GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

GEOTECHNICAL INVESTIGATION

FOR

NEW GOLDEN ST LEONARDS PTY LIMITED

3 Holdsworth Avenue, St Leonards

Report No: 21/2493_Rev2

Project No: 31154/5392D-G

1 June 2022

14/1 Cowpasture Place, Wetherill Park, NSW 2164, Australia
(PO Box 6989, Wetherill Park, NSW 2164, Australia)
T +61 2 9756 2166 | **F** +61 2 9756 1137
www.stsgeo.com.au | enquiries@stsgeo.com.au
ABN 45 636 179 729 | **ACN** 636 179 729

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DOCUMENT CONTROL

REPORT TITLE: Geotechnical Investigation

REPORT NO: 21/2493_Rev2

Revision	Details	Date	Amended By
0	Original	1 December 2021	
1	Updated Drawings	8 June 2022	IW
2	Updated Site Address	8 June 2022	IW

Following advice from the Building Commissioner, the advice, recommendations, and design parameters provided in this report are only valid and to be relied upon if during construction, geotechnical inspections of the foundations and support/shoring systems are conducted by STS Geotechnics Pty Ltd.

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1. INTRODUCTION

This report presents the results of a geotechnical investigation carried out by STS Geotechnical Pty Ltd (STS) at the request of New Golden St Leonards Pty Limited for the proposed construction of residential unit building at 3 Holdsworth Avenue St Leonards.

The investigation has been carried out in accordance with the agreed scope of works outlined in STS' proposal referenced P20-647B, dated 20 July 2021.

Proposed Development

The following documents, supplied by the Client were used to assist with the preparation of this investigation report:

- Architectural drawings prepared by PTW Pty Ltd, Project Ref. PA030370, Drawings
  - DA-09-0010, Revision B, dated 6.6.2022
  - DA-30-0001, Revision D, dated 6.6.2022
  - DA-30-0002, Revision D, dated 6.6.2022
  - DA-30-0003, Revision D, dated 6.6.2022
- Site Survey Plan, prepared by M.Y.XU & Co., Ref. 14676-T1, dated 9/10/2020.

Based on the drawings provided, STS understands the proposed development is to involve the construction of a thirteen-storey residential apartment building, overlying a four-level basement. The lowest basement (B4) is proposed to have a finished floor level of 56.80 metres AHD, excavation of up to 18.90 metres below existing ground level is anticipated during construction.

Objectives

The purpose of the investigation was to assess the subsurface conditions over the site at two borehole locations and provide preliminary geotechnical advice and recommendations addressing the following.

- Subsurface conditions,
- Excavation conditions,
- Retaining wall design parameters,
- Appropriate foundation system for the site including design parameters,
- Earthquake loading factor in accordance with AS1170.4:2007, and
- Exposure classification in accordance with AS2870 & AS2159.

Our scope of work did not include a contamination assessment.

2. FIELDWORK DETAILS

The fieldwork consisted of drilling three (3) boreholes numbered BH1 to BH3 at the locations shown on Drawing No. 21/2493. Restricted site access dictated the borehole locations. All boreholes were drilled using a track mounted drilling rig equipped with Tungsten-Carbide (T-C) bit and NMLC diamond coring equipment.

Soils were drilled using rotary solid flight augers. Soil strengths were determined by undertaking Standard Penetration Tests (SPT) and visual observation of the recovered rock cuttings at each borehole location. The recovered core was boxed on site and brought back to the STS laboratory where it was logged, photographed, and point load tests were carried out.

The subsurface conditions observed are recorded on the borehole logs given in Appendix A together with photographs of the recovered rock core and results of the point load testing. An explanation of the terms used on the logs is also given in Appendix A. Notes relating to geotechnical reports are also attached.

3. LABORATORY TESTING

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

- Electrical Conductivity,
- pH,
- Sulfate content as SO_4,
- Chloride content as CL.

Detailed test reports are given in Appendix B.

4. GEOLOGY AND SITE CONDITIONS

As shown on **Plate 1**, the Sydney geological series sheet at a scale of 1:100,000 shows that the site is underlain by Ashfield Shale (Rwa). Bedrock within this formation comprises black to dark-grey shale and laminite. the Ashfield Shale is underlain by Hawkesbury sandstone (Rh), which consists of medium to coarse-grained quartz sandstone with very minor shale and laminite lenses.

The site is rectangular in shape with a combined area of approximately 2631 m^2. At the time of the fieldwork, there were brick and timber residential buildings onsite. The site is bounded by residential dwellings to the south and west, Marshall Avenue to the north and Holdsworth Avenue to the east.

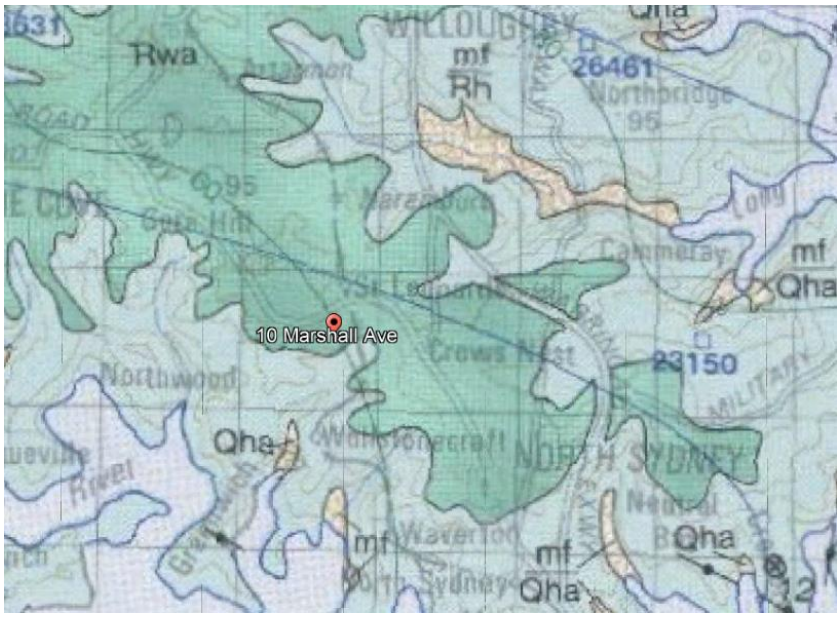


Plate 1: Excerpt of geological map showing location of site.

The ground surface falls approximately 5 metres to the east, a mortared sandstone block retaining wall, approximately 2 metres in height was observed along the eastern boundary. Based on a visual inspection, the retaining wall was assessed to be in average condition, with some signs of deterioration and remediation works observed.

5. SUBSURFACE CONDITIONS

5.1. Stratigraphy

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 that has been previously developed.

The stratigraphy observed in the geotechnical Investigation has been grouped into four geotechnical units. A summary of the subsurface conditions across the site, interpreted from the assessment results, is presented in Table 5.1. More detailed descriptions of subsurface conditions at each borehole location are available on the borehole logs presented in **Appendix A**. The details of the methods of soil and rock classifications, explanatory notes and abbreviations adopted on the borehole logs are also presented in **Appendix A**.

Table 5.1 – Stratigraphy Summary

Unit	Material	Depth to Top of Unit (m)[1]	Observed Thickness (m)[1]	Comments
1	Fill	Surface	0.2-0.6	Grey, fine to medium grained silty sand with some brick and sandstone fragments. The fill was overlain by brick pavers in BH1
2	Stiff and Very Stiff Sandy Clay	0.2-0.6	0.4-1.3	Pale grey and brown, low and medium plasticity, stiff to very stiff sandy clay and silty clay.
3	Class IV/V Sandstone	0.9-1.9	4.9 - 6.7	Pale grey and brown, very low to low strength, extremely to distinctly weathered, medium to coarse grained sandstone with some clay and dark grey shale layers, and some medium strength regions
4	Class II/III Sandstone	6.8-7.8	-[2]	Pale grey medium to high strength, slightly weathered to fresh medium to coarse grained sandstone with occasional dark grey shale layers.

Notes:

1 Approximate depth at the time of our assessment. Depths and levels may vary across the site.
2 Observed to the termination depth in all boreholes.

Due to limited site access, no boreholes could be drilled within the property at No. 3 Holdsworth Avenue, STS recommends an additional borehole is completed in these properties following demolition of the existing structures onsite.

5.2. Groundwater Observation

Following completion of drilling, groundwater monitoring wells were installed in BH1 and BH3. The groundwater level was then measured within the monitoring wells as noted in Table 5.2. Water circulation due to coring within the boreholes prevented further observations of groundwater levels within BH2. We note that the groundwater levels may not have become evident or stabilised in the augered borehole within the limited observation period.

