		0.6				
		0.7				
		0.8				
		0.9				
1.0	SILTY CLAY: low to medium plasticity, grey mottled brown	CL/CI	VERY STIFF	<PL		
1.1	WEATHERED SHALE: brown		EXTREMELY LOW STRENGTH	D		
1.2						
1.3						
1.4						
1.5						
1.6						
1.7						
1.8						
1.9						
2.0	AUGER REFUSAL AT 2.1 M ON WEATHERED SHALE					
2.1						
2.2						
2.3						
2.4						
2.5						
2.6						
2.7						
2.8						
2.9						
3.0						
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: Christie Hole Diameter (mm): 100		
NOTES: See explanation sheets for meaning of all descriptive terms and symbols				Angle from Vertical (°): 0 Drill Bit: Spiral		

Client: NSW Land & Housing Corporation		Project / STS No. 32062/7123D-G		<b>BOREHOLE NO.:</b> BH 8		
Project: 17-27 Hardwicke Street, Riverwood		Date: January 31, 2023		Sheet 1 of 1		
Location: Refer to Drawing No. 23/0234		Logged: MB Checked By: KS				
W A T E R L E V E L	S A M P L E S	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT  Soil Name, grain size /plasticity, colour; secondary constituents (Inc. Description) , minor constituents including other remarks	S Y M B O L	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	M O I S T U R E
	S4 @ 0.3 m	0.5	SILTY CLAY: low plasticity, brown	CL	FIRM	=PL
					STIFF	
		1.0	SILTY CLAY: medium plasticity, orange brown mottled grey	CI	STIFF	<PL
					VERY STIFF	
		1.5				
		2.0	SILTY CLAY: low to medium plasticity, grey mottled red brown	CL/CI	VERY STIFF	<PL
		2.5	WEATHERED SHALE: brown		EXTREMELY LOW STRENGTH	D
			AUGER REFUSAL AT 2.1 M ON WEATHERED SHALE			
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: Christie Hole Diameter (mm): 100 Angle from Vertical (°): 0 Drill Bit: Spiral		
NOTES: See explanation sheets for meaning of all descriptive terms and symbols						

## Dynamic Cone Penetrometer Test Report

Project: 17-27 HARDWICKE STREET, RIVERWOOD

Project No.: 32062/7123D

Client: NSW LAND & HOUSING CORPORATION

Report No.: 23/0233

Address: Level G, 12 Darcy Street, Parramatta

Report Date: 2/2/2023

Test Method: AS 1289.6.3.2

Page: 1 of 2

Site No.	P1	P2	P3	P4	P5	P6
Location	Refer to Drawing No. 23/0234	Refer to Drawing No. 23/0234	Refer to Drawing No. 23/0234	Refer to Drawing No. 23/0234	Refer to Drawing No. 23/0234	Refer to Drawing No. 23/0234
Date Tested	31/1/2023	31/1/2023	31/1/2023	31/1/2023	31/1/2023	31/1/2023
Starting Level	Surface Level	Surface Level	Surface Level	Surface Level	Surface Level	Surface Level
Depth (m)	Penetration Resistance (blows / 150mm)					
0.00 - 0.15	3	2	3	2	4	2
0.15 - 0.30	2	2	4	2	3	3
0.30 - 0.45	3	3	3	2	3	3
0.45 - 0.60	4	5	8	7	5	6
0.60 - 0.75	4	7	10	7	5	6
0.75 - 0.90	6	7	10	8	11	10
0.90 - 1.05	6	9	14	13	11	10
1.05 - 1.20	8	9	23+	19	18	23+
1.20 - 1.35	10	10	Refusal	23+	23+	Refusal
1.35 - 1.50	23+	16		Refusal	Refusal	
1.50 - 1.65	Refusal	23+				
1.65 - 1.80		Refusal				
1.80 - 1.95						
1.95 - 2.10						
2.10 - 2.25						
2.25 - 2.40						
2.40 - 2.55						
2.55 - 2.70						
2.70 - 2.85						
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

Technician: MB

Approved Signatory.....



Orlando Mendoza - Laboratory Manager

## Dynamic Cone Penetrometer Test Report

Project: 17-27 HARDWICKE STREET, RIVERWOOD

Project No.: 32062/7123D

Client: NSW LAND & HOUSING CORPORATION

Report No.: 23/0233

Address: Level G, 12 Darcy Street, Parramatta

Report Date: 2/2/2023

Test Method: AS 1289.6.3.2

Page: 2 of 2

Site No.	P7	P8				
Location	Refer to Drawing No. 23/0234	Refer to Drawing No. 23/0234				
Date Tested	31/1/2023	31/1/2023				
Starting Level	Surface Level	Surface Level				
Depth (m)	Penetration Resistance (blows / 150mm)					
0.00 - 0.15	2	2				
0.15 - 0.30	2	2				
0.30 - 0.45	4	4				
0.45 - 0.60	4	4				
0.60 - 0.75	8	8				
0.75 - 0.90	9	8				
0.90 - 1.05	9	18				
1.05 - 1.20	13	23+				
1.20 - 1.35	17	Refusal				
1.35 - 1.50	23+					
1.50 - 1.65	Refusal					
1.65 - 1.80						
1.80 - 1.95						
1.95 - 2.10						
2.10 - 2.25						
2.25 - 2.40						
2.40 - 2.55						
2.55 - 2.70						
2.70 - 2.85						
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

Technician: MB

Approved Signatory.....



