Place Studio AU Pty Ltd

Project: Proposed Residential Development
Site Location: 20 Heradale Pde, Batemans Bay NSW
Reference: GR23206-A Rev 01
Report Date: 03/09/2024

RE: Groundwater Assessment

1. Introduction

We, CEC Pty Ltd (CEC Geotechnical), the practicing Geotechnical Engineers for the project, carried out a groundwater assessment for the development at the above **20 Heradale Pde, Batemans Bay NSW.**

1.1 Provided Information

The following information was received relevant to this assessment:

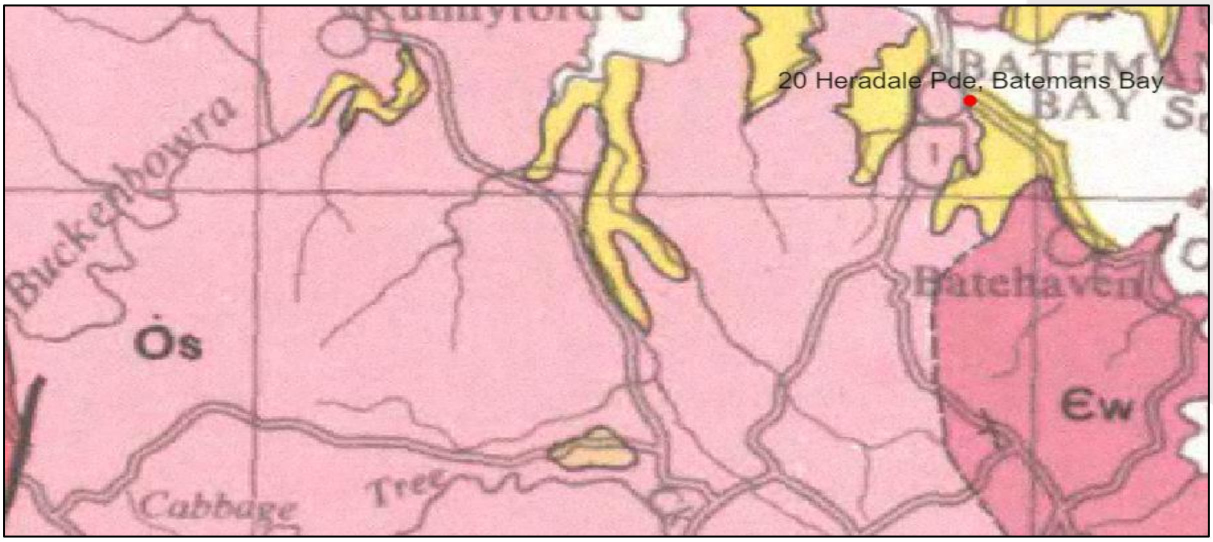
- A set of Architectural including site plans, floor plans, elevations and sections, prepared by Place Studio, Project No. 2021029, Rev E issued 03/09/2024.
- Geotechnical Desktop Assessment for 20 Heradale Pde Batemans Bay by CEC Geotechnical Ref. GR22297 dated 10/01/2023
- Geotechnical Investigation for 20 Heradale Pde Batemans Bay by CEC Geotechnical Ref. GR23206 Rev 01 dated 03/09/2024.

2. Desktop Assessment

2.1 Topography and Geological Description

Based on the architectural drawings, the site is relatively flat. The 1:100,000 scale Geological map of the Ulladulla region (Figure 1) indicates that the subject site is underlain by (Os) which consists of siltstone, claystone, sandstone, quartzite and chert from the Ordovician period.

Figure 1: 1:100,000 scale Geological Series Map of the Ulladulla Region



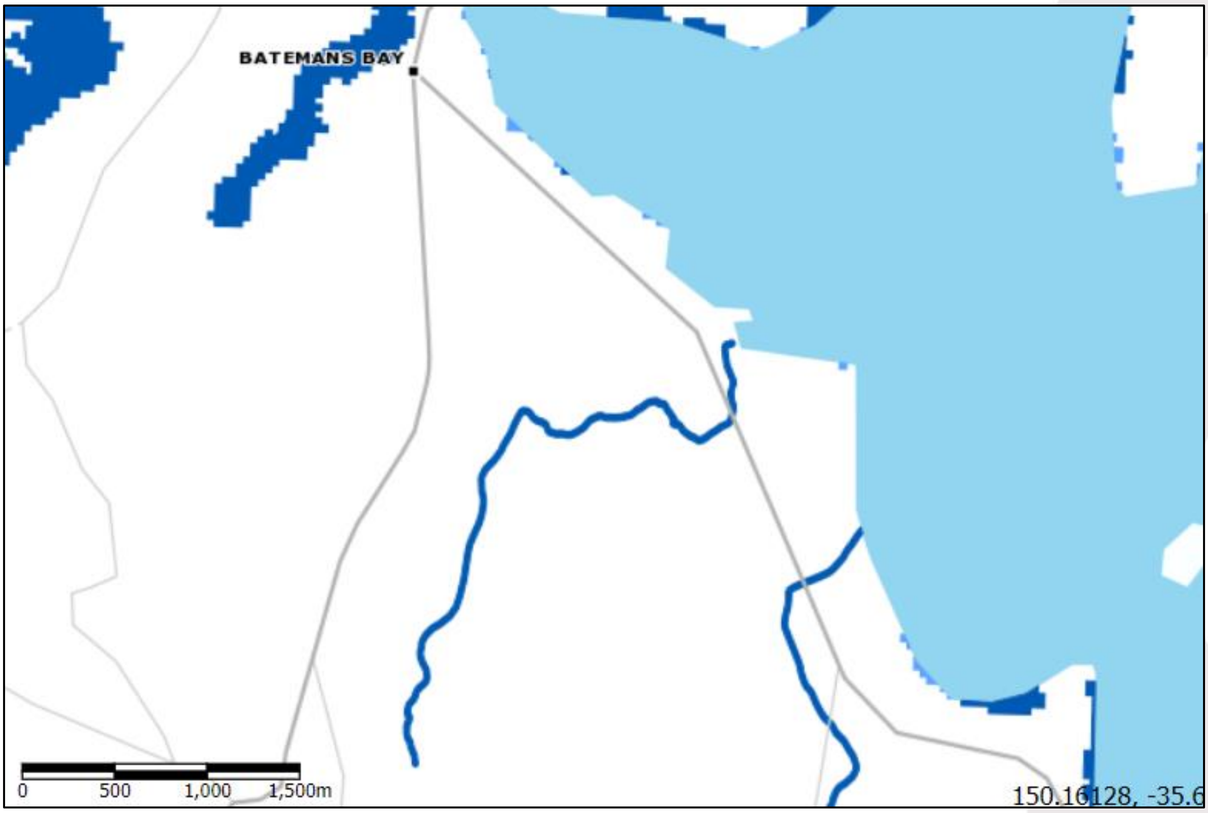
2.2 Groundwater Map

The Bureau of Meteorology (BOM) Groundwater Atlas provides the following information:

- There are no identified water supply bores within 500 m of the site.
- There are no identified groundwater dependent ecosystems within 500 m of the site.

Nearby bores and the absence of nearby Groundwater Dependent Ecosystems (GDE) are shown below is shown in Figure 2.

Figure 2: Groundwater Atlas Map of GDE



3. Investigation

The geotechnical site investigation was carried out on 14/10/2023 and included drilling of 6 boreholes to a maximum depth of 10m. Four groundwater monitoring wells were installed in the boreholes (BH01, BH02, BH03 and BH04). The Groundwater levels were measured during additional site visits on 14th of Oct 2023, 19th of Oct 2023 and 25th of Oct 2023 are summarised in the table below. The measurement was conducted after the fieldwork was completed to allow the groundwater levels to stabilise. A geotechnical engineer regularly monitored the water levels for 3 weeks to establish a baseline groundwater level at the proposed site.