Table 5.2 – Groundwater Levels

Borehole ID	Measurement Date	Depth to Groundwater (m BEGL)	Approximate Surface RL at Borehole Location	RL Groundwater (m AHD)
BH1	17/09/2021	7.15	76.00	68.85
BH3	17/09/2021	4.65	73.50	68.85

6. DISCUSSION

6.1. Geotechnical Issues

Based on the results of the investigation, we consider the following to be the main geotechnical issues for the proposed development:

- Basement excavation and retention to limit lateral deflections and ground loss because of excavations, resulting in damage to nearby structures,
- Rock excavation,
- Groundwater within the depth of the excavation, and
- Foundation design for building loads.

6.2. Dilapidation Surveys

Prior to excavation and construction, we recommend that detailed dilapidation surveys be carried out on all structures and infrastructures surrounding the site that falls within the zone of influence of the excavation to allow assessment of the recommended vibration limits and protect the client against spurious claims of damage. The zone of influence of the excavation is defined by a distance back from the excavation perimeter of twice the total depth of the excavation. The reports would provide a record of existing conditions prior to commencement of the work. A copy of each report should be provided to the adjoining property owner who should be asked to confirm that it represents a fair assessment of existing conditions. The reports should be carefully reviewed prior to demolition and construction.

6.3. Excavation Methodology

Prior to any excavation commencing, we recommend that reference be made to the Safe Work Australia Excavation Work Code of Practice, dated January 2020.

STS assumes that the proposed development will require a bulk excavation level of RL 56.5 meters AHD, which includes a 0.3-meter allowance for construction of the ground floor slab. To achieve this bulk excavation level, excavation of up to approximately 18.90 metres

below existing ground level is anticipated. Locally deeper excavations for footings, service trenches, crane pads and lifts overrun pits may be required.

Based on the borehole logs, the proposed basement excavations will therefore extend through all units as outlined in Table 5-1 above. As such, an engineered retention system must be installed prior to excavation commencing.

Units 1 and 2 could be excavated using buckets of large earthmoving Hydraulic Excavators, particularly if fitted with 'Tiger Teeth'. Excavation of Units 3 and 4 may present hard or heavy ripping, or "hard rock" excavation conditions. Ripping would require a high capacity and heavy bulldozer for effective production. Wear and tear should also be allowed for. The use of a smaller size bulldozer will result in lower productivity and higher wear and tear, and this should be allowed for. Alternatively, hydraulic rock breakers, rock saws, ripping hooks or rotary grinders could be used, though productivity would be lower, and equipment wear increased, and this should be allowed for.

Should rock hammers be used for the excavation of the bedrock, excavation should commence away from the adjoining structures and the transmitted vibrations monitored to assess how close the hammer can operate to the adjoining structures while maintaining transmitted vibrations within acceptable limits. To fall within these limits, we recommend that the size of rock hammers do not exceed a medium sized rock hammer, say 900 kg, such as a Krupp 580, and be trialled prior to use. The transmitted vibrations from rock hammers should be measured to determine how close each individual hammer can operate to the adjoining buildings.

The vibration measurements can be carried out using either an attended or an unattended vibration monitoring system. An unattended vibration monitoring system must be fitted with an alarm in the form of a strobe light or siren, or alerts sent directly to the site supervisor to make the plant operator aware immediately when the vibration limit is exceeded.

If it is found that the transmitted vibrations using rock hammers are unacceptable, then it would be necessary to change to a smaller excavator with a smaller rock hammer, or to a rotary grinder, rock saws, jackhammers, ripping hooks, chemical rock splitting and milling machines. Although these are likely to be less productive, they would reduce or possibly eliminate risks of damage to adjoining properties through vibration effects transmitted via the ground. Such equipment would also be required for detailed excavation, such as footings or service trenches, and for trimming of faces. Final trimming of faces may also be completed using a grinder attachment rather than a rock breaker to assist in limiting vibrations. The use of rotary grinders generally generates dust, and this may be supressed by spraying with water.

To assist in reducing vibrations and over-break of the sandstone, we recommend that initial saw cutting of the excavation perimeters through the bedrock may be provided using rock saw attachments fitted to the excavator. Rock sawing of the excavation perimeter has several advantages as it often reduces the need for rock bolting as the cut faces generally remain more stable and require a lower level of rock support than hammer cut excavations, ground vibrations from rock saws are minimal and the saw cuts will provide a slight increase in buffer distance for use of rock hammers. However, the effectiveness of such approach must be confirmed by the results of vibration monitoring.

Also, there is a potential for poorly oriented defects within the excavated bedrock to result in localized rockslide/topple failure with potential impact to the work site or the adjacent structures. However, through selection of suitable excavation equipment, geotechnical inspections and mapping during the excavation works along with the installation of support measures as determined necessary by the inspections, the risk from the proposed works can be maintained within 'Acceptable' levels. In addition, we recommend that only excavation contractors with appropriate insurances and experience on similar projects be used. The contractor should also be provided with a copy of this report to make his own judgement on the most appropriate excavation equipment.

Groundwater seepage monitoring should be carried out during bulk excavation works and prior to finalising the design of a pump out facility. Outlets into the stormwater system will require Council approval.

Furthermore, any existing buried services, which run below the site, will require diversion prior to the commencement of excavation or alternatively be temporarily supported during excavation, subject to permission or other instructions from the relevant service authorities. Enquiries should also be made for further information and details, such as invert levels, on the buried services.

6.4. Excavation Monitoring

Consideration should be made to the impact of the proposed development upon neighbouring structures, roadways and services. Basement excavation retention systems should be designed to limit lateral deflections.

Contractors should also consider the following limits associated with carrying out excavation and construction activities:

- Limit lateral deflection of temporary or permanent retaining structures.
- Limit vertical settlements of ground surface at common property boundaries and services easement; and
- Limit Peak Particle Velocities (PPV) from vibrations, caused by construction equipment or excavation, experienced by any nearby structures and services.

Monitoring of deflections of retaining structures and surface settlements should be carried out by a registered surveyor at agreed points along the excavation boundaries and along existing building foundations / services/ pavements and other structures located within or near the zone of influence of the excavation. Owners of existing services adjacent to the site should be consulted to assess appropriate deflection limits for their infrastructures. Measurements should be taken in the following sequence:

- Before commencing installation of retaining structures where appropriate to determine the baseline readings. Two independent sets of measurements must be taken confirming measurement consistency.
- After installation of the retaining structures, but before commencement of excavation.
- After excavation to the first row of supports or anchors, but prior to installation of these supports or anchors.
- After excavation to any subsequent rows of supports or anchors, but prior to installation of these supports or anchors.
- After excavation to every 1.5m interval thereafter.
- After excavation to the base of the excavation.
- After de-stressing and removal of any rows of supports or anchors; and
- One month after completion of the permanent retaining structure or after three consecutive measurements not less than a week apart showing no further movements, whichever is the latter.

6.5. Maximum Permissible Temporary and Permanent Batter Slopes and Retaining Wall Design Parameters

Based on the provided architectural drawings, STS does not consider temporary batters to be suitable for this site. As such a suitable retention system must be installed prior to excavation commencing, for the support of the excavation within soils or weathered sandstone materials.

For the support of units 1, 2 and 3 on this site, STS recommends a propped or anchored soldier pile wall with shotcrete panels between the piles be founded into Class II/III sandstone (Unit 4). Consideration may be made for some piles, which are not supporting the vertical structural loads of the building, to be terminated at least 0.5m, into Unit 4 material or better, above the base of the bulk excavation levels. The capping beam must be designed to follow the existing ground level such that the entire depth of the excavation is always supported.

Excavation within Unit 4 sandstone should generally be able to be cut vertically and without support, provided an anchor is installed at the toe of the solider pile wall and regular geotechnical inspections are conducted during excavation. Anchors/props and mass concrete must be installed progressively as excavation proceeds.

For vertical cuts, the excavations must be inspected by a geotechnical engineer at regular intervals to check for any inclined joints or weak seams that require stabilisation. these inclined joints and weak seams were evident in the boreholes, particularly in BH2. Such geotechnical inspections should be carried out at depth intervals of no more than 1.5m. If adverse defects are encountered, the stabilisation measures may comprise rock bolts, shotcrete and mesh or dental treatment of thin weak seams using non-shrink grout, and this should be allowed for.

It is of course important that the onsite excavations do not endanger the adjacent properties. 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.

The parameters used to proportion retaining wall support depends on whether the walls can be permitted to deflect. Retention systems onsite may be designed using the parameters as outlined in Table 6.2.

