GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

GEOTECHNICAL INVESTIGATION

FOR

DREAMBUILD PTY LIMITED

1 Bilambee Lane, Bilgola Plateau, New South Wales

Report No: 20/1862

Project No: 30538/3959D-G

June 2020

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1. INTRODUCTION

This report presents the results of a geotechnical investigation carried out by STS Geotechnics Pty Limited (STS) for a proposed new mixed-use development to be constructed at 1 Bilambee Lane, Bilgola Plateau. We have been informed the development comprises the demolition of existing structures on the site prior to the construction of a three level mixed use building comprising a ground floor commercial space and two levels of residential units, together with two levels of basement carparking. We understand that construction of the basement will require excavating up to 6 metres below the ground surface.

The purpose of the investigation was to:

- assess the subsurface conditions over the site,
- provide a Site Classification to AS2870,
- provide recommendations regarding the appropriate foundation system for the site including design parameters,
- comment on excavation conditions and provide parameters for the temporary and permanent support of the excavation, and
- comment on soil aggressiveness to buried steel and concrete.

This report has been written to support a DA for Northern Beaches Council. The investigation was undertaken at the request of Dreambuild Pty Limited.

Our scope of work did not include a contamination assessment.

2. NATURE OF THE INVESTIGATION

2.1. Fieldwork

The fieldwork consisted of drilling two (2) boreholes numbered BH101 and BH102, at the locations shown on Drawing No. 20/1862. The boreholes were drilled using a track mounted Hanjin DB8 drilling rig owned and operated by BG Drilling. Soils and weathered rock were drilled using rotary solid flight augers. Soil strengths were determined by undertaking

Standard Penetration Tests (SPT) at each borehole location. In order to measure the groundwater levels, a PVC standpipe piezometer was installed in BH101.

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

The subsurface conditions observed are recorded on the borehole logs given in Appendix A together with the core photos 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.

2.2. Laboratory Testing

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

- pH,
- Sulfate content (SO_4),
- Chloride content (Cl), and
- Electrical Conductivity (EC).

The detailed test reports are given in Appendix B.

3. GEOLOGY AND SITE CONDITIONS

The Sydney geological series sheet at a scale of 1:100,000 indicates that the site is underlain by Triassic Age bedrock belonging to the Hawkesbury Sandstone formation. Bedrock within this formation comprises fine to medium grained quartz sandstone.

The site is irregular in shape with an area of approximately 930m^2. We understand that the site is a former service station, and at the time of the fieldwork the site was occupied by a brick and clad commercial building with metal roof, a canopy structure and separate shed. The existing ground surface is covered by a concrete slab, however a section of the slab has been removed and backfilled with gravel. We understand that this likely occurred during the removal and backfilling of buried fuel storage tanks. Site vegetation comprised grass and shrubs in the garden beds along the site boundaries.

The ground surface falls approximately 0.5 metres to the east.

To the north, east and south of the site are Bilambee Lane, Bilkura Avenue and Bilambee Avenue, respectively. To the west of the site are a series of two storey brick commercial buildings that extend to the site boundary.

4. SUBSURFACE CONDITIONS

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

The subsurface conditions generally consist of concrete and fill overlying silty sandy clays, clayey sands and weathered sandstone. Concrete was cored in BH102 with a thickness of 110 mm. Fill was encountered in BH101 to a depth of 2.9 metres and appeared poorly compacted. The fill is likely to be associated with the backfilling of old fuel storage tanks.

Natural silty sandy clays, clayey sands and sandy clays were encountered below the fill in BH101, and below the concrete in BH102. The natural soils extend to depths of 11.2 to 11.3 metres, and the soils were assessed to be residual in origin below depths of 5.0 to 5.7 metres. The strength of the soils varies from firm to stiff, stiff and very stiff. The residual soils were assessed to be typically stiff and very stiff. Weathered sandstone (equivalent to Class V) underlies the soils and continued to the termination depth of 12 metres in both boreholes.

Groundwater seepage was observed at depths of 6.5 metres in BH101 and 8.4 metres in BH102 during drilling. The piezometer installed in BH101 was bailed on completion of drilling. The water level in BH101 was re-measured after a period of 12 days. The water level was recorded as 6.2 metres in BH101.