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 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 Soil 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 <sub>c</sub> (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 indicated 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

## Shrink Swell Index Report

Project: 17-27 HARDWICKE STREET, RIVERWOOD

Client: **NSW LAND & HOUSING CORPORATION**

Address: Level G, 12 Darcy Street, Parramatta

Test Method: AS 1289.7.1.1

Project No.: 32062

Report No.: 23/0249

Report Date: 6/02/2023

Page: 1 OF 1

Sampling Procedure: AS 1289.1.3.1 Clause 3.1.3.2 - Thin Walled Sampler

STS / Sample No.		7123D-L/1	7123D-L/2	7123D-L/3			
Sample Location		Borehole 1 Refer to Drawing No. 23/0234	Borehole 4 Refer to Drawing No. 23/0234	Borehole 7 Refer to Drawing No. 23/0234			
Material Description		Silty Sandy Clay, red brown/yellow	Silty Gravelly Clay, yellow grey/red	Silty Clay, orange brown, trace of gravel			
Depth (m)		0.9 - 1.1	1.0 - 1.2	1.0 - 1.2			
Sample Date		31/01/2023	31/01/2023	31/01/2023			
Shrink	Moisture Content (%)	27.8	23.7	20.4			
	Soil Crumbling	Nil	Nil	Nil			
	Extent of Cracking	Open Cracks	Open Cracks	Fine Cracks			
	Strain (%)	4.0	4.1	2.4			
Swell	Moisture Content Initial (%)	30.2	18.8	18.1			
	Moisture Content Final (%)	34.4	16.7	25.0			
	Strain (%)	1.4	2.9	0.4			
Inert Inclusions (%)		<25	<30	<25			
Shrink Swell Index (%)		<b>2.6</b>	<b>3.1</b>	<b>1.4</b>			

Remarks:

Approved Signatory.....

Technician: DH

Orlando Mendoza - Laboratory Manager

## CERTIFICATE OF ANALYSIS

<b>Work Order</b>	<b>: ES2303115</b>	<b>Page</b>	<b>: 1 of 2</b>
<b>Client</b>	<b>: STS Geotechnics</b>	<b>Laboratory</b>	<b>: Environmental Division Sydney</b>
<b>Contact</b>	<b>: ENQUIRES STS</b>	<b>Contact</b>	<b>: Customer Services ES</b>
<b>Address</b>	<b>: Unit 14/1 Cowpasture Place Wetherill Park 2164</b>	<b>Address</b>	<b>: 277-289 Woodpark Road Smithfield NSW Australia 2164</b>
<b>Telephone</b>	<b>: ----</b>	<b>Telephone</b>	<b>: +61-2-8784 8555</b>
<b>Project</b>	<b>: 30055/32062</b>	<b>Date Samples Received</b>	<b>: 01-Feb-2023 11:20</b>
<b>Order number</b>	<b>: 2023-035</b>	<b>Date Analysis Commenced</b>	<b>: 02-Feb-2023</b>
<b>C-O-C number</b>	<b>: ----</b>	<b>Issue Date</b>	<b>: 06-Feb-2023 18:28</b>
<b>Sampler</b>	<b>: MB</b>		
<b>Site</b>	<b>: ----</b>		
<b>Quote number</b>	<b>: EN/222</b>		
<b>No. of samples received</b>	<b>: 5</b>		
<b>No. of samples analysed</b>	<b>: 5</b>		



Accreditation No. 825  
Accredited for compliance with  
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. 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.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Ankit Joshi	Senior Chemist - Inorganics	Sydney Inorganics, Smithfield, NSW
Edwandy Fadjar	Organic Coordinator	Sydney Inorganics, Smithfield, NSW



## General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the 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 Contract 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.

## Analytical Results

Sub-Matrix: SOIL  
 (Matrix: SOIL)

Sample ID

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	30055/8726	32062/S1	32062/S2	32062/S3	32062/S4
Sampling date / time					31-Jan-2023 00:00	31-Jan-2023 00:00	31-Jan-2023 00:00	31-Jan-2023 00:00	31-Jan-2023 00:00
Compound	CAS Number	LOR	Unit	ES2303115-001	ES2303115-002	ES2303115-003	ES2303115-004	ES2303115-005	
				Result	Result	Result	Result	Result	
EA002: pH 1:5 (Soils)									
pH Value	----	0.1	pH Unit	6.8	6.0	5.4	5.2	6.2	
EA010: Conductivity (1:5)									
Electrical Conductivity @ 25°C	----	1	µS/cm	231	44	26	40	20	
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	0.1	%	10.8	23.1	24.3	13.6	19.5	
ED040S : Soluble Sulfate by ICPAES									
Sulfate as SO4 2-	14808-79-8	10	mg/kg	140	10	30	50	<10	
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	10	mg/kg	----	40	<10	20	10	