Table 6.2 – Design Allowable Bearing Parameters

Material[1]		Unit 1 Fill	Unit 2 Stiff and Very stiff Residual Soil	Unit 3 Class V/IV Sandstone	Unit 4 Class II/III Sandstone
Depth to Top of Unit (m)[2]		Surface	0.2-0.6	0.9-1.9	6.8-7.7
Bulk Unit Weight (kN/m^3)		17	19	24	24
Friction Angle ϕ' (°)		25	25	35	40
Earth Pressure Coefficients	At rest K_o[3]	0.6	0.6	0.5	0.4
	Active K_a[3]	0.4	0.4	0.3	0.2
	Passive K_p[3]	2.5	2.5	3.7	4.6
Allowable Bearing Pressure (kPa)[6]		-	100	800	3,500 or 6,000[5]
Allowable Shaft Adhesion (kPa)[4,6]	In Compression	-	-	80	350
	In Uplift	-	-	40	175
Allowable Toe Resistance		-	-	-	200
Allowable Bond Stress		-	-	50	200

Notes:

1 More detailed descriptions of subsurface conditions are available on the borehole logs presented in **Appendix A.**

2 Approximate levels of top of unit at the time of our investigation. Levels may vary across the site.

3 Earth pressures are provided on the assumption that the ground behind the retaining walls is horizontal.

4 Side adhesion values given assume there is intimate contact between the pile and foundation material and should achieve a clean socket roughness category R2 or better. Design engineer to check both 'piston pull-out' and 'cone lift out' mechanics in accordance with AS4678-2002 Earth Retaining Structures.

5 An allowable bearing capacity of 6,000kPa can only be adopted if spoon testing is conducted in at least one third of all footings and the additional borehole is completed.

6 To adopt these parameters, we have assumed that:

- Footings have a nominal socket of at least 0.3m, into the relevant founding material.
- For piles, there is intimate contact between the pile and foundation material (a clean socket roughness category of R2 or better);
- Potential soil and groundwater aggressivity will be considered in the design of piles and footings.
- Piles should be drilled in the presence of a Geotechnical Engineer prior to pile construction to verify that ground conditions meet design assumptions. Where groundwater ingress is encountered during pile excavation, concrete is to be placed as soon as possible upon completion of pile excavation. Pile excavations should be pumped dry of water prior to pouring concrete, or alternatively a tremie system could be used.
- The bases of all pile, pad and strip footing excavations are cleaned of loose and softened material and water is pumped out prior to placement of concrete.
- The concrete is poured on the same day as drilling, inspection and cleaning.
- The allowable bearing pressures given above are based on serviceability criteria of settlements at the footing base/pile toe of less than or equal to 1% of the minimum footing dimension (or pile diameter).

6.6. Groundwater Considerations

Groundwater was observed in BH1 and BH3 as mentioned above in Table 5.2. Due to the low permeability of the soils and bedrock profile, any groundwater inflows into the excavation should not have an adverse impact on the proposed development or on the neighbouring sites and should be manageable. However, we expect some groundwater inflows into the excavation along the soil/rock interface and through any defects within the sandstone bedrock (such as jointing, and bedding planes, etc.) particularly following a period of heavy rainfall. We recommend that monitoring of seepage be implemented during the excavation works to confirm the capacity of the drainage system.

We expect that any seepage that does occur will be able to be controlled by a conventional sump and pump system. We recommend that a sump-and-pump system be used both during construction and for permanent groundwater control below the basement floor slab.

In the long term, drainage should be provided behind all basement retaining walls, around the perimeter of the basement and below the basement slab. The completed excavation and water inflows should be inspected by the hydraulic engineer to confirm that adequate drainage has been allowed for. Drainage should be connected to the sump-and-pump system and discharged into the stormwater system. The permanent groundwater control system should consider any possible soluble substances in the groundwater which may dictate whether groundwater can be pumped into the stormwater system.

The design of drainage and pump systems should take the above issues into account along with careful ongoing inspections and maintenance programs.

6.7. Foundation Design Parameters

Following bulk excavation to RL 56.5 metres AHD, we expect Unit 4 material to be exposed at BEL.

It is recommended that all footings for the building be founded within the sandstone bedrock of similar strength to provide uniform support and reduce the potential for differential settlements.

Pad or strip footings founded within Unit 4 may be preliminarily designed for an allowable bearing capacity of 3500kPa, based on serviceability. If higher bearing capacities are required, pad and strip footings may be designed for an allowable bearing capacity of 6000kPa, however spoon testing must be completed within at least one third of all footings and the additional borehole as mentioned above must be completed.

Geotechnical inspections of foundations are recommended to determine that the required bearing capacity has been achieved and to determine any variations that may occur between the boreholes and inspected locations.

6.8. Earthquake Site Risk Classification

Reference to AS 1170.4:2007 suggests an earthquake subsoil class of Class Be (Rock) is applicable to the site.

The applicable hazard factor (z) for Sydney is 0.08.

6.9. 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 6.3.

Table 6.3 – Soil Aggressiveness Summary

Sample No.	Location	Depth (m)	pH	Chloride (mg/kg)	Sulfate (mg/kg)	Electrical Conductivity (dS/m)	
						$EC_{1:5}$	EC_e
S1	BH1	0.5	5.0	20	10	0.032	0.3
S2	BH3	0.8	5.8	<10	<10	0.014	0.2

The soils on the site consist of low permeability silty and sandy clays. Therefore, the soil conditions B are considered appropriate (AS2159).

A review of the durability aspects indicates that:

- pH : minimum value of 5.0
- SO_4 : maximum value of 10 mg/kg (ppm) < 5000 ppm
- Cl : maximum value of 20 mg/kg (ppm) < 5000 ppm
- EC_e : maximum value of 0.3 dS/m

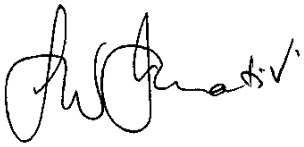
In accordance with AS2159-2009 the exposure classification for the onsite soils is mildly aggressive to concrete and non-aggressive for steel. In accordance with AS2870-2011 the soils are classified as A2.

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.

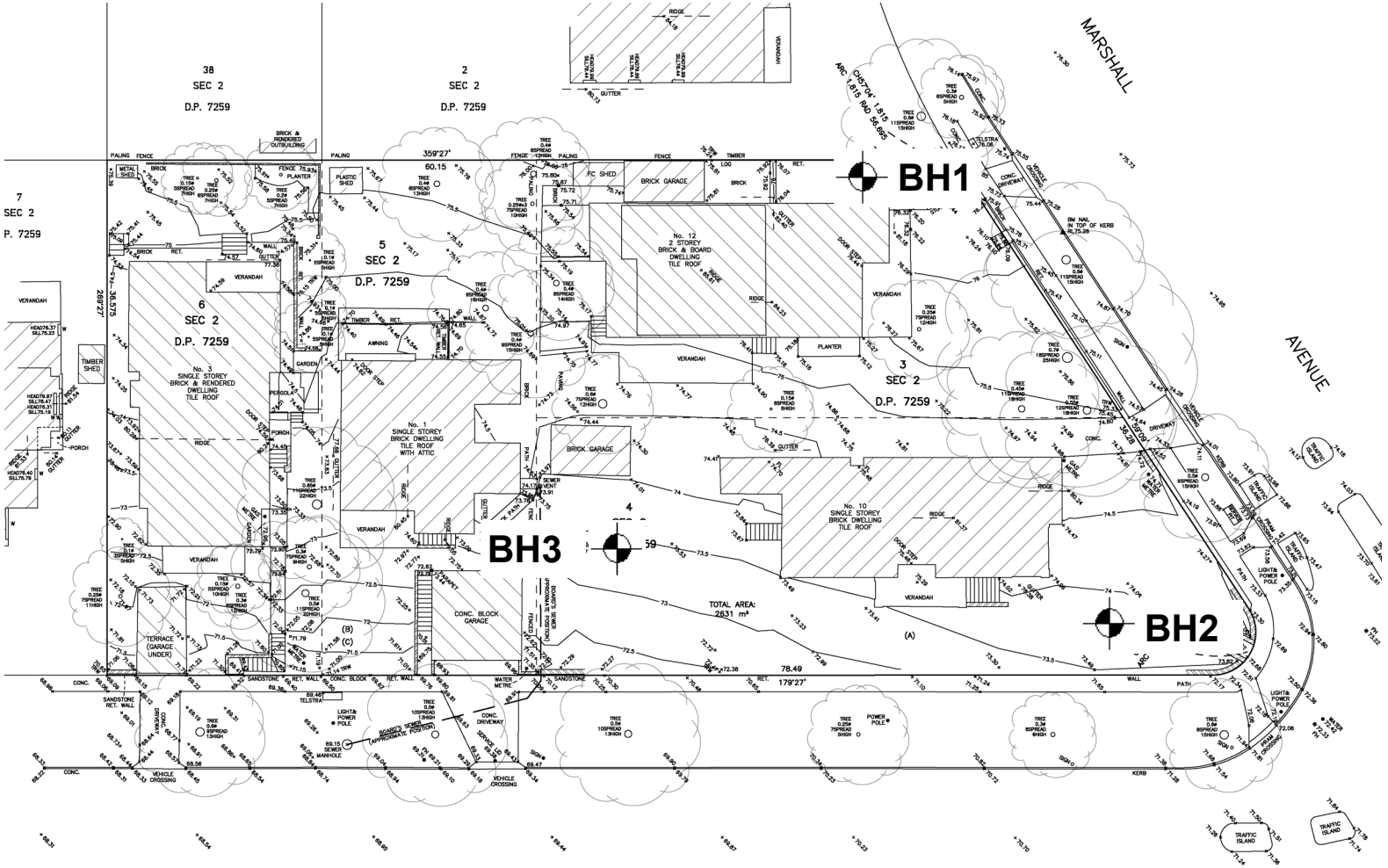
As discussed above, if the shoring system is to be terminated above bulk excavation level it is important the excavation is inspected regularly as it progresses. Also, the exposed bearing surfaces for footings must be inspected by a geotechnical engineer to ensure the allowable pressure provided in this report have been achieved during construction.