5. DISCUSSION

5.1. Site Classification to AS2870

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

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

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

5.2. Excavation Conditions and Support

Based on the subsurface conditions observed in the boreholes the proposed basement excavation will encounter concrete, fill and natural soils consisting of clayey sands and silty sandy clays, and possibly completely weathered sandstone. Excavators without assistance should be able to remove the soils and any weathered sandstone to the proposed depth of excavation, 6.0 metres. Some ripping may be required if higher strength bands of sandstone or ironstone are encountered.

It is of course important that the onsite excavations are adequately supported at all times and do not endanger the adjacent properties. Temporary slopes in the natural soils and weathered rock may be constructed at a maximum angle of 1 to 1. Where this is not possible it will be necessary to provide temporary support.

For excavations in cohesive (clayey) soils, a solider pile wall with shotcrete infill panels is typically the most effective method of support. However, if sandy lenses are present then the soils between the piles can collapse before the shotcrete has been installed. Therefore, if soldier piles are adopted, we would recommend adopting a pile spacing of no greater than 2.5 times the pile dimeter (centre to centre). Alternatively, you may wish to consider the use of contiguous bored piles or steel sheet piles. Steel sheet piles would however need to be vibrated into position, and may require pre-drilling to penetrate the lower very stiff clays, and therefore may be less suited to the site than bored piles. Regardless of which system is adopted the support will need to be fixed into the materials below the base of the excavation.

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

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

Soil:

Active Earth Pressure Coefficient (K_a)	=	0.4
At Rest Pressure Coefficient (K_o)	=	0.55
Passive Earth Pressure Coefficient (K_p)	=	3.0 (Very Stiff Clay)
Total (Bulk) Density	=	20 kN/m^3

Weathered Sandstone (Class V)):

Passive Earth Pressure Coefficient (K_p)	=	4.0 (Class V)
Total (Bulk) Density	=	20 kN/m^3

Based on the observations during drilling and in the piezometers, the basement excavation is not expected to encounter the groundwater table. However, some minor perched water seepage may flow into the excavation from the soils. The inflow rates are likely to be minor and therefore a sump and a pump should be sufficient to control the anticipated seepage during construction.

Some localised dewatering may also be required during foundation construction or for other structures that extend below the basement such as OSD tanks and lift pits.

In the long term the lift pit and OSD should be sealed/waterproofed. A gravel drainage layer should be installed below the basement floor slab with a series of interconnected subsoil drains to channel any seepage to the sump, which should be fitted with a failsafe pump.

5.3. Foundation Design

The existing fill materials in the vicinity of the tank backfill should not be relied upon for foundation support. High level footings that bear in firm to stiff natural clayey soils may be proportioned using an allowable bearing pressure of 100 kPa. The minimum depth of founding must comply with the requirements of AS2870.

After the basement excavation has been completed the exposed material will likely comprise a very stiff residual clay. An allowable bearing pressure of 300 kPa applies to footings or piles founded in very stiff clays. For piled foundations, an allowable adhesion of 20 kPa may be adopted for the portion of the pile shaft below a depth of 0.5 metres in natural soils.

Should a higher bearing pressure be required then the building loads may be transferred to the underlying weathered bedrock using piles.

An allowable bearing pressure of 700 kPa applies to piles founded in weathered sandstone. An allowable adhesion of 70 kPa applies to the portion of the pile shaft within the weathered rock. When piers are founded in rock the adhesion in the overlying soils must be ignored.

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

The possible presence of groundwater needs to be considered when drilling piers and pouring concrete. Temporary liners may be required to support the pile sidewalls when drilling piles below the groundwater table. Liners may also be required if piles are drilled through the existing tank backfill. Any groundwater that accumulates in the base of the piles during installation will need to be removed using pumps prior to pouring the concrete. Alternatively, the concrete may be poured using the Tremie method to displace any water from the pile base.

5.4. Soil Aggressiveness

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

Table 5.1 – Soil Aggressiveness Summary Table

Sample No.	Location	Depth (m)	pH	Sulfate (mg/kg)	Chloride (mg/kg)	Electrical Conductivity (dS/m)	
						$EC_{1:5}$	EC_e
S1	BH2	1.1	5.7	200	<10	0.103	0.7
S2	BH2	4.4	5.4	<10	<10	0.016	0.2

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

The report results range between:

- pH - 5.4 and 5.7
- soluble SO_4 - <10 and 200 mg/kg (ppm)
- soluble chloride - <10 mg/kg (ppm)
- Electrical Conductivity EC_e 0.2 and 0.7 Ds/.m

A review of the durability aspects indicates that:

- pH : minimum value of 5.4
- SO_4 : maximum value of 200 mg/kg (ppm) < 5000 ppm
- Cl : maximum value of <10 mg/kg (ppm) < 5000 ppm
- EC_e : maximum value of 0.7 dS/m

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

Reference to DLWC (2002) “Site Investigations for Urban Salinity” indicates that EC_e values of 0.2 and 0.7 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.