Table 1: Observed Groundwater Levels

Groundwater Well	Borehole	Ground RL	Groundwater Level (m bgl)/RL			Approximate depth of Rock Level Encountered bgl
			14/10/23	19/10/23	25/10/2023	
GW1	BH01	2.17	2.10m/ RL 0.07	1.7m/ RL 0.47	1.65m/ RL 0.52	4.1m/ RL -1.93
GW2	BH02	1.94	1.60m/ RL 0.34	1.6m/ RL 0.34	1.56m/ RL 0.38	5.8m/ RL -3.86
GW3	BH04	1.78	1.61m/ RL 0.17	1.4m/ RL 0.38	1.54m/ RL 0.24	4.1m/ RL -2.32
GW4	BH05	1.67	1.55m/ RL 0.12	1.65m/ RL0.02	1.58m/ RL0.09	3.5m/ RL -1.83

4. Groundwater Modelling

A finite element analysis was carried out to estimate the seepage volume and phreatic surface after drawdown.

The subsurface materials used in the analysis were based on the rock core drilling and groundwater well installation/monitoring undertaken by CEC Geotechnical in October and November 2023. The subsurface profile is summarised in Table 2 below.

Table 2: Subsurface Profile

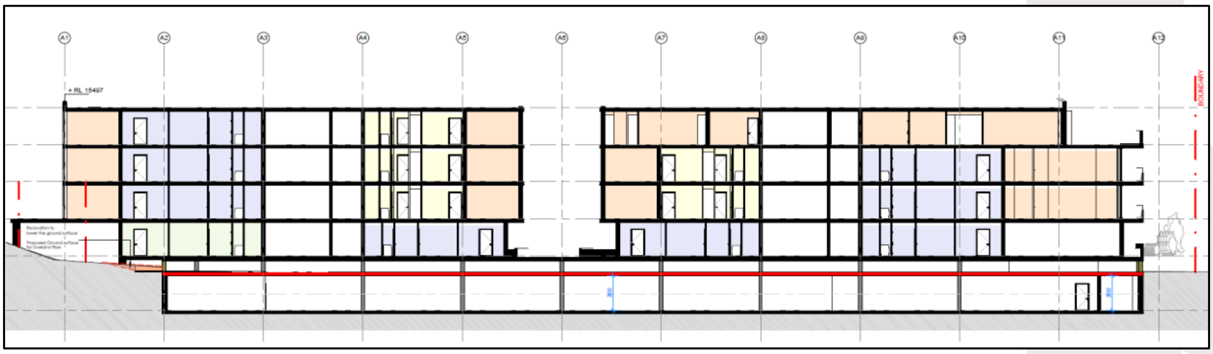
Unit	Description	BH01 (m)*	BH02 (m)*	BH03 (m)*	BH04 (m)*	BH05 (m)*	BH06 (m)*
Unit – 1: Topsoil	Sandy SILT (ML): soft, low plasticity, brown yellow	0.0 – 0.2	0.0 – 0.2	0.0 – 0.2	0.0 – 0.2	0.0 – 0.2	0.0 – 0.2
Unit – 2: Marine Deposit	Clayey SAND (SC): loose to medium, low to medium plasticity clay, brown yellow	0.2 – 2.8	0.2 – 2.8	0.2 – 2.2	0.2 – 3.6	0.2 – 2.8	0.2 – 2.5
Unit – 3: Residual	Silty CLAY (CI): stiff to hard, medium plasticity, grey brown	2.8 – 4.1	2.8 – 5.8	2.2 – 5.5	3.6 – 5.8	2.8 – 4.1	2.5 – 3.5
Unit – 4: Rock (Class V)	Extremely weathered, rock Silty CLAY (SHL): hard, low plasticity, brown, orange	4.1 – 7.0	5.8 – 7.0	5.5 – 7.0	5.8 – 8.3	4.1 – 6.8	3.5 – 6.0
Unit – 5: Rock (Class IV)	SILTSTONE: distinctly weathered, low to medium strength, grey, brown	7.0 – 9.5	7 - 10	-	8.3 – 10	6.8 – 10	-

**The high permeability of the soil is due to fractures and verification through the pump test carried out onsite.*

Figure 2: Coring Photos – Borehole BH01 (Top) and BH02 (Bottom)

The Numerical modelling was carried out based on the information from the architectural drawing as shown on Figure 3 below.

Figure 3: Section Used for Groundwater Modelling



The analysis was carried out based on the available information including geotechnical information, groundwater level monitoring during a 1-month period, rainfall history and its impact on groundwater level and the anticipated duration of construction.

5. Seepage Modelling Analysis

The subsurface profile and permeability parameters required for the analysis are summarised in Table 2. A steady state finite element model was used to estimate the flow rates.

Figures 5 shows the model geometry. Figure 6 shows results of seepage analysis including the seepage vectors. A steady state analysis was carried out with the groundwater with the initial level being 1m below the ground level. Groundwater was drawn down to the base of the excavation in the basement area. This was then analysed with the established phreatic surface and seepage velocity and volume calculated. Secant piles are used as shoring wall that provides a semi-impermeable wall against seepage.

Figure 5: Model Geometry for Numerical modelling

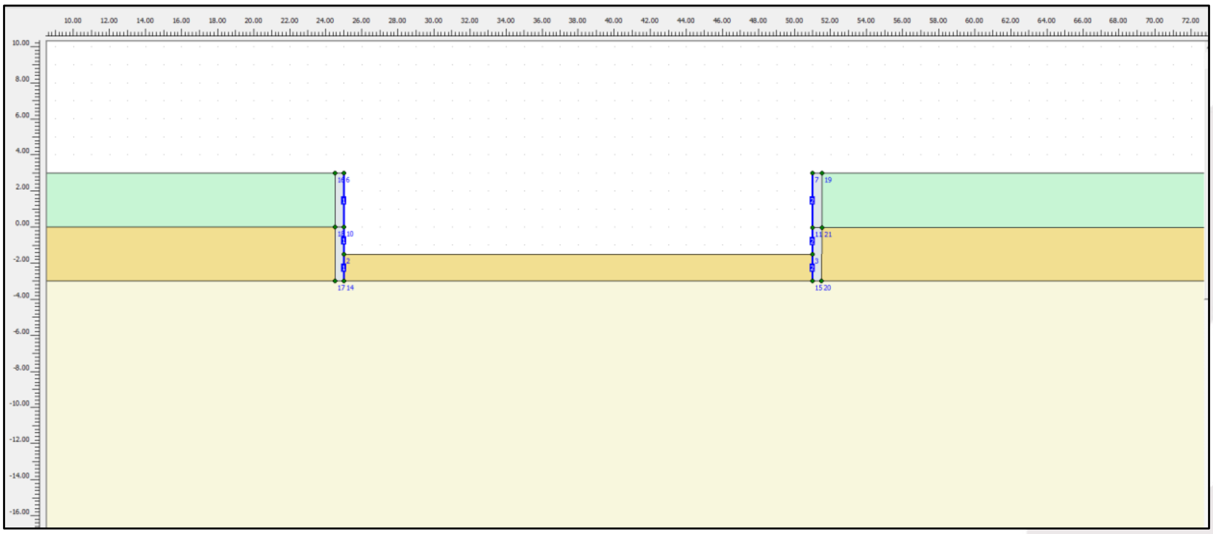
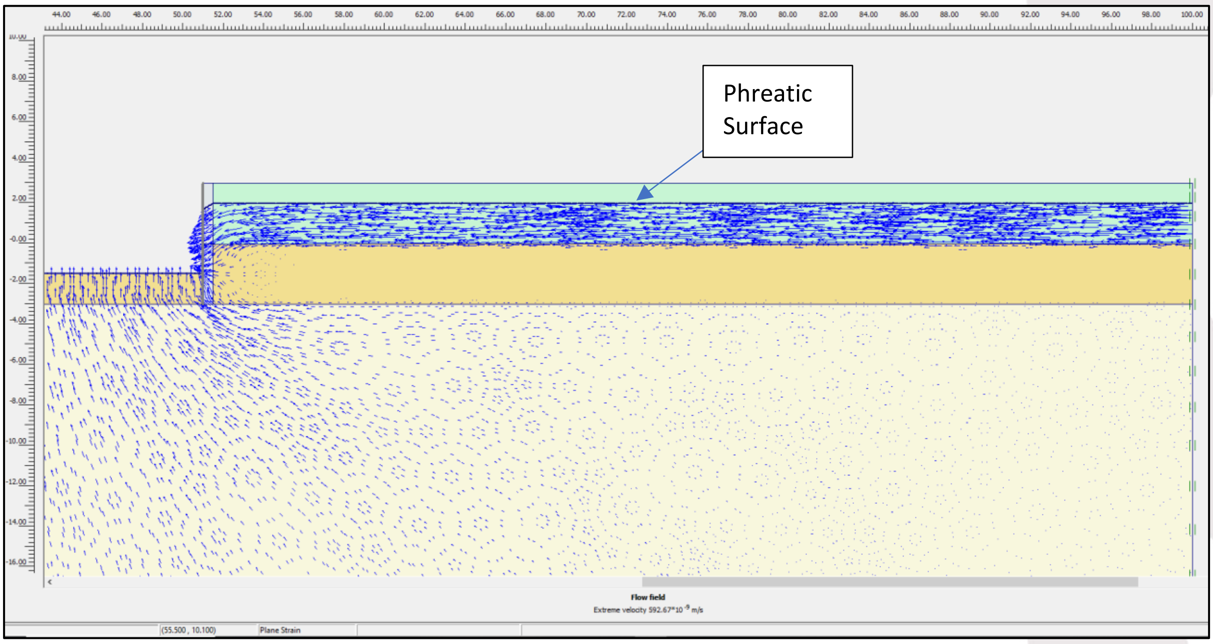