Yours Faithfully



Ian Watts
Geotechnical Engineer
STS Geotechnics Pty Limited

Laurie Ihnativ BE, MEngSc, MBA, FIEAust
Principal Geotechnical Engineer
STS Geotechnics Pty Limited



STS Geotechnics Pty. Ltd.	Scale: Unknown	Date: September 2021
Client: NEW GOLDEN ST. LEONARDS PTY LIMITED		
GEOTECHNICAL INVESTIGATION **3 HOLDSWORTH AVENUES, ST. LEONARDS** **BOREHOLE LOCATIONS**		Project No. 31154/5392D-G Drawing No: 21/2493

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, CORE PHOTOGRAPHS, POINT LOAD TESTING RESULTS AND EXPLANATION SHEETS

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: New Golden St. Leonards Pty Limited	Project / STS No. 31154/5392D-G	**BOREHOLE NO.: BH 1**
Project: 3 Holdsworth Avenue, St. Leonards	Date: August 16, 2021	BH Surface RL: 76.0m
Location: Refer to Drawing No. 21/2493	Logged: IW Checked By: LWI	Sheet 1 of 5

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
			PAVERS: brown, brick pavers (50 mm thick)	-	-	-
			FILL: SAND: yellow, medium grained	-	-	-
	SPT 0.5-0.95 m 6, 8, 12 N = 20		SILTY CLAY: brown, low to medium plasticity, some sand	CL	VERY STIFF	M<PL
		1.0	WEATHERED SANDSTONE: pale grey and brown, very low strength, extremely weathered, medium to coarse grained, clay layers	-	-	-
		2.0	AUGER DISCONTINUED AT 1.8 M ON WEATHERED SANDSTONE For core details refer to core log sheets			
		3.0				
		4.0				
		5.0				

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

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

Contractor: Geosense

Equipment: Geo 205

Hole Diameter (mm): 100

Angle from Vertical (^{o}): 0

Drill Bit: Spiral

STS Geotechnics — **GEOTECHNICAL LOG - CORED BOREHOLE**

Client: New Golden St. Leonards Pty Limited
Project: 3 Holdsworth Avenue, St. Leonards
Location: Refer to Drawing No. 21/2493
Project / STS No. 31154/5392D-G
Date: August 16, 2021
Logged: IW
Checked By: LWI

BOREHOLE NO. BH 1
Sheet 2 of 5

DRILLING				MATERIAL STRENGTH											DISCONTINUITIES	
						Estimated Rock Strength							Average Defect Spacing (mm)			
Method	Water	RQD (SCR)	Recovery / TCR	Depth (m)	Rock Type (Colour, Grain Size, Structure & Minor Components)	Weathering	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High	20 40 100 300 1000	Visual	Additional Data (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
				1.0	For non core details, refer to non core log sheets START CORING AT 1.8 M											
NMLC CORING	50% RETURN	23%	100%	2.0	SANDSTONE: pale grey and red brown, medium to coarse grained, some extremely weathered zoned and clay seams	DW										1.94m J, 40 deg. Pl, Uro 2.12-2.15m, EWS, clay 2.36-2.69m, EW, clay
				3.0		EW DW										3.0m, J, 80 deg. Ir, Uro
		86%	100%	4.0		SW										3.53, J, 50 deg. Pl, Uro 3.74-3.75m, EWS, clay 4.27m, J, 20 deg. Uro
				5.0												5.32m, B, 5 deg. Uro, Clay 2 mm 5.61-5.71m, EW, clay

Notes:

Contractor: Geosense
Equipment: Geo 205
Hole Diameter (mm): 100 mm
Angle from Vertical (°): 90

See explanation sheets for meaning of all descriptive terms and symbols

STS Geotechnics — **GEOTECHNICAL LOG - CORED BOREHOLE**

Client: New Golden St. Leonards Pty Limited
Project: 3 Holdsworth Avenue, St. Leonards
Location: Refer to Drawing No. 21/2493

Project / STS No. 31154/5392D-G
Date: August 16, 2021
Logged: IW
Checked By: LWI

BOREHOLE NO. BH 1
Sheet 3 of 5

DRILLING					MATERIAL STRENGTH											DISCONTINUITIES	
							Estimated Rock Strength							Average Defect Spacing (mm)			
Method	Water	RQD (SCR)	Recovery / TCR	Depth (m)	Rock Type (Colour, Grain Size, Structure & Minor Components)	Weathering	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High	20 40 100 300 1000	Visual	Additional Data (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
NMLC CORING	50% RETURN	81%	100%	7.0	SANDSTONE: pale grey with red brown, medium to coarse grained, some extremely weathered zones, clay seams	SW				●						6.41-6.46m, EWS, clay
					SHALE: dark grey, very low strength, extremely weathered	DW			●							7.16-7.75m, EWS, clay
				8.0	SANDSTONE: pale grey, medium to coarse grained, some dark grey shale laminations	Fr				●						
				9.0												
		94%	100%	10.0						●						
				11.0							●					10.93-10.95m, EWS, clay 20 mm

Notes:

Contractor: Geosense
Equipment: Geo 205
Hole Diameter (mm): 100 mm
Angle from Vertical (°): 90

See explanation sheets for meaning of all descriptive terms and symbols

STS Geotechnics — **GEOTECHNICAL LOG - CORED BOREHOLE**

Client: New Golden St. Leonards Pty Limited
Project: 3 Holdsworth Avenue, St. Leonards
Location: Refer to Drawing No. 21/2493

Project / STS No. 31154/5392D-G
Date: August 16, 2021
Logged: IW
Checked By: LWI

BOREHOLE NO. BH 1
Sheet 4 of 5

DRILLING				MATERIAL STRENGTH											DISCONTINUITIES	
						Estimated Rock Strength							Average Defect Spacing (mm)			
Method	Water	RQD (SCR)	Recovery / TCR	Depth (m)	Rock Type (Colour, Grain Size, Structure & Minor Components)	Weathering	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High	20 40 100 300 1000	Visual	Additional Data (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
NMLC CORING	50% RETURN	95%	100%		SANDSTONE: pale grey, medium to coarse grained, some dark grey shale laminations						●					12.83m, B, 5%, Pl, Uro, clay 2 mm
				13.0	Grading to red brown	Fr										
					Grading to pale grey						●					
				14.0							●					
				15.0							●					
		100%	100%	16.0							●					
				17.0							●					

Notes:

Contractor: Geosense
Equipment: Geo 205
Hole Diameter (mm): 100 mm
Angle from Vertical (°): 90

See explanation sheets for meaning of all descriptive terms and symbols

STS Geotechnics — **GEOTECHNICAL LOG - CORED BOREHOLE**

Client: New Golden St. Leonards Pty Limited
Project: 3 Holdsworth Avenue, St. Leonards
Location: Refer to Drawing No. 21/2493

Project / STS No. 31154/5392D-G
Date: August 16, 2021
Logged: IW
Checked By: LWI

BOREHOLE NO. BH 1
Sheet 5 of 5

DRILLING				MATERIAL STRENGTH											DISCONTINUITIES	
						Estimated Rock Strength							Average Defect Spacing (mm)			
Method	Water	RQD (SCR)	Recovery / TCR	Depth (m)	Rock Type (Colour, Grain Size, Structure & Minor Components)	Weathering	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High	20 40 100 300 1000	Visual	Additional Data (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
NMLC CORING	50% RETURN	100%	100%	19.0	SANDSTONE: pale grey, medium to coarse grained, some dark grey shale laminations	Fr					●					
		100%	100%	20.0							●					
				21.0							●					
				22.0							●					
				23.0							●					
					BOREHOLE DISCONTINUED AT 23.85 M											

Notes:

Contractor: Geosense
Equipment: Geo 205
Hole Diameter (mm): 100 mm
Angle from Vertical (°): 90

See explanation sheets for meaning of all descriptive terms and symbols

PROJECT: 3 HOLDSWORTH AVENUE, ST LEONARDS

PROJECT NO. 31154/5392D-G

CLIENT: NEW GOLDEN ST LEONARDS PTY LIMITED

BOREHOLE NUMBER: BH1

DEPTH (m) START 1.8m - 23.85m END

BOX 1-2 OF 5

PROJECT: 3 HOLDSWORTH AVENUE, ST LEONARDS

PROJECT NO. 31154/5392D-G

CLIENT: NEW GOLDEN ST LEONARDS PTY LIMITED

BOREHOLE NUMBER: BH1

DEPTH (m) START 1.8m - 23.85m END

BOX 3-4 OF 5

PROJECT: 3 HOLDSWORTH AVENUE, ST LEONARDS
PROJECT NO. 31154/5392D-G
CLIENT: NEW GOLDEN ST LEONARDS PTY LIMITED
BOREHOLE NUMBER: BH1
DEPTH (m) START 1.8m - 23.85m END
BOX 5 OF 5