It is important the excavation is inspected regularly as it progresses. Also the exposed bearing surfaces for footings should be inspected by a geotechnical engineer to ensure the allowable pressure given has been achieved.

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

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Matthew Green
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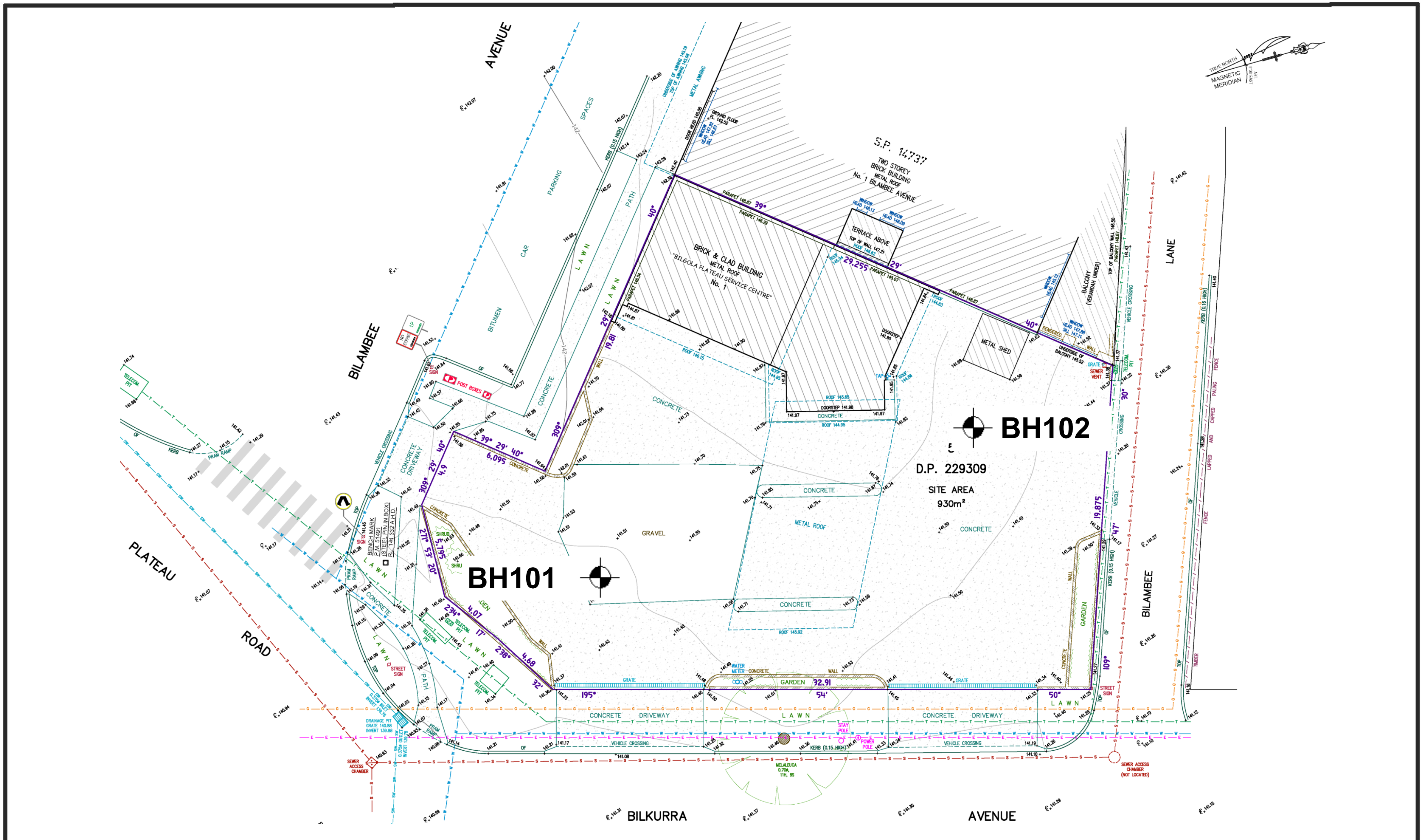
STS Geotechnics Pty Limited