Figure 6: Drawdown after Basement Excavation and Dewatering



The analysis results are presented in Table 3. A total seepage of 473m^3 is expected for a duration of 12 months. This is assumed to be sufficient time to complete the basement works.

Table 3: Expected Seepage Due to Excavation for Duration of Projects

Section	Flow(L/Sec)	Total Flow for 12-month Construction per metre width
Along Building as per Figure 1	0.015	0.47 ML*

*ML: Mega Litre

6. Conclusion and Recommendation for Design Consideration

Based on observations during the fieldwork, water level monitoring and available hydrogeological data for the site available at the time of the investigation, water table is above the basement slab level, it is considered that the excavation will encounter seepage. Because the seepage required constant pumping to the stormwater system, the discharge requires the Council's permission.

7. Report Limitations

The conclusions and recommendations presented in this report have been based on available information obtained during the work carried out by CEC Geotechnical and in the provided documents.

For and on behalf of CEC Geotechnical Pty Ltd

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Principal Engineering Geologist
B.SC. M.SC. MAIG

Attachment:

- Geotechnical Investigation Report

GEOTECHNICAL INVESTIGATION REPORT

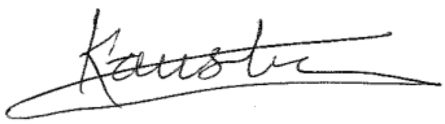
Client – Place Studio AU Pty Ltd
Project Title – 20 Heradale Pde, Batemans Bay
Project Type – Proposed Residential Development
Project No. – GR23206 Rev 01
Date Issued – 3/09/2024
Description of Services – Geotechnical Investigation Report

Document Control

Report Title: Geotechnical Investigation Report

Report No: GR23206 Rev 01

Copies	Recipient
1. Soft Copy (PDF – Sent via eml)	Place Studio

Author	Technical Reviewer
	
Kaustuv Timalsina Geotechnical Engineer	***Shyam Ghimire*** Principal Engineering Geologist

Revision	Details	Date	Amended By
	Original	6.11.2023	
01	Update Plans	3.9.24	DM

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1. Introduction

1.1 Background

CEC Geotechnical Pty Ltd was engaged by the client, Place Studio to carry out a geotechnical investigation for the proposed residential building at 20 Heradale PDE, Batemans Bay.

This report provides geotechnical recommendations regarding the existing ground conditions in order to have a clear guidance for design and construction of ground structures.

The results presented in this report are mainly based on the investigation, the laboratory tests and the author's experience. This report is prepared based on the information received from the client. If the site conditions change before, during or after construction, the geotechnical engineer shall be notified.

1.2 Provided Information

- A set of Architectural drawings, including site plans, floor plans, elevations and sections, prepared by Place Studio, Project No. 2021029, Rev: E issued 03/09/2024.
- Survey Plan prepared by CEH Consulting Pty Ltd. Drawing No. A0-D221258 issued on 14/05/2021.
- Geotechnical Desktop Assessment report prepared by CEC Geotechnical, Project no. GR22297, issued on 10/01/2022

1.3 Proposed Development

With reference to the information provided by the client, it is understood that the proposed development will comprise of the construction of a four-storey residential buildings, overlying one level basement.

The lowest proposed basement has a Finished Floor level (FFL) of -1300 and hence the maximum excavation depths will be approximately 4.5m. Deeper excavation is expected locally for the proposed lift shafts, building footings and service pits and trenches.

1.4 Objectives

The objective of this report included:

- Assessment of subsurface profiles and groundwater considerations.
- Excavation methodologies and monitoring.
- Design parameters and allowable bearing capacities.
- Earthquake subsoil classification in accordance with Australian Standards *"AS 1170.4-2007".*
- Soil salinity and aggressivity assessment.
- Acid Sulphate soils assessment
- General geotechnical recommendations regarding site preparation.

1.5 Scope of Works

The geotechnical site investigation was carried out on 12/10/2023 by an experienced geotechnical engineer in accordance with "*AS 1289*". The scope of works included:

- Desktop Study including a review of existing architectural drawings, survey plan, geology and topography of the site and neighbouring properties.
- Drilling of 6 boreholes (BH01 to BH06) by a 4x4 drill rig with 100 mm diameter solid flight auger to depth of 10m (location found in Appendix A and logs found in Appendix B)
- Dynamic Cone Penetration (DCP) testing in accordance with Australian Standards "*AS 1289*"
- Site classification (see Section 4.1) in accordance with Australian Standards "*AS 1726-2017*".
- 14 soil samples were extracted from the borehole, to test the soil/rock salinity and aggressivity (see Appendix C)

1.6 Constraints

If a more detailed geotechnical investigation regarding soil reactivity is available, it should be provided to CEC Geotechnical Pty Ltd. In addition, any details related to the site's history should be supplied. This report was produced based on a limited geotechnical investigation in line with the requirements of "*AS 1726 and AS 2870*".

This classification is based on the findings in this investigation, including visual-tactile identification of the soil profile combined with the author's local knowledge and experience. If the site conditions change from those of the original investigation, the findings of this report may be void.