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: New Golden St. Leonards Pty Limited	Project / STS No. 31154/5392D-G	**BOREHOLE NO.: BH 2**
Project: 3 Holdsworth Avenue, St. Leonards	Date: August 16, 2021	BH Surface RL: 74.0m
Location: Refer to Drawing No. 21/2493	Logged: IW Checked By: LWI	Sheet 1 of 5

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 SAND: grey, fine to medium grained	-	-	M
	SPT 0.6-1.05 m 1, 4, 7 N = 11		SANDY CLAY: light grey and light brown, low plasticity, medium grained sand	CL	STIFF	M≈PL
		1.0				
	SPT 1.5-1.95 m 25, 13, 19/50 HB					
		2.0	WEATHERED SANDSTONE: light grey and light brown, very low strength, extremely weathered medium to coarse grained, clay layers	-	-	-
		3.0	AUGER DISCONTINUED AT 2.9 M ON SANDSTONE For core log details, refer to core log sheets			
		4.0				
		5.0				

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

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

Contractor: Geosense

Equipment: Geo 205

Hole Diameter (mm): 100

Angle from Vertical (°): 0

Drill Bit: Spiral

STS Geotechnics — **GEOTECHNICAL LOG - CORED BOREHOLE**

Client: New Golden St. Leonards Pty Limited
Project: 3 Holdsworth Avenue, St. Leonards
Location: Refer to Drawing No. 21/2493
Project / STS No. 31154/5392D-G
Date: August 16, 2021
Logged: IW
Checked By: LWI

BOREHOLE NO. BH 2
Sheet 2 of 5

DRILLING					MATERIAL STRENGTH										DISCONTINUITIES	
							Estimated Rock Strength							Average Defect Spacing (mm)		
Method	Water	RQD (SCR)	Recovery / TCR	Depth (m)	Rock Type (Colour, Grain Size, Structure & Minor Components)	Weathering	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High	20 40 100 300 1000	Visual	Additional Data (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
				1.0												
				2.0	for non core details, refer to non core log sheets START CORING AT 2.9 M											
NMLC CORING	80% RETURN	42%	74%	3.0	SANDSTONE: light grey and brown, medium to coarse grained, some EW seams	SW				●						
					CORE LOSS 3.64 TO 3.92 M (280 mm)											
				4.0	SANDSTONE: light grey and brown, medium to coarse grained, some EW seams	DW			●							4.254.83m, EWS, clay
					CORE LOSS 4.44 TO 4.62M (180 mm)											
					SANDSTONE: light grey and brown, medium to coarse grained, some EW seams	DW										
				5.0	CORE LOSS 4.87 TO 5.04 M (170 mm)											
					SANDSTONE: light grey and brown, medium to coarse grained, some EW seams	DW										5.09-5.28m, EW, clay
		44%	85%		CORE LOSS 5.28 TO 5.83 M (550 mm)											
					SANDSTONE; light grey, fine to medium grained, dark grey shale laminations	DW		●								5.95-5.98m, EWS, clay

Notes:

Contractor: Geosense
Equipment: Geo 205
Hole Diameter (mm): 100 mm
Angle from Vertical (°): 90

See explanation sheets for meaning of all descriptive terms and symbols

STS Geotechnics — **GEOTECHNICAL LOG - CORED BOREHOLE**

Client: New Golden St. Leonards Pty Limited
Project: 3 Holdsworth Avenue, St. Leonards
Location: Refer to Drawing No. 21/2493
Project / STS No. 31154/5392D-G
Date: August 16, 2021
Logged: IW
Checked By: LWI

BOREHOLE NO. BH 2
Sheet 3 of 5

DRILLING					MATERIAL STRENGTH										DISCONTINUITIES	
							Estimated Rock Strength							Average Defect Spacing (mm)		
Method	Water	RQD (SCR)	Recovery / TCR	Depth (m)	Rock Type (Colour, Grain Size, Structure & Minor Components)	Weathering	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High	20 40 100 300 1000	Visual	Additional Data (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
NMLC CORING	80% RETURN	44%	85%	7.0	SANDSTONE: light grey, fine to medium grained, some dark grey shale laminations	DW										7.4m, J, 60 deg. Un, Uro 7.64-7.76m, EWS, clay
				8.0		SW										
				9.0												
		90%	100%	10.0												
					SANDSTONE: light grey and brown, medium to coarse grained											10.42-10.45m, EWS, clay
				11.0												11.4m, B, 0 deg. Ro, clay, 2mm

Notes:

Contractor: Geosense
Equipment: Geo 205
Hole Diameter (mm): 100 mm
Angle from Vertical (°): 90

See explanation sheets for meaning of all descriptive terms and symbols

STS Geotechnics — **GEOTECHNICAL LOG - CORED BOREHOLE**

Client: New Golden St. Leonards Pty Limited
Project: 3 Holdsworth Avenue, St. Leonards
Location: Refer to Drawing No. 21/2493
Project / STS No. 31154/5392D-G
Date: August 16, 2021
Logged: IW
Checked By: LWI

BOREHOLE NO. BH 2
Sheet 4 of 5

DRILLING				MATERIAL STRENGTH										DISCONTINUITIES		
						Estimated Rock Strength							Average Defect Spacing (mm)			
Method	Water	RQD (SCR)	Recovery / TCR	Depth (m)	Rock Type (Colour, Grain Size, Structure & Minor Components)	Weathering	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High	20 40 100 300 1000	Visual	Additional Data (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
NMLC CORING	80% RETURN	100%	100%	13.0	SANDSTONE: light grey and brown, medium to coarse grained	Fr										
				14.0												
				15.0												
		100%	100%	16.0												16.3m, J, 70-90 deg. Un, Uro
				17.0												

Notes:

Contractor: Geosense
Equipment: Geo 205
Hole Diameter (mm): 100 mm
Angle from Vertical (°): 90

See explanation sheets for meaning of all descriptive terms and symbols

STS Geotechnics — **GEOTECHNICAL LOG - CORED BOREHOLE**

Client: New Golden St. Leonards Pty Limited
Project: 3 Holdsworth Avenue, St. Leonards
Location: Refer to Drawing No. 21/2493
Project / STS No. 31154/5392D-G
Date: August 16, 2021
Logged: IW
Checked By: LWI

BOREHOLE NO. BH 2
Sheet 5 of 5

DRILLING					MATERIAL STRENGTH										DISCONTINUITIES	
							Estimated Rock Strength							Average Defect Spacing (mm) 20 40 100 300 1000		
Method	Water	RQD (SCR)	Recovery / TCR	Depth (m)	Rock Type (Colour, Grain Size, Structure & Minor Components)	Weathering	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High		Visual	Additional Data (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
NMLC CORING	80% RETURN	100%	100%	19.0	SANDSTONE: light grey and brown, medium to coarse grained	Fr					●					19.06m, J, 70-90 deg. Un, Uro
											●					19.06m, j, 30 deg. Pl, Uro
				20.0							●					
				21.0								●				21.08m, J, 30 deg. Un, Uro
				22.0	BOREHOLE DISCONTINUED AT 21.98 M											
				23.0												

Notes:

Contractor: Geosense
Equipment: Geo 205
Hole Diameter (mm): 100 mm
Angle from Vertical (°): 90

See explanation sheets for meaning of all descriptive terms and symbols

PROJECT: 3 HOLDSWORTH AVENUE, ST LEONARDS

PROJECT NO. 31154/5392D-G

CLIENT: NEW GOLDEN ST LEONARDS PTY LIMITED

BOREHOLE NUMBER: BH2

DEPTH (m) START 2.9m - 21.5m END

BOX 1-2 OF 4

PROJECT: 3 HOLDSWORTH AVENUE, ST LEONARDS
PROJECT NO. 31154/5392D-G
CLIENT: NEW GOLDEN ST LEONARDS PTY LIMITED
BOREHOLE NUMBER: BH2
DEPTH (m) START 2.9m - 21.5m END
BOX 3-4 OF 4

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: New Golden St. Leonards Pty Limited	Project / STS No. 31154/5392D-G	**BOREHOLE NO.: BH 3**
Project: 3 Holdsworth Avenue, St. Leonards	Date: August 16, 2021	BH Surface RL: 73.5m
Location: Refer to Drawing No. 21/2493	Logged: IW Checked By: LWI	Sheet 1 of 5