STS Geotechnics Pty. Ltd.	Scale: Unknown	Date: June 2020
Client: DREAMBUILD		
GEOTECHNICAL INVESTIGATION 1 BILAMBEE LANE, BILGOLA PLATEAU BOREHOLE LOCATIONS		Project No. 30538/3959D-G Drawing No: 20/1862

NOTES RELATING TO GEOTECHNICAL REPORTS

Introduction

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

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

Geotechnical Reports

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

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

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

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

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

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

Unforeseen Conditions

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

Subsurface Information

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

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

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

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

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

Supply of Geotechnical Information or Tendering Purposes

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

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APPENDIX A – BOREHOLE LOGS AND EXPLANATION SHEETS

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Dreambuild	Project / STS No. 30538/3959D-G		BOREHOLE NO.: BH 101
Project: 1 Bilambee Lane, Bilgola Plateau	Date: June 12, 2020		
Location: Refer to Drawing No. 20/1862	Logged: JK	Checked By: MG	Sheet 1 of 2

WATER TABLE	SAMPLES	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT (Soil type, colour, grain size, plasticity, minor components, observations)	SYMBOL	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	MOISTURE
			CONCRETE: (110 mm thick)			
	S1 @ 1.1m SPT 1.0-1.45m 2, 3, 2 N=5 SPT 2.5-2.95m 2, 4, 5 N=9 SPT 4.0-4.45m 5, 5, 6 N=11	1.0 2.0 3.0 4.0	SILTY SANDY CLAY: orange brown, fine grained, medium to high plasticity	CL/CH	FIRM TO STIFF STIFF	M
	S2 @4.4m SPT 5.5-5.95m 5, 5, 6 N=11	5.0	CLAYEY SAND: yellow brown/orange brown with light grey, fine to medium grained	SC	STIFF	M
			CLAYEY SAND: light grey with orange brown, fine to medium grained (CW Sandstone)	SC	STIFF	M

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

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

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

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Dreambuild	Project / STS No. 30538/3959D-G	**BOREHOLE NO.: BH 101**
Project: 1 Bilambee Lane, Bilgola Plateau	Date: June 12, 2020	
Location: Refer to Drawing No. 20/1862	Logged: JK Checked By: MG	Sheet 2 of 2

WATER TABLE	SAMPLES	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT (Soil type, colour, grain size, plasticity, minor components, observations)	SYMBOL	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	MOISTURE
			CLAYEY SAND: light grey with orange brown, fine to medium grained (CW Sandstone)	SC	STIFF	M
					VERY STIFF	
	SPT 7.0-7.45m 18, 25, 30 N=55	7.0				
		8.0				
			SILTY SANDY CLAY: light grey, fine grained sand, medium to high plasticity (CW Sandstone)	CL/CH	VERY STIFF	M-W
WT 12/6/20	SPT 8.5-8.95m 10, 16, 22 N=38					
		9.0				
	SPT 10.0-10.15m 22+ N>22	10.0				
						M-D
		11.0				
	SPT 11.5m 32 N>32		WEATHERED SANDSTONE: red brown, fine to medium grained		EXTREMELY LOW STRENGTH	D
			BOREHOLE DISCONTINUED AT 12.0 M ON WEATHERED SANDSTONE			

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: BG Drilling
Equipment: Hanjin
Hole Diameter (mm): 100
Angle from Vertical (^{o}): 0
Drill Bit: Spiral

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

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Dreambuild	Project / STS No. 30538/3959D-G		BOREHOLE NO.: BH 102
Project: 1 Bilambee Lane, Bilgola Plateau	Date: June 12, 2020		
Location: Refer to Drawing No. 20/1862	Logged: JK	Checked By: MG	Sheet 1 of 2

WATER TABLE	SAMPLES	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT (Soil type, colour, grain size, plasticity, minor components, observations)	SYMBOL	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	MOISTURE
			FILL: GRAVELLY CLAYEY SAND: light brown with light grey and orange brown, fine to medium grained, some sandstone gravel	SC	APPEARS POORLY COMPACTED	D-M
	SPT 1.0-1.45m 3, 4, 3 N=7	1.0				
		2.0				
	SPT 2.5-2.95m 1, 1, 1 N=2					
		3.0	SILTY SANDY CLAY: orange brown, fine grained, medium plasticity	CL	FIRM TO STIFF	M
	SPT 4.0-4.45m 2, 2, 3 N-5	4.0				
		5.0	SANDY CLAY: light grey with orange brown, fine to medium grained sand, (CW Sandstone)	CL	VERY STIFF	M
	SPT 5.5-5.95m 12, 14, 16 N=30					