2. Desktop Assessment

2.1 General Site Description

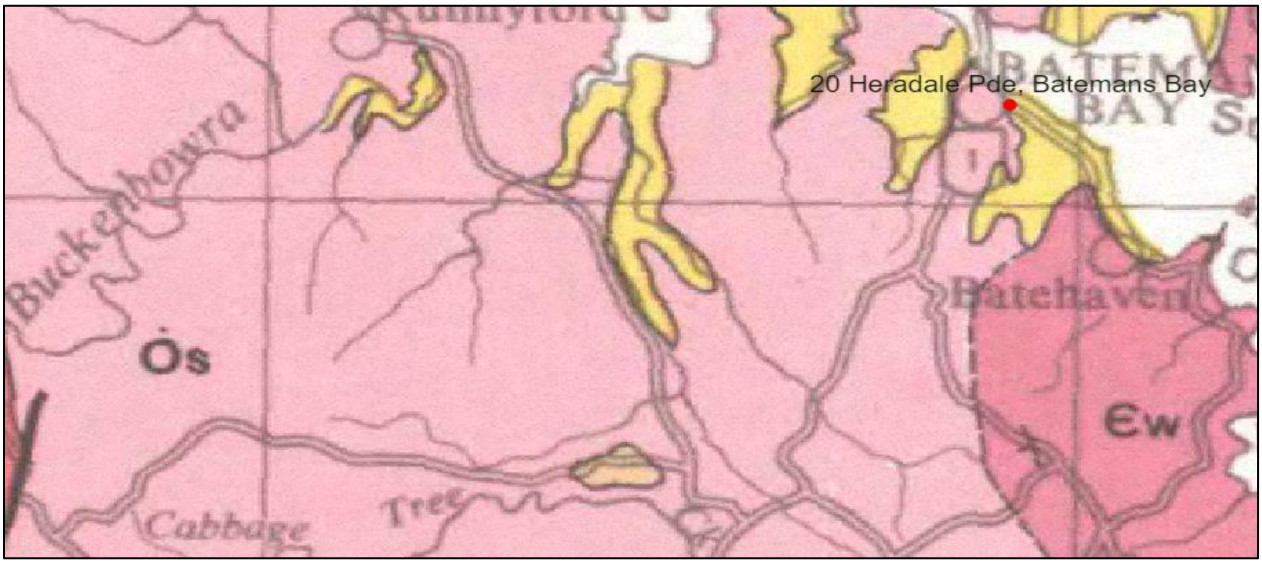
The site is located within the Local Government Area (LGA) of Eurobodalla and is registered as Lot 1 DP1135117. The site is covering an area of 8409m2 and is bounded by Heradale Parade to the north, Bavarde Ave to the south and residential properties on the other sides of the property as shown in Figure 1. During the site visit it was observed that there were two existing single-storey dwelling situated on the site, surrounded by grass and foreign materials.

<u>Figure 1:</u> Site Location (20 Heradale Parade Batemans Bay)

2.2 Topography and Geological Description

Based on the architectural drawings, it can be noted that the site is sloping from south to north. The 1:100,000 scale Geological map of the Ulladulla region (Figure 2) indicates that the subject site is underlain by (Os) which consists of siltstone, claystone, sandstone, quartzite and chert from the Ordovician period.

Figure 2: 1:100,000 scale Geological Series Map of the Ulladulla Region



3. Geotechnical Investigation Results

3.1 Sub-Surface Conditions

The results of the investigation indicate that the subsurface profile comprises poorly graded sand underlain by siltstone bedrock. Based on the borehole information, a summary of subsurface conditions is presented below. The location of each borehole can be found in Appendix A and more detailed logs can be found in Appendix B

Table 1: Subsurface Conditions

Unit	Description	BH01 (m)*	BH02 (m)*	BH03 (m)*	BH04 (m)*	BH05 (m)*	BH06 (m)*
Unit – 1: Topsoil	Sandy SILT (ML): soft, low plasticity, brown yellow	0.0 – 0.2	0.0 – 0.2	0.0 – 0.2	0.0 – 0.2	0.0 – 0.2	0.0 – 0.2
Unit – 2: Marine Deposit	Clayey SAND (SC): loose to medium, low to medium plasticity clay, brown yellow	0.2 – 2.8	0.2 – 2.8	0.2 – 2.2	0.2 – 3.6	0.2 – 2.8	0.2 – 2.5
Unit – 3: Residual	Silty CLAY (CI): stiff to hard, medium plasticity, grey brown	2.8 – 4.1	2.8 – 5.8	2.2 – 5.5	3.6 – 5.8	2.8 – 4.1	2.5 – 3.5
Unit – 4: Rock (Class V)	Extremely weathered, rock Silty CLAY (SHL): hard, low plasticity, brown orange	4.1 – 7.0	5.8 – 7.0	5.5 – 7.0	5.8 – 8.3	4.1 – 6.8	3.5 – 6.0
Unit – 5: Rock (Class IV)	SILTSTONE: distinctly weathered, low to medium strength, grey brown	7.0 – 9.5	7 - 10	-	8.3 – 10	6.8 – 10	-

**Depths below ground level (BGL) at the location of each borehole. This may vary depending on other areas of the site.*
BH01, BH02, BH03, BH04, BH05 and BH06 were terminated/met refusal at depths of 9.5m, 10m, 7.0m, 10m, 10m and 6.0m.

3.2 Groundwater Observation

Groundwater was encountered within the investigated depths during the geotechnical investigation on the of 12th Oct 2023. However, due to the usage of water during the rock coring, the data for the water level was not accurate.

Four groundwater monitoring wells were installed in the boreholes (BH01, BH02, BH04 and BH05). The Groundwater levels were measured during additional site visits on 14th of Oct 2023, 19th of Oct 2023 and 25th of Oct 2023 are summarised in the table below. The measurement was conducted after the fieldwork was completed to allow the groundwater levels to stabilise. A geotechnical engineer regularly monitored the water levels for 3 weeks in order to establish a baseline groundwater level at the proposed site.

Table 2: Observed Groundwater Levels

Groundwater Well	Borehole	Ground RL	Groundwater Level (m bgl)/RL			Approximate depth of Rock Level Encountered bgl
			14/10/23	19/10/23	25/10/2023	
GW1	BH01	2.17	2.10m/ RL 0.07	1.7m/ RL 0.47	1.65m/ RL 0.52	4.1m/ RL -1.93
GW2	BH02	1.94	1.60m/ RL 0.34	1.6m/ RL 0.34	1.56m/ RL 0.38	5.8m/ RL -3.86
GW3	BH04	1.78	1.61m/ RL 0.17	1.4m/ RL 0.38	1.54m/ RL 0.24	4.1m/ RL -2.32
GW4	BH05	1.67	1.55m/ RL 0.12	1.65m/ RL0.02	1.58m/ RL0.09	3.5m/ RL -1.83

3.3 Lab Test Results

14 samples were collected from the boreholes (BH01 to BH06) at depths of 0.5m to 5.0m. The samples were submitted to NATA accredited laboratories for further testing. These tests included:

- Chemical testing (Salinity, pH, Chloride (Cl), sulphates (SO_4), and electrical conductivity) to assess soil salinity and aggressivity.

3.3.1 Soil Salinity & Aggressivity Test Results

The soil encountered is Silty Clay and was tested as stipulated in the Department of Natural Resources (DNR) publication “Site Investigations for Urban Salinity” (2002).

Results of the laboratory testing are attached to this report in Appendix C and summarised in Tables 2 and 3.

Table 3: Results of Electrical Conductivity Test (Salinity)

Borehole	Depth (m bgl)	Electrical Conductivity (dS/m)	Multiplication Factor [a]	Electrical Conductivity of Saturated Extract (dS/m)	Soil Type
				EC_e	
BH01	2.0	0.026	8.5	0.221	Light Clay
BH01	3.0	0.035	8.5	0.298	Light Clay
BH02	0.5	0.100	14	1.400	Sandy Loams
BH02	4.5	0.019	8.5	0.162	Light Clay
BH03	1.5	0.086	14	1.204	Sandy Loams
BH03	4.5	0.140	8.5	0.119	Light Clay
BH04	0.5	0.064	14	0.896	Sandy Loams
BH04	1.5	0.094	14	1.316	Sandy Loams
BH04	3.0	0.140	14	1.960	Sandy Loams
BH05	1.5	0.086	14	1.204	Sandy Loams
BH05	1.5	0.063	14	0.882	Sandy Loams
BH05	3.0	0.082	8.5	0.697	Light Clay
BH06	0.5	0.076	14	1.064	Sandy Loams
BH06	5.0	0.110	9	0.990	Clay Loam

"Site Investigations for Urban Salinity" (2002)

Non-saline <2 dS/m
Saline at >4 dS/m
Slightly saline 2-4 dS/m
Moderately saline 4-8 dS/m
Very saline 8-16 dS/m
Highly saline >16 dS/m

Table 4: Soil pH, Chloride, Sulphate and Electrical Resistivity Test Results (AS 2159-2009)

Borehole	Depth (m bgl)	MC* (%)	pH	Chloride (mg/kg)	Sulphate as $S0^4$ (mg/kg)	Electrical Resistivity (ohm.cm)
BH01	2.0	12	6.0	15	24	38000
BH01	3.0	15	6.1	13	28	29000
BH02	0.5	22	8.1	<10	<10	9600
BH02	4.5	13	8.2	<10	<10	52000
BH03	1.5	12	9.1	15	18	12000
BH03	4.5	17	8.4	17	33	7300
BH04	0.5	7	8.7	<10	<10	16000
BH04	1.5	15	8.7	20	12	11000
BH04	3.0	20	8.7	23	64	7100
BH05	1.5	10	9.1	23	13	12000
BH05	1.5	13	9.0	<10	<10	16000
BH05	3.0	19	8.6	11	16	12000
BH06	0.5	6.8	8.2	14	<10	13000
BH06	5.0	23	7.6	18	72	9100

**MC = Moisture Content*
Note: Electrical Resistivity converted from Electrical Conductivity

4. Discussion and Recommendations

4.1 Site Classification

Due to the presence of trees and topsoil, the overall site is classified as **Class P** in accordance with *"AS 2870 2011"*. Once topsoil/fill is removed, this site will then be classified as **CLASS M** in accordance with *"AS 2870 2011"*. Class M is indicative of 20 to 40mm movement due to moisture changes.
At the basement slab level, the site will be classified as Class M in accordance with *"AS 2870 2011"*.