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 SAND: grey with some brick and sandstone fragments	-	-	M
	SPT 0.8-1.25 m 7, 7, 14 N = 21		SILTY CLAY: grey, medium plasticity, some grained sand, medium plasticity	CL	VERY STIFF	M<PL
		1.0	SANDSTONE: brown, light grey, medium to coarse grained, very low strength, extremely weathered, with some clay layers	-	-	-
		2.0				
		3.0	AUGER DISCONTINUED AT 2.95 M For core details, refer to core log sheets			
		4.0				
		5.0				

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

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

Contractor: Geosense
Equipment: Geo 205
Hole Diameter (mm): 100
Angle from Vertical (^{o}): 0
Drill Bit: Spiral

STS Geotechnics — **GEOTECHNICAL LOG - CORED BOREHOLE**

Client: New Golden St. Leonards Pty Limited
Project: 3 Holdsworth Avenue, St. Leonards
Location: Refer to Drawing No. 21/2493
Project / STS No. 31154/5392D-G
Date: August 16, 2021
Logged: IW
Checked By: LWI

BOREHOLE NO. BH 3
Sheet 2 of 5

DRILLING					MATERIAL STRENGTH										DISCONTINUITIES		
							Estimated Rock Strength							Average Defect Spacing (mm)			
Method	Water	RQD (SCR)	Recovery / TCR	Depth (m)	Rock Type (Colour, Grain Size, Structure & Minor Components)	Weathering	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High	20 40 100 300 1000	Visual	Additional Data (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
				1.0												
				2.0	For non core details, refer to non core log sheets START CORING AT 2.95 M											
NMLC CORING	80% RETURN	54%	100%	3.0	SANDSTONE: light brown, grey and red brown, medium to coarse grained, some EW seams	DW										3.16-3.25m, EWS, clay 3.48-3.55m, EWS, clay
				4.0												4.13-4.14m, B, 5 deg. Pl, Uro, clay 10 mm 4.3m, J, 20 deg. Pl, Uro 4.33m, J, 20 deg. Pl, Uro 4.45m, J, 20 deg. Pl, Uro
				5.0												
					SANDSTONE: light grey, fine to medium grained, some dark grey shale laminations and bands	EW DW										5.25-5.5m, EWS, Clay
		70%	100%													

Notes:

Contractor: Geosense
Equipment: Geo 205
Hole Diameter (mm): 100 mm
Angle from Vertical (°): 90

See explanation sheets for meaning of all descriptive terms and symbols

STS Geotechnics — **GEOTECHNICAL LOG - CORED BOREHOLE**

Client: New Golden St. Leonards Pty Limited
Project: 3 Holdsworth Avenue, St. Leonards
Location: Refer to Drawing No. 21/2493

Project / STS No. 31154/5392D-G
Date: August 16, 2021
Logged: IW
Checked By: LWI

BOREHOLE NO. BH 3
Sheet 3 of 5

DRILLING				MATERIAL STRENGTH											DISCONTINUITIES	
						Estimated Rock Strength							Average Defect Spacing (mm)			
Method	Water	RQD (SCR)	Recovery / TCR	Depth (m)	Rock Type (Colour, Grain Size, Structure & Minor Components)	Weathering	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High	20 40 100 300 1000	Visual	Additional Data (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
NMLC CORING	80% RETURN	70%	100%	7.0	SANDSTONE: light grey, fine to medium grained, some dark grey shale laminations and bands	SW										7.83m, J, 80 deg. Ir, Uro 7.84m, J, 90 deg. Ir, Uro 7.9-8.14m, Cz
				8.0												
				9.0												9.12-9.14m, EWS, Clay
		91%	100%	10.0												10.24-10.26m, EWS, Clay
				11.0	SANDSTONE: light grey, medium to coarse grained	Fr										10.9m, B, 50 deg. Pl, Uro, Clay
		100%	100%													

Notes:

Contractor: Geosense
Equipment: Geo 205
Hole Diameter (mm): 100 mm
Angle from Vertical (°): 90

See explanation sheets for meaning of all descriptive terms and symbols

STS Geotechnics — **GEOTECHNICAL LOG - CORED BOREHOLE**

Client: New Golden St. Leonards Pty Limited
Project: 3 Holdsworth Avenue, St. Leonards
Location: Refer to Drawing No. 21/2493

Project / STS No. 31154/5392D-G
Date: August 16, 2021
Logged: IW
Checked By: LWI

BOREHOLE NO. BH 3
Sheet 4 of 5

DRILLING				MATERIAL STRENGTH										DISCONTINUITIES	
						Estimated Rock Strength							Average Defect Spacing (mm) 20 40 100 300 1000		
Method	Water	RQD (SCR)	Recovery / TCR	Depth (m)	Rock Type (Colour, Grain Size, Structure & Minor Components)	Weathering	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High	Visual	Additional Data (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
NMLC CORING	80% RETURN	100%	100%	13.0	SANDSTONE: light grey, medium to coarse grained	Fr					●				
				14.0							●				
				15.0							●				
		100%	100%	16.0							●				16.43m, J, 30 deg. Pl, Ro
				17.0							●				

Notes:

Contractor: Geosense
Equipment: Geo 205
Hole Diameter (mm): 100 mm
Angle from Vertical (°): 90

See explanation sheets for meaning of all descriptive terms and symbols

STS Geotechnics — **GEOTECHNICAL LOG - CORED BOREHOLE**

Client: New Golden St. Leonards Pty Limited
Project: 3 Holdsworth Avenue, St. Leonards
Location: Refer to Drawing No. 21/2493

Project / STS No. 31154/5392D-G
Date: August 16, 2021
Logged: IW
Checked By: LWI

BOREHOLE NO. BH 3
Sheet 5 of 5

DRILLING					MATERIAL STRENGTH										DISCONTINUITIES	
							Estimated Rock Strength							Average Defect Spacing (mm)		
Method	Water	RQD (SCR)	Recovery / TCR	Depth (m)	Rock Type (Colour, Grain Size, Structure & Minor Components)	Weathering	Extremely Low	Very Low	Low	Medium	High	Very High	Extremely High	20 40 100 300 1000	Visual	Additional Data (Joints, partings, seams, zones etc. Description, orientation, infilling, or coating, shape, roughness, thickness, other)
NMLC CORING	80% RETURN	100%	100%	19.0	SANDSTONE: light grey, medium to coarse grained	Fr					●					
					SANDSTONE: light grey, some shale laminations and bands						●					
				20.0							●					19.6-19.61m, EWS, Clay
				21.0							●					
					BOREHOLE DISCONTINUED AT 21.18 M											
				22.0												
				23.0												

Notes:

Contractor: Geosense
Equipment: Geo 205
Hole Diameter (mm): 100 mm
Angle from Vertical (°): 90

See explanation sheets for meaning of all descriptive terms and symbols

PROJECT: 3 HOLDSWORTH AVENUE, ST LEONARDS

PROJECT NO. 31154/5392D-G

CLIENT: NEW GOLDEN ST LEONARDS PTY LIMITED

BOREHOLE NUMBER: BH3

DEPTH (m) START 2.95m - 21.18m END

BOX 1-2 OF 4

PROJECT: 3 HOLDSWORTH AVENUE, ST LEONARDS
PROJECT NO. 31154/5392D-G
CLIENT: NEW GOLDEN ST LEONARDS PTY LIMITED
BOREHOLE NUMBER: BH3
DEPTH (m) START 2.95m - 21.18m END
BOX 3-4 OF 4

STS GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

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

Point Load Strength Index Repor

*t*Project: 3 Holdsworth Avenue, St Leonards

Client: EI Australia Pty Ltd

Address: Suite 6.01, 55 Miller St Pyrmont NSW 2009

~~Test Method: AS 4133.4.1~~

Project No.: 31154/5392d-l
Report No.: 21/2462
Report Date: 30/08/2021
Page: 1 of 3

Sampling Procedure: Samples Supplied By Client (Not covered under NATA Scope of Accreditation)

Date Samples Drilled / Taken: 18/08/2021

Borehole No. 1

Depth	Test Type	Is(50) (Mpa)	Rock Type	Failure Type	Moisture
2.27	A	**0.24**	SS	3	M
3.60	A	**0.62**	SS	3	M
4.42	A	**0.59**	SS	3	M
5.47	A	**0.36**	SS	3	M
6.27	A	**0.53**	SS	3	M
7.61	A	**0.18**	SS	3	M
8.21	A	**0.86**	SS	3	M
9.41	A	**0.15**	SS	3	M
10.55	A	**0.97**	SS	3	M
11.35	A	**1.30**	SS	3	M
12.33	A	**1.20**	SS	3	M
13.45	A	**1.20**	SS	3	M
14.43	A	**1.50**	SS	3	M
15.32	A	**1.60**	SS	3	M
16.38	A	**1.80**	SS	3	M

Sampling Procedure: Samples Supplied By Client (Not covered under NATA Scope of Accreditation)

Date Samples Drilled / Taken: 18/08/2021

Borehole No. 1

Depth	Test Type	Is(50) (Mpa)	Rock Type	Failure Type	Moisture
17.60	A	**1.40**	SS	3	M
18.45	A	**1.40**	SS	3	M
19.35	A	**1.20**	SS	3	M
20.29	A	**1.50**	SS	3	M
21.52	A	**1.90**	SS	3	M
22.37	A	**1.60**	SS	3	M
23.55	A	**2.20**	SS	3	M

FAILURE TYPE
1= FRACTURE THROUGH BEDDING OR WEAK PLANE
2= FRACTURE ALONG BEDDING
3= FRACTURE THROUGH ROCK MASS
4= FRACTURE INFLUENCED BY NATURAL DEFECT OR DRILLING
5= PARTIAL FRACTURE OR CHIP (INVALID RESULT)

TEST TYPE
A= AXIAL
D= DIAMETRAL
I= IRREGULAR
C= CUBE

MOISTURE CONDITION
W= WET
M= MOIST
D= DRY

ROCK TYPE
SS= SANDSTONE
ST= SILTSTONE
SH= SHALE
YS= CLAYSTONE
IG= IGNEOUS

Remarks:

Approved Signatory..... .....