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: BG Drilling
Equipment: Hanjin
Hole Diameter (mm): 100
Angle from Vertical (°): 0
Drill Bit: Spiral

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

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Dreambuild	Project / STS No. 30538/3959D-G	**BOREHOLE NO.: BH 102**
Project: 1 Bilambee Lane, Bilgola Plateau	Date: June 12, 2020	
Location: Refer to Drawing No. 20/1862	Logged: JK Checked By: MG	Sheet 2 of 2

WATER TABLE	SAMPLES	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT (Soil type, colour, grain size, plasticity, minor components, observations)	SYMBOL	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	MOISTURE
WT 24/6/20 WT 12/6/20			SANDY CLAY: light grey with orange brown, fine to medium grained sand, (CW Sandstone)	CL	VERY STIFF	M-W
	SPT 7.0-7.45m 12, 15, 19 N=34	7.0				
		8.0				
	SPT 8.5-8.95m 12, 12, 15 N=27		SILTY SANDY CLAY: light grey with dark grey bands, fine grained sand, medium plasticity (CW Sandstone)	CL	VERY STIFF	M
		9.0				
		10.0				
		11.0	SANDY CLAY: red brown with light grey, fine grained sand, medium plasticity (CW Sandstone)	SC	VERY STIFF	M
	SPT 11.5m 22+ N>22		WEATHERED SANDSTONE: orange brown, fine to medium grained STANDPIPE PIEZOMETER INSTALLED		EXTREMELY LOW STRENGTH	D
			BOREHOLE DISCONTINUED AT 12.0 M ON WEATHERED SANDSTONE			

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: BG Drilling
Equipment: Hanjin
Hole Diameter (mm): 100
Angle from Vertical (°): 0
Drill Bit: Spiral

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_c (MPa)	DENSITY INDEX (%)
Very Loose	0 - 3	0 - 2	0 - 15
Loose	3 - 8	2 - 5	15 - 35
Medium Dense	8 - 25	5 - 15	35 - 65
Dense	25 - 42	15 - 20	65 - 85
Very Dense	>42	>20	>85

E1.4 Soil Structure

(a) Zoning

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

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

(b) Defects

Defects which are present in the sample can include:

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

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

E1.5 Soil Origin

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

Common terms used are:

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

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

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

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

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

E1.6 Fine Grained Soils

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

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

The field characteristics of clay soils include:

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

The field characteristics of silt soils include:

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

E1.7 Organic Soils

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

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

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

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

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

APPENDIX B – LABORATORY TEST RESULTS

CERTIFICATE OF ANALYSIS

Work Order	: **ES2020538**	Page	: 1 of 4
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	: 30046/30055/30523/30543/30538/30544	Date Samples Received	: 15-Jun-2020 12:45
Order number	: E-2020-0214	Date Analysis Commenced	: 16-Jun-2020
C-O-C number	: ----	Issue Date	: 18-Jun-2020 14:20
Sampler	: ----		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 9		
No. of samples analysed	: 9		

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. 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: LOR raised for Chloride on sample 4 due to sample matrix.

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

Compound	CAS Number	LOR	Unit	30046/323	30046/325	30055/6601	30523/S1	30543/S1
Client sampling date / time				12-Jun-2020 00:00	12-Jun-2020 00:00	12-Jun-2020 00:00	12-Jun-2020 00:00	12-Jun-2020 00:00
				ES2020538-001	ES2020538-002	ES2020538-003	ES2020538-004	ES2020538-005
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**7.0**	**5.9**	**6.9**	**7.4**	**5.7**
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**100**	**28**	**322**	**32**	**386**
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**7.5**	**9.4**	**9.0**	**19.4**	**9.7**
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**60**	**40**	**240**	**70**	**350**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	----	----	----	<100	**240**

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL**)

			Client sample ID	30538/S1	30538/S2	30544/S1	30544/S2	----
			Client sampling date / time	12-Jun-2020 00:00	12-Jun-2020 00:00	12-Jun-2020 00:00	12-Jun-2020 00:00	----
Compound	CAS Number	LOR	Unit	ES2020538-006	ES2020538-007	ES2020538-008	ES2020538-009	--------
				Result	Result	Result	Result	----
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.7	5.4	5.8	5.7	----
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	103	16	195	476	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	20.1	8.4	20.8	15.6	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	200	<10	240	270	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	<10	100	490	----