4.2 Excavation Assessment

Accordance with the proposed basement levels, the excavations for the proposed basement should mostly encounter residual sandy/silty clay. Removal of materials should be carried out using conventional earthmoving equipment, such as a hydraulic excavator or backhoe. If rock hammers are to be used, such works will need to be completed carefully as there may be direct transmission of ground vibration to existing structures. We recommend that a geotechnical engineer to be present at the site as they may be required to carry out quantitative vibration monitoring to confirm vibration units do not exceed the maximum Peak Particle Velocity (PPV) values provided in Table 4 below.

Table 5: Recommended Maximum PPV

Type of Building or Structure	Maximum PPV (mm/sec)
Historical buildings or structures in sensitive conditions	2
Residential and low-rise buildings	5
Brick or unreinforced structures in good condition	10
Commercial and industrial buildings or structures of reinforced concrete or steel construction	25

It is recommended that monitoring is carried out during demolition and excavation using a vibration monitoring instrument (Vibra) and alarm levels (being the appropriate PPV).

If the vibrations exceed the above values or appear excessive, the excavations should cease, and the project Geotechnical Engineer should be contacted immediately.

4.3 Shoring/Footings Design Parameters

The following parameters established from Rankine's theory would be valid in the design of a retention system. These bearing pressures apply where footings are founded minimum 300mm into the specified material.

Table 6: Geotechnical Design Parameters

Material Description	Unit Weight (kN/m^3)	Allowable Bearing Capacity (kPa)	Ultimate Bearing Capacity	C (kPa)	Friction Angle (°)	K_a#	K_p#	K_o#	Modulus of Elasticity (MPa)	Poisson's Ratio v'
Unit 2: Clayey SAND (SC): loose to medium dense	18	100	300	0	28	0.36	2.77	0.53	5	0.3
Unit 3: Silty CLAY (CI): stiff to hard	19	200	600	5	26	0.39	2.56	0.58	10	0.3
Unit 4: Extremely weathered ROCK (Class V)	22	700	2,100	20	35	0.27	3.69	0.43	300	0.25
Unit 5: Distinctly weathered ROCK (Class IV)	23	1500	4,500	75	35	0.27	3.69	0.43	600	0.25

**Approximate depth below ground level based on borehole logs completed during geotechnical investigation.*
#K_a, K_p and K_o are the active, passive and at-rest earth pressure coefficients.

The following may need to be adopted in response to the design of any retaining wall structures:

- The retaining walls which are propped or restrained by concrete slabs, should be designed using a triangular lateral earth pressure distribution and the K_o, as mentioned in Table 6, for the soil profiles and other backfill materials.
- Free-standing cantilever walls should be designed using a triangular lateral earth pressure distribution and the K_a, as mentioned in Table 5, for the soil profiles and other backfill materials.
- Lateral toe restraint can be achieved through passive resistance adjacent to the wall using a triangular lateral earth pressure and the K_p, as mentioned in Table 5, for the soil profiles and other backfill materials.
- All surcharge loads should be allowed for in the retaining wall design, including building footings and construction related activities, using the appropriate earth pressure coefficient as mentioned in Table 5. (Sloping needs to be considered a surcharge)

4.4 Batter Slopes (Temporary)

The following temporary batter slopes may be considered in areas where sufficient space exists between the basement excavation and the boundary and where an adjacent footing is outside a zone of influence obtained by drawing a line at a 45° angle up from the toe of the proposed excavation.

Table 7: Recommended Batter Slopes (temporary)

Material	Maximum Batter Slope (H:V)
Topsoil / Fill	2:1
Silty Clay	1.5:1
Rock: SILTSTONE	1:1

4.5 Groundwater Management

Based on observations during the fieldwork, water level monitoring data, available hydrogeological data, and information for the site available at the time of the investigation, the water table is above the basement slab level, it is considered that the excavation will be predominantly in a wet condition. A tanked basement system is required . RL 1.52m can be consider as a design groundwater level.

We, CEC Geotechnical, have prepared separate hydrogeological report for the groundwater assessment.

4.6 Earthquake Site Assessment

In accordance with Australian Standard *"AS 1170.4-2007"* (Reference 2) the site may be classified as a "Shallow Soil Site" (Class Ce).

4.7 Exposure Classification

The lab results show that the electrical conductivity of saturated extracts (ECe) is approximately 0.119 ds/m to 1.960 ds/m, and hence the samples of residual deposit soil are "**Non-Saline**".

- In accordance with *"AS 2159" Piling – Design and Installation*, the lab results indicated that the soil is: **"Non-aggressive"** for Steel piles and "**Non-aggressive"** for Reinforced Concrete Piles
- Chloride, Sulphate and Electrical resistivity is **"Non-aggressive"** for Steel Piles and Reinforced Concrete Piles.

4.8 Sub-grade Preparation

- Fill should be compacted close to its optimum moisture content (+/- 2%) during compaction.
- The compaction method and equipment shall suit the filled material. The compaction of soil shall be tested by a NATA accredited laboratory and Geotechnical Inspection and Testing Authority (GITA) to ensure it meets the requirements of "*AS 3798-2007 Guidelines on earthworks for commercial and residential developments*".
- Any organic materials (including topsoil) within the proposed building envelope are to be removed.
- The site should be proof rolled after an initial site scrape to unveil any soft spots. Any soft areas are to be removed and backfilled with compacted fill material as described in "*AS 2870-2011*", cl 6.4.2.

4.9 Conditions of the Recommendations

- The descriptions of the soils encountered in the boreholes follow those outlined in "*AS 726-2017*", Geotechnical Site Investigations. Colour descriptions can vary with soil moisture content and individual interpretation.
- The advice given in this report assumes that the test results are representative of the overall subsurface conditions. However, it should be noted that actual conditions in some parts of the building site may differ from those found in the boreholes. If excavations reveal soil conditions significantly different from those shown in our attached Borehole Log(s), CEC Geotechnical shall be consulted and the excavations shall be stopped immediately.
- Depths mentioned in this report are measured from the surface during testing and may vary accordingly if any filling or excavation works are carried out. The description of the foundation material has been provided for ease of recognition over the whole building site.
- Any sketches in this report should be considered as only approximate pictorial evidence of our work. Therefore, unless otherwise stated, any dimensions or slope information should not be used for any building cost calculations and/or positioning of the building. Dimensions on logs are correct.

5. Further Geotechnical Recommendations

CEC Geotechnical should be engaged at the following stages:

- If soil conditions encountered differ significantly from those described within this report.
- If the proposed development is altered significantly from what has been assessed and described within this report.
- To confirm safe batter angles and excavation methods during construction.
- To confirm founding materials and allowable bearing capacity.
- If the site conditions at the time of construction differ from those described in this report, then CEC Geotechnical shall be contacted. The owner/builder will be responsible for any fees associated with this additional work.