Technician: FV

STS GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

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

Point Load Strength Index Repor

*t*Project: 3 Holdsworth Avenue, St Leonards

Client: EI Australia Pty Ltd

Address: Suite 6.01, 55 Miller St Pyrmont NSW 2009

~~Test Method: AS 4133.4.1~~

Project No.: 31154/5392d-l
Report No.: 21/2462
Report Date: 30/08/2021

Sampling Procedure: Samples Supplied By Client (Not covered under NATA Scope of Accreditation)

Date Samples Drilled / Taken: 18/08/2021

Borehole No. 2

Depth	Test Type	Is(50) (Mpa)	Rock Type	Failure Type	Moisture
3.22	A	**0.44**	SS	3	M
4.09	A	**0.17**	SS	3	M
5.90	A	**0.083**	SS	3	M
6.68	A	**0.33**	SS	3	M
7.45	A	**0.50**	SS	3	M
8.41	A	**0.78**	SS	3	M
9.63	A	**1.70**	SS	3	M
10.23	A	**2.60**	SS	3	M
11.65	A	**1.30**	SS	3	M
12.37	A	**1.30**	SS	3	M
13.43	A	**1.70**	SS	3	M
14.60	A	**0.86**	SS	3	M
15.27	A	**1.80**	SS	3	M
16.48	A	**1.60**	SS	3	M
17.71	A	**1.90**	SS	3	M

Sampling Procedure: Samples Supplied By Client (Not covered under NATA Scope of Accreditation)

Date Samples Drilled / Taken: 18/08/2021

Borehole No. 2

Depth	Test Type	Is(50) (Mpa)	Rock Type	Failure Type	Moisture
18.56	A	**2.10**	SS	3	M
19.40	A	**1.90**	SS	3	M
20.37	A	**1.60**	SS	3	M
21.62	A	**2.90**	SS	3	M

FAILURE TYPE
1= FRACTURE THROUGH BEDDING OR WEAK PLANE
2= FRACTURE ALONG BEDDING
3= FRACTURE THROUGH ROCK MASS
4= FRACTURE INFLUENCED BY NATURAL DEFECT OR DRILLING
5= PARTIAL FRACTURE OR CHIP (INVALID RESULT)

TEST TYPE
A= AXIAL
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MOISTURE CONDITION
W= WET
M= MOIST
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ROCK TYPE
SS= SANDSTONE
ST= SILTSTONE
SH= SHALE
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IG= IGNEOUS

Remarks:

Approved Signatory..... .....

Technician: FV

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Point Load Strength Index Repor

*t*Project: 3 Holdsworth Avenue, St Leonards

Client: EI Australia Pty Ltd

Address: Suite 6.01, 55 Miller St Pyrmont NSW 2009

~~Test Method: AS 4133.4.1~~

Project No.: 31154/5392d-l
Report No.: 21/2462
Report Date: 30/08/2021
Page: 3 of 3

Sampling Procedure: Samples Supplied By Client (Not covered under NATA Scope of Accreditation)

Date Samples Drilled / Taken: 18/08/2021

Borehole No. 3

Depth	Test Type	Is(50) (Mpa)	Rock Type	Failure Type	Moisture
3.70	A	**0.67**	SS	3	M
4.52	A	**0.98**	SS	3	M
5.54	A	**0.55**	SS	3	M
6.56	A	**1.3**	SS	3	M
7.32	A	**0.61**	SS	3	M
8.37	A	**1.50**	SS	3	M
9.64	A	**1.60**	SS	3	M
10.44	A	**1.20**	SS	3	M
11.53	A	**1.90**	SS	3	M
12.36	A	**1.60**	SS	3	M
13.25	A	**1.40**	SS	3	M
14.67	A	**1.40**	SS	3	M
15.55	A	**1.60**	SS	3	M
16.60	A	**1.60**	SS	3	M
17.33	A	**1.70**	SS	3	M

Sampling Procedure: Samples Supplied By Client (Not covered under NATA Scope of Accreditation)

Date Samples Drilled / Taken: 18/08/2021

Borehole No. 3

Depth	Test Type	Is(50) (Mpa)	Rock Type	Failure Type	Moisture
18.56	A	**1.60**	SS	3	M
19.24	A	**1.50**	SS	3	M
20.60	A	**2.60**	SS	3	M
21.13	A	**2.30**	SS	3	M

FAILURE TYPE
1= FRACTURE THROUGH BEDDING OR WEAK PLANE
2= FRACTURE ALONG BEDDING
3= FRACTURE THROUGH ROCK MASS
4= FRACTURE INFLUENCED BY NATURAL DEFECT OR DRILLING
5= PARTIAL FRACTURE OR CHIP (INVALID RESULT)

TEST TYPE
A= AXIAL
D= DIAMETRAL
I= IRREGULAR
C= CUBE

MOISTURE CONDITION
W= WET
M= MOIST
D= DRY

ROCK TYPE
SS= SANDSTONE
ST= SILTSTONE
SH= SHALE
YS= CLAYSTONE
IG= IGNEOUS

Remarks:

Approved Signatory..... .....

Technician: FV

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 (AS1726-2017, 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.

E2 CLASSIFICATION OF ROCKS

E2.1 Uniform Rock Description

The aim of a rock description for engineering purposes is to give an indication of the expected engineering properties of the material.

In a similar manner to soil materials, the assessment of site conditions where rock is encountered has to be based on the use of a descriptive method which is uniform and repeatable. Description has to:

- provide a clear identification of the rock substance and its engineering properties, and
- include details of the features which affect the engineering properties of the rock mass.

There is no internationally accepted system for rock description but STS Geotechnics Pty Ltd has adopted a method which incorporates terminology defined by common usage in the engineering geological profession. Most feature definitions are as recommended by the International Society of Rock Mechanics and by the Standards Association of Australia.

For uniform presentation the different features are described in order:

Rock Substance

- NAME (in block letters)
- Mineralogy
- Grain Size
- Colour
- Fabric
- Strength
- Weathering/Alteration

Rock Mass

- Defect type
- Defect orientation
- Defect features
- Defect spacing

E2.2 Rock Substance

(a) Rock name

Each rock type has a specific name which is based on:

- mineralogy
- grain size
- fabric
- origin

The only method of determining the precise rock name is by thin section petrography.

Field identification of rocks for engineering purposes should be based on the use of common, easily understood, simple, geological names. In many cases knowledge of the precise name is of little consequence in the assessment of site conditions. If required the "field name" can be qualified by reference to a petrographic report. Reference to local geological reports often provides information on the rock types which may be expected.

(b) Mineralogy

The rock description should include the identification of the prominent minerals. This identification is usually restricted to the more common minerals in medium and coarse grained rocks.

(c) Grain Size

Rock material descriptions should include general grouping of the size of the predominant mineral grains as defined in Table E2.2.1. The maximum size, or size range, of the larger mineral grains or rock fragments should be recorded.

TABLE E2.2.1. - GRAIN SIZE GROUPS

TERM	GRAIN SIZE (mm)
Very Coarse	>60
Coarse	2 – 60
Medium	0.06 – 2
Fine	0.002 - 0.06
Very Fine	<0.002
Glassy	

(d) Colour

The colour of the rock 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 by a combination of two colours, eg: grey-blue.

(e) Fabric

The fabric of a rock includes all the features of texture and structure, though the term refers specifically to the arrangement of the constituent grains or crystals in a rock. The fabric can provide an indication of the mode of formation of the rock:

- in sedimentary rocks bedding indicates depositional conditions,
- in igneous rocks the texture indicates the rate of cooling, and
- in metamorphic rocks the foliation indicates the stress conditions

Descriptions of fabric should include structure orientation, either with reference to North and horizontal, or to a plane normal to the core axis.

Tables E2.2.2, E2.2.3 and E2.2.4 list common textural features of sedimentary, igneous and metamorphic rocks with the subdivision of stratification spacing in Table E2.2.5.