6. Limitations

This report and its associated recommendations have been prepared exclusively for our client who is named on the front page of this report and is the only intended entity to benefit from this report. CEC Geotechnical notes that reliance on the information provided in this report by any third party will be at their own risk. It should be noted that the analysis and conclusions made in this report may rely on works by other consultants and entities and hence, should these documents and investigations be incorrect, CEC Geotechnical must be made aware and the results of this report may be void.

For and on behalf of CEC Geotechnical Pty Ltd

Kaustuv Timalsina	Shyam Ghimire
Geotechnical Engineering BEng. (Civil)	Principal

References

- AS 2870 -2011, Residential Slab and Footings – Construction
- AS 1726-2017, Geotechnical Site Investigations
- AS 2159-2009, Piling - Design and Installation
- AS 3798-2007 "Guidelines on earthworks for commercial and residential developments"
- Geological Series Sheet S1 56-13, Map of the Ulladulla Region, Scale 1:250,000
- Site investigations for urban salinity, Date 1 January 2002, Department of Land and Water Conservation.

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Appendix A:

Site Plan with Borehole Locations

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N

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Drawn	**KT**	**CLIENT: PLACE STUDIO AU PTY LTD** **SITE ADDRESS: 20 Heradale Pde, Batemans Bay**	**Figure**	**1**
Checked	**SG**		**Title**	**Site Plan**
Date	**12/10/2023**			
Scale @ A3	**NTS**		**Job No**	**GR23206**

Appendix B:

Borehole Logs and DCP Test Results

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Geotechnical Log - Borehole

BH01

UTM	: 56H	**Drill Rig**	: Truck mounted Rig	**Job Number**	: GR23206
Easting (m)	: 0.0	**Driller Supplier**	: Total Drilling	**Client**	: Place Studio AU Pty Ltd
Northing (m)	: 0.0	**Logged By**	: KT	**Project**	: Proposed Development
Ground Elevation	: Not Surveyed	**Reviewed By**	:	**Location**	: 20 Heradale Pde, Batemans Bay
Total Depth	: 9.5 m BGL	**Date**	: 12/10/2023	**Loc Comment**	:

Drilling Method	Depth (m)	Water	Soil Origin	Graphic Log	Classification Code	Material Description	Moisture	Testing: SPT	Consistency/Density	Well Diagram
100mm SFA	0.2		Top Soil		ML	Top soil Sandy SILT (ML) : soft, low plasticity, brown yellow, fine grained sand, organic, w < pl.	w < PL		S	
	1.5		Marine Deposit		SC	Marine deposit Clayey SAND (SC) : loose, low plasticity clay, brown yellow, fine grained, with fine sized gravel, moist.	M		L	
	2.8		Residual		SC	Residual Clayey SAND (SC) : medium dense, medium plasticity clay, grey brown, fine grained, moist.		3, 10, 11, (N = 21)	MD	
	4.1		Residual		CI	Residual Silty CLAY (CI) : very stiff, medium plasticity, grey brown, trace fine grained sand, inorganic, moist.		7, 10, 15, (N = 25)	VSt	
			Rock		SHL	Extremelyweathered, rock Sandy CLAY (SHL) : hard, low plasticity, brown orange, fine grained sand, inorganic, moist.			H	

Depth scale: 1, 2, 3, 4

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Geotechnical Log - Borehole

BH01

UTM	**: 56H**	**Drill Rig**	**: Truck mounted Rig**	**Job Number**	**: GR23206**
Easting (m)	**: 0.0**	**Driller Supplier**	**: Total Drilling**	**Client**	**: Place Studio AU Pty Ltd**
Northing (m)	**: 0.0**	**Logged By**	**: KT**	**Project**	**: Proposed Development**
Ground Elevation	**: Not Surveyed**	**Reviewed By**	**:**	**Location**	**: 20 Heradale Pde, Batemans Bay**
Total Depth	**: 9.5 m BGL**	**Date**	**: 12/10/2023**	**Loc Comment**	**:**

Drilling Method	Depth (m)	Water	Soil Origin	Graphic Log	Classification Code	Material Description	Moisture	Testing: SPT	Consistency/Density	Well Diagram
100mm SFA	6		Rock		SHL	Extremelyweathered, rock Sandy CLAY (SHL) : hard, low plasticity, brown orange, fine grained sand, inorganic, moist.			H	
	7, 8, 9					**7m : Commenced NMLC Coring;**				

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Geotechnical Log - Borehole

BH01

UTM : 56H	Drill Rig : Truck mounted Rig	Job Number : GR23206	
Easting (m) : 0.0	Driller Supplier : Total Drilling	Client : Place Studio AU Pty Ltd	
Northing (m) : 0.0	Logged By : KT	Project : Proposed Development	
Ground Elevation : Not Surveyed	Reviewed By :	Location : 20 Heradale Pde, Batemans Bay	
Total Depth : 9.5 m BGL	Date : 12/10/2023	Loc Comment :	

Drilling Method	Water	Depth (m)	Soil Origin	Graphic Log	Classification Code	Material Description	Weathering	Estimated Strength (VLS LS MS HS VHS EHS)	Is(50)	RQD% and TCR%	Defect Spacing (mm) (30 100 300 1000 3000)	Defect Description (type, inclination, planarity, roughness, coating thickness)	Well Diagram
NMLC Coring		7	Rock		SLT	Rock SILTSTONE: distinctly weathered, very low strength, grey brown, coarse grained, wet.	DW	VLS	0.09			XWS, SO, IR, CT, J, RO, IR, CT, C CS, RO, IR, STN, CS, RO, IR, CL, C J, RO, CV, CL, C J, RO, CV, CL, C CS, RO, IR, CL, C J, VR, PL, CL, C J, RO, PL, CL, C J, RO, CV, CL, OP CS, RO, IR, CL, OP J, RO, PL, CL, C J, RO, CV, CL, OP SZ, RO, IR, CL, C J, RO, PL, CL, OP J, RO, CV, CL, OP J, RO, PL, CL, OP J, RO, PL, CL, OP J, RO, CV, CL, OP J, RO, CV, CL, OP J, RO, CV, CL, C	
		8											

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Geotechnical Log - Borehole

BH01

UTM	: 56H	Drill Rig	: Truck mounted Rig	Job Number	: GR23206
Easting (m)	: 0.0	Driller Supplier	: Total Drilling	Client	: Place Studio AU Pty Ltd
Northing (m)	: 0.0	Logged By	: KT	Project	: Proposed Development
Ground Elevation	: Not Surveyed	Reviewed By	:	Location	: 20 Heradale Pde, Batemans Bay
Total Depth	: 9.5 m BGL	Date	: 12/10/2023	Loc Comment	:

Drilling Method	Water	Depth (m)	Soil Origin	Graphic Log	Classification Code	Material Description	Weathering	Estimated Strength (VLS, LS, MS, HS, VHS, EHS)	Is(50)	RQD% and TCR%	Defect Spacing (mm) (30, 100, 300, 1000, 3000)	Defect Description (type, inclination, planarity, roughness, coating thickness)	Well Diagram
NMLC Coring		9	Rock		SLT	Rock SILTSTONE: distinctly weathered, low strength, grey brown, coarse grained, wet.	DW	LS	0.12			CS, SO, IR, CL, OP	
		10				**BH01 Terminated at 9.5 m**							
		11											

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Geotechnical Log - Borehole

BH02

UTM	**: 56H**	**Drill Rig**	**: Truck mounted Rig**	**Job Number**	**: GR23206**
Easting (m)	**: 0.0**	**Driller Supplier**	**: Total Drilling**	**Client**	**: Place Studio AU Pty Ltd**
Northing (m)	**: 0.0**	**Logged By**	**: KT**	**Project**	**: Proposed Development**
Ground Elevation	**: Not Surveyed**	**Reviewed By**	**:**	**Location**	**: 20 Heradale Pde, Batemans Bay**
Total Depth	**: 10 m BGL**	**Date**	**: 12/10/2023**	**Loc Comment**	**:**