TABLE E2.2.2 - COMMON STRUCTURES IN IGNEOUS ROCKS

STRATIFICATION (Planar)	STRATIFICATION (Irregular)
Bedding	Washout
Cross Bedding	Slump Structure
Graded Bedding	Shale Breccia
Lamination	

TABLE E2.2.3 - COMMON STRUCTURES IN IGNEOUS ROCKS

	FINE GRAINED ROCKS	COARSE GRAINED ROCKS
Uniform Grain Size	Massive	Massive
	Flow Banded	Granitic
	Vesicular	Pegmatitic
Different Grain Size	Porphyritic	Porphyritic

TABLE E.2.2.4 - COMMON STRUCTURES IN METAMORPHIC ROCKS

FINE GRAINED ROCKS	COARSE GRAINED ROCKS
Slatey Cleavage	Granoblastic
Spotted	Porphyroblastic
Hornsfelsic	Lincated
Foliated	Gneissic
Mylonitic	Mylonitic

TABLE E2.2.5 - STRATIFICATION SPACING

TERM	SEPARATION (mm)
Very Thickly Bedded	>2000
Thickly Bedded	600 - 2000
Medium Bedded	200 - 600
Thinly Bedded	60 - 200
Very Thinly Bedded	20 - 60
Laminated	6 - 20
Thinly Laminated	<6

(f) Strength

Substance strength is one of the most important engineering features of a rock and every description should include at least an estimate of the rock strength class of the material. This estimate can be calibrated by test results, either by Point Loan Strength Index or by Unconfined Compressive Strength.

The rock strength class in As 1726-2017 is defined by Point Loan Strength Index I_s,(50). The relationship between Point Loan and Unconfined Strength is commonly assumed to be about 20, but can range from 4 (in some carbonate rocks) to 40 (in some igneous rocks). It is necessary to confirm the relationship for each rock type and project. classification should be based on material at field moisture content, as some rocks give a significantly higher strength when tested dry.

Table E2.2.6 defines the rock strength classes, with indicative field tests listed in Table E2.2.7 which assist in classification when testing equipment is not available.

TABLE E2.2.6 - CLASSIFICATION OF ROCK STRENGTH

SYMBOL	TERM	POINT LOAD STRENGTH (MPa)	APPROX Qu (MPa)
EL	Extremely low	<0.03	<1
VL	very low	0.03 - 0.1	1 - 3
L	Low	0.1 - 0.3	3 - 10
M	Medium	0.3 - 1	10 - 30
H	High	1 - 3	30 - 70
VH	very high	3 - 10	70 - 200
EH	Extremely high	>10	>200

TABLE E2.2.7 - FIELD TESTS FOR ROCK STRENGTH CLASSIFICATION

STRENGTH CLASS	FIELD TEST
Extremely Low	Indented by thumb nail with difficulty
Very Low	Scratched by thumb nail
Low	Easily broken by hand or pared with a knife
Medium	Broken by hand or scraped with a knife
High	Broken in hand by firm hammer blows
Very High	Broken against solid object with several hammer blow
Extremely High	Difficult to break against solid object with several hammer blows

(g) Weathering/Alteration

In addition to the description of rock substance as examined, an assessment is required of the extent to which the original rock material has been affected by subsequent events. The usual processes are:

- Weathering - Decomposition due to the effect of surface or near surface activities
- Alteration - Chemical modification by the action of materials originating from within the mantle below.

The classification of weathering/alteration presented in Table E2.2.8 is based on the extent/degree to which the original rock substance has been affected. This classification has little engineering significance, as the properties of the rock as examined may bear no relationship to the properties of the fresh rock.

TABLE E2.2.8 - CLASSIFICATION OR ROCK WEATHERING/ALTERATION

TERMS	DEFINITION
Fresh (Fr)	Rock substance unaffected.
Fresh Stained (FR St)	Rock substance unaffected. Staining of defect surfaces.
Slightly (SW)	Partial staining or discolouration of rock substance.
Moderately (MW)	Staining or discolouration extends throughout the whole rock substance.
Highly (HW)	Rock substance partly decomposed.
Completely (CW)	Rock substance entirely decomposed.

E2.3 Rock Mass

The engineering properties of rock mass reflect the effect which the presence of defects has on the properties of the rock substance. Description of the rock mass properties consists of supplementing the description covered by Section E2.2 with data on the defects which are present.

(a) Defect type

The different defect types are described in Table E2.3.1.

(b) Defect orientation

Descriptions of defects should include orientation, either of individual fractures or of groups of fractures. Orientation should be with reference to North and horizontal, or to a plane normal to the core axis.

TABLE E2.3.1 - ROCK DEFECT TYPES

TYPE	SYMBOL	DESCRIPTION
Parting	Pt	A defect parallel or subparallel to a layered arrangement of mineral grains or micro-fractures which has caused planar anistrophy in the rock substance.
Joint	Jt	A defect across which the rock substance has little tensile strength and is not related to textural or structural features with the rock substance.
Sheared Zone	SZ	A zone with roughly parallel planar boundaries or rock substance containing closely spaced, often slickensided, joints.
Crushed Zone	CZ	A zone with roughly parallel planar boundaries of rock substance composed of disoriented, usually angular, fragments of rock.
Seam	Sm	A zone with roughly parallel boundaries infilled by soil or decomposed rock.
Drilling Break	DB	Break in core due to drilling
Handling Break	HB	Break in core during handling

(c) Defect features

The character of a defect is described by its continuity, planarity, surface roughness, width, and infilling.

Continuity In outcrop the extent of a joint, bedding plane or similar defect both along and across the strike can be measured. In core, continuity measurement is restricted to defects nearly parallel to the core axis.

Planarity Described as “Planar”, “Irregular”, “Curved” or “Undulose”.

Roughness Described as “Rough”, “Smooth”, “Polished” or “Slickensided”.

Width Measured in millimetres normal to the plane of the defect

Infilling Described as “Clean”, “Stained”, “Veneer” (<1 mm) or “Infill” (>1 mm). The coating or infilling material should be identified.

(d) Defect spacing

The spacing of defects, particularly where they occur in parallel groups or sets, provides an indication of the rock block sizes which:

- have to be supported in the face or roof of an excavation
- will be produced by the excavation operation.

It is preferable to provide measured data but discontinuity spacing is grouped as shown in Table E2.3.2.

TABLE E2.3.2 - DISCONTINUITY SPACING

DESCRIPTION	SPACING (mm)
Extremely Widely Spaced	>6000
Very Widely Spaced	2000 - 6000
Widely Spaced	600 - 2000
Medium Spaced	200 - 600
Closely Spaced	60 - 200
Very Closely Spaced	20 - 60
Extremely Closely Spaced	<20

E3. DESCRIPTION OF WELL CONSTRUCTION, PID AND GROUNDWATER SYMBOLS

TABLE E3.1 – BORE CONSTRUCTION DETAILS

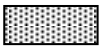
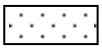
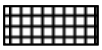
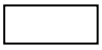
SHADING / SYMBOL	DESCRIPTION
	Cement-Based Grout
	Bentonite Seal
	Sand Filter
	Borehole Cuttings
	Class 18 PVC casing
	Class 18 PVC Slotted Screen
	End Caps
	Vapour Probe Tip
	Teflon Tubing

TABLE E3.2 – PID SYMBOLS

SYMBOL	MEANING
I	Insitu
A	Above Soil
H	Headspace

TABLE E3.3 – WATERTABLE SYMBOLS

SYMBOL	DESCRIPTION
	Standing Water Level
	Inflow
	Outflow

APPENDIX B – LABORATORY TEST RESULTS

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2130408**	Page	: 1 of 2
Client	: **STS Geotechnics**	Laboratory	: Environmental Division Sydney
Contact	: ENQUIRES STS	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	: 31154/5392D-R	Date Samples Received	: 20-Aug-2021 12:50
Order number	: E-2021-0277	Date Analysis Commenced	: 23-Aug-2021
C-O-C number	: ----	Issue Date	: 24-Aug-2021 16:32
Sampler	: IW		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 2		
No. of samples analysed	: 2		

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.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	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 Contact for details.

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

- ED045G: The presence of Thiocyante, Thiosulfate and Sulfite can positively contribute to the Chloride result, thereby may bias higher than expected. Results should be scrutinised accordingly.

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			Sample ID	**31154/BH1/S1**	**31154/BH3/S2**	**----**	**----**	**----**
			Sampling date / time	18-Aug-2021 00:00	18-Aug-2021 00:00	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**ES2130408-001**	**ES2130408-002**	**--------**	**--------**	**--------**
				Result	Result	----	----	----
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**5.0**	**5.8**	**----**	**----**	**----**
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**32**	**14**	**----**	**----**	**----**
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**11.8**	**14.4**	**----**	**----**	**----**
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**10**	<10	**----**	**----**	**----**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	**20**	<10	**----**	**----**	**----**