Drilling Method	Depth (m)	Water	Soil Origin	Graphic Log	Classification Code	Material Description	Moisture	Testing SPT	Consistency/Density	Well Diagram
100mm SFA	0.2		Top Soil		ML	Top soil Sandy SILT (ML) : soft, low plasticity, brown yellow, fine grained sand, organic, w < pl.	w < PL		S	
	1		Marine Deposit		SM	Marine deposit Silty SAND (SM) : loose, brown yellow, fine grained, with medium sized gravel, slightly moist.	SM		L	
	2.8		Residual		SC	Residual Clayey SAND (SC) : medium dense, medium plasticity clay, grey brown, fine grained, moist.	M	5, 8, 8, (N = 16)	MD	
	4.1		Residual		CI	Residual Silty CLAY (CI) : firm, medium plasticity, grey brown, inorganic, moist.		0, 3, 4, (N = 7)	F	
			Residual		CI	Residual Silty CLAY (CI) : stiff, medium plasticity, grey brown, inorganic, moist.		3, 4, 10, (N = 14)	St	

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Geotechnical Log - Borehole

BH02

UTM	: 56H	Drill Rig	: Truck mounted Rig	Job Number	: GR23206
Easting (m)	: 0.0	Driller Supplier	: Total Drilling	Client	: Place Studio AU Pty Ltd
Northing (m)	: 0.0	Logged By	: KT	Project	: Proposed Development
Ground Elevation	: Not Surveyed	Reviewed By	:	Location	: 20 Heradale Pde, Batemans Bay
Total Depth	: 10 m BGL	Date	: 12/10/2023	Loc Comment	:

Drilling Method	Depth (m)	Water	Soil Origin	Graphic Log	Classification Code	Material Description	Moisture	Testing: SPT	Consistency/Density	Well Diagram
100mm SFA			Residual		CI	Residual Silty CLAY (CI) : stiff, medium plasticity, grey brown, inorganic, moist.			St	
	5.8 – 6		Rock		SHL	Extremelyweathered, rock Sandy CLAY (SHL) : hard, medium plasticity, brown orange, fine grained sand, inorganic, wet.	W	10, 22, 25, (N = 47)	H	
	7					**7m : Commenced NMLC Coring;**				
	8									
	9									

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Geotechnical Log - Borehole

BH02

UTM	: 56H	Drill Rig	: Truck mounted Rig	Job Number	: GR23206
Easting (m)	: 0.0	Driller Supplier	: Total Drilling	Client	: Place Studio AU Pty Ltd
Northing (m)	: 0.0	Logged By	: KT	Project	: Proposed Development
Ground Elevation	: Not Surveyed	Reviewed By	:	Location	: 20 Heradale Pde, Batemans Bay
Total Depth	: 10 m BGL	Date	: 12/10/2023	Loc Comment	:

Drilling Method	Water	Depth (m)	Soil Origin	Graphic Log	Classification Code	Material Description	Weathering	Estimated Strength (VLS, LS, MS, HS, VHS, EHS)	Is(50)	RQD% and TCR%	Defect Spacing (mm) (30, 100, 300, 1000, 3000)	Defect Description (type, inclination, planarity, roughness, coating thickness)	Well Diagram
NMLC Coring		7	Rock		SLT	Rock SILTSTONE: distinctly weathered, low strength, brown grey, medium to coarse grained, wet.	DW	LS				CS, VR, IR, CL, OP J, RO, CV, CL, C J, RO, PL, CL, C J, RO, CV, CL, OP J, RO, CV, CL, OP SZ, RO, IR, VN, CORELOSS, CS, RO, IR, CL, OP CORELOSS,	
		8											
		8.5	Rock		SLT	Rock SILTSTONE: distinctly weathered, medium strength, brown grey, coarse grained, wet.	DW	MS	0.18			J, RO, PL, CL, C J, RO, CV, CL, OP J, RO, PL, CL, OP	

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Geotechnical Log - Borehole

BH02

UTM	: 56H	Drill Rig	: Truck mounted Rig	Job Number	: GR23206
Easting (m)	: 0.0	Driller Supplier	: Total Drilling	Client	: Place Studio AU Pty Ltd
Northing (m)	: 0.0	Logged By	: KT	Project	: Proposed Development
Ground Elevation	: Not Surveyed	Reviewed By	:	Location	: 20 Heradale Pde, Batemans Bay
Total Depth	: 10 m BGL	Date	: 12/10/2023	Loc Comment	:

Drilling Method	Water	Depth (m)	Soil Origin	Graphic Log	Classification Code	Material Description	Weathering	Estimated Strength (VLS LS MS HS VHS EHS)	Is(50)	RQD% and TCR%	Defect Spacing (mm) (30 100 300 1000 3000)	Defect Description (type, inclination, planarity, roughness, coating thickness)	Well Diagram
NMLC Coring			Rock		SLT	Rock SILTSTONE: distinctly weathered, medium strength, brown grey, coarse grained, wet.	DW	MS	0.39			J, RO, PL, CL, C J, RO, PL, CL, OP	
		10				**BH02 Terminated at 10 m**							
		11											

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Geotechnical Log - Borehole

BH03

UTM	**: 56H**	**Drill Rig**	**: Truck mounted Rig**	**Job Number**	**: GR23206**
Easting (m)	**: 0.0**	**Driller Supplier**	**: Total Drilling**	**Client**	**: Place Studio AU Pty Ltd**
Northing (m)	**: 0.0**	**Logged By**	**: KT**	**Project**	**: Proposed Development**
Ground Elevation	**: Not Surveyed**	**Reviewed By**	**:**	**Location**	**: 20 Heradale Pde, Batemans Bay**
Total Depth	**: 7 m BGL**	**Date**	**: 12/10/2023**	**Loc Comment :**	

Drilling Method	Depth (m)	Water	Soil Origin	Graphic Log	Classification Code	Material Description	Moisture	Testing SPT	Consistency/Density	Well Diagram
100mm SFA	0.2		Top Soil		ML	Top soil Sandy SILT (ML) : soft, low plasticity, brown yellow, fine grained sand, organic, w < pl.	w < PL		S	
	2.2		Residual		SM	Residual Silty SAND (SM) : medium dense, brown yellow, fine grained, with medium sized gravel, dry.	D	4, 5, 6, (N = 11)	MD	
								0, 5, 7, (N = 12)		
			Residual		CI	Residual Sandy CLAY (CI) : stiff, medium plasticity, grey brown, fine grained sand, inorganic, moist.	M	3, 6, 6, (N = 12)	St	
								2, 3, 6, (N = 9)		

Depth scale: 1, 2, 3, 4

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Geotechnical Log - Borehole

BH03

UTM	: 56H	Drill Rig	: Truck mounted Rig	Job Number	: GR23206
Easting (m)	: 0.0	Driller Supplier	: Total Drilling	Client	: Place Studio AU Pty Ltd
Northing (m)	: 0.0	Logged By	: KT	Project	: Proposed Development
Ground Elevation	: Not Surveyed	Reviewed By	:	Location	: 20 Heradale Pde, Batemans Bay
Total Depth	: 7 m BGL	Date	: 12/10/2023	Loc Comment	:

Drilling Method	Depth (m)	Water	Soil Origin	Graphic Log	Classification Code	Material Description	Moisture	Testing SPT	Consistency/Density	Well Diagram
100mm SFA			Residual		CI	Residual Sandy CLAY (CI) : stiff, medium plasticity, grey brown, fine grained sand, inorganic, moist.	M		St	
	5.5		Rock		SHL	Extremelyweathered, rock Sandy CLAY (SHL) : hard, low plasticity, brown orange, fine grained sand, inorganic, moist.			H	
	6									
	7					**BH03 refusal at 7 m**				
	8									
	9									

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Geotechnical Log - Borehole

BH04

UTM	: 56H	Drill Rig	: Truck mounted Rig	Job Number	: GR23206
Easting (m)	: 0.0	Driller Supplier	: Total Drilling	Client	: Place Studio AU Pty Ltd
Northing (m)	: 0.0	Logged By	: KT	Project	: Proposed Development
Ground Elevation	: Not Surveyed	Reviewed By	:	Location	: 20 Heradale Pde, Batemans Bay
Total Depth	: 10 m BGL	Date	: 12/10/2023	Loc Comment	:

Drilling Method	Depth (m)	Water	Soil Origin	Graphic Log	Classification Code	Material Description	Moisture	Testing: SPT	Consistency/Density	Well Diagram
100mm SFA	0.0–0.2		Top Soil		ML	Top soil Sandy SILT (ML) : soft, low plasticity, brown yellow, fine grained sand, organic, w < pl.	w < PL		S	
	0.2–2		Marine Deposit		SM	Marine deposit Silty SAND (SM) : loose, brown yellow, fine grained, with medium sized gravel, dry.	D	2, 3, 4, (N = 7)	L	
	2–3.6		Residual		SC	Residual Clayey SAND (SC) : medium dense, medium plasticity clay, grey brown, fine grained, with coarse sized gravel, moist.	M	20, 31, 0, (N = 62)	MD	
	3.6–		Residual		CI	Residual Silty CLAY (CI) : hard, medium plasticity, grey brown, trace fine grained sand, inorganic, moist.		17, 7, 6, (N = 13)	H	

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Geotechnical Log - Borehole

BH04

UTM	: 56H	Drill Rig	: Truck mounted Rig	Job Number	: GR23206
Easting (m)	: 0.0	Driller Supplier	: Total Drilling	Client	: Place Studio AU Pty Ltd
Northing (m)	: 0.0	Logged By	: KT	Project	: Proposed Development
Ground Elevation	: Not Surveyed	Reviewed By	:	Location	: 20 Heradale Pde, Batemans Bay
Total Depth	: 10 m BGL	Date	: 12/10/2023	Loc Comment	:

Drilling Method	Depth (m)	Water	Soil Origin	Graphic Log	Classification Code	Material Description	Moisture	Testing: SPT	Consistency/Density	Well Diagram
100mm SFA			Residual		CI	Residual Silty CLAY (CI) : hard, medium plasticity, grey brown, trace fine grained sand, inorganic, moist.			H	
	5.8		Rock		SHL	Extremelyweathered, rock Sandy CLAY (SHL) : hard, medium plasticity, brown orange, fine grained sand, inorganic, wet.	W			
	6									
	7									
	8									
						8.3m : Commenced NMLC Coring;				
	9									

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Geotechnical Log - Borehole

BH04

UTM	: 56H	Drill Rig	: Truck mounted Rig	Job Number	: GR23206
Easting (m)	: 0.0	Driller Supplier	: Total Drilling	Client	: Place Studio AU Pty Ltd
Northing (m)	: 0.0	Logged By	: KT	Project	: Proposed Development
Ground Elevation	: Not Surveyed	Reviewed By	:	Location	: 20 Heradale Pde, Batemans Bay
Total Depth	: 10 m BGL	Date	: 12/10/2023	Loc Comment	:

Drilling Method	Water	Depth (m)	Soil Origin	Graphic Log	Classification Code	Material Description	Weathering	Estimated Strength (VLS, LS, MS, HS, VHS, EHS)	Is(50)	RQD% and TCR%	Defect Spacing (mm) (30, 100, 300, 1000, 3000)	Defect Description (type, inclination, planarity, roughness, coating thickness)	Well Diagram
		7											
		8											
NMLC Coring			Rock		SLT	Rock SILTSTONE: distinctly weathered, low strength, grey brown, medium to coarse grained, wet.	DW	LS		RQD = 11.18%		CS, SO, IR, CT, CS, RO, IR, CT,	

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Geotechnical Log - Borehole

BH04

UTM	**: 56H**	**Drill Rig**	**: Truck mounted Rig**	**Job Number**	**: GR23206**
Easting (m)	**: 0.0**	**Driller Supplier**	**: Total Drilling**	**Client**	**: Place Studio AU Pty Ltd**
Northing (m)	**: 0.0**	**Logged By**	**: KT**	**Project**	**: Proposed Development**
Ground Elevation	**: Not Surveyed**	**Reviewed By**	**:**	**Location**	**: 20 Heradale Pde, Batemans Bay**
Total Depth	**: 10 m BGL**	**Date**	**: 12/10/2023**	**Loc Comment**	**:**

Drilling Method	Water	Depth (m)	Soil Origin	Graphic Log	Classification Code	Material Description	Weathering	Estimated Strength (VLS, LS, MS, HS, VHS, EHS)	Is(50)	RQD% and TCR%	Defect Spacing (mm) (30, 100, 300, 1000, 3000)	Defect Description (type, inclination, planarity, roughness, coating thickness)	Well Diagram
NMLC Coring			Rock		SLT	Rock SILTSTONE: distinctly weathered, low strength, grey brown, medium to coarse grained, wet.	DW	LS	0.21	RQD = 11.18%		CS, RO, IR, CL, OP J, RO, CV, STN, OP J, RO, CV, CL, OP J, RO, PL, CL, C J, RO, CV, CL, OP J, RO, CV, CL, OP CS, RO, IR, CL, OP	
		10				**BH04 refusal at 10 m**							
		11											

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Geotechnical Log - Borehole

BH05

UTM	: 56H	Drill Rig	: Truck mounted Rig	Job Number	: GR23206
Easting (m)	: 0.0	Driller Supplier	: Total Drilling	Client	: Place Studio AU Pty Ltd
Northing (m)	: 0.0	Logged By	: KT	Project	: Proposed Development
Ground Elevation	: Not Surveyed	Reviewed By	:	Location	: 20 Heradale Pde, Batemans Bay
Total Depth	: 10 m BGL	Date	: 13/10/2023	Loc Comment	:

Drilling Method	Depth (m)	Water	Soil Origin	Graphic Log	Classification Code	Material Description	Moisture	Testing SPT	Consistency/Density	Well Diagram
100mm SFA	0.0 – 0.2		Top Soil		ML	Top soil Sandy SILT (ML) : soft, low plasticity, brown yellow, fine grained sand, organic, w < pl.	w < PL		S	
	0.2 – 1.1		Marine Deposit		SM	Marine deposit Silty SAND (SM) : loose to medium dense, brown yellow, fine grained, trace medium plasticity clay, dry.	D		L-MD	
	1.1 – 2.8		Residual		SC	Residual Clayey SAND (SC) : medium dense, medium plasticity clay, grey brown, fine grained, with coarse sized gravel, moist.	M	7, 31, 30, (N = 61)	MD	
	2.8 – 4.1		Residual		CI	Residual Silty CLAY (CI) : stiff, medium plasticity, grey brown, with fine grained sand, trace medium sized gravel, inorganic, wet.	W	18, 8, 5, (N = 13)	St	
	4.1 –		Rock		SHL	Extremelyweathered, rock Silty CLAY (SHL) : hard, medium plasticity, brown orange, with medium sized gravel, with fine grained sand, inorganic, wet.			H	

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Geotechnical Log - Borehole

BH05

UTM	: 56H	Drill Rig	: Truck mounted Rig	Job Number	: GR23206
Easting (m)	: 0.0	Driller Supplier	: Total Drilling	Client	: Place Studio AU Pty Ltd
Northing (m)	: 0.0	Logged By	: KT	Project	: Proposed Development
Ground Elevation	: Not Surveyed	Reviewed By	:	Location	: 20 Heradale Pde, Batemans Bay
Total Depth	: 10 m BGL	Date	: 13/10/2023	Loc Comment	:

Drilling Method	Depth (m)	Water	Soil Origin	Graphic Log	Classification Code	Material Description	Moisture	Testing: SPT	Consistency/Density	Well Diagram
100mm SFA	6		Rock		SHL	Extremelyweathered, rock Silty CLAY (SHL) : hard, medium plasticity, brown orange, with medium sized gravel, with fine grained sand, inorganic, wet.			H	
150mm Washbore	6.8 7 8 9		Rock		SST	Rock SANDSTONE: distinctly weathered, very low to low strength, brown yellow, fine to medium grained, wet.			VLS-LS	

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Geotechnical Log - Borehole

BH06

UTM	: 56H	Drill Rig	: Truck mounted Rig	Job Number	: GR23206
Easting (m)	: 0.0	Driller Supplier	: Total Drilling	Client	: Place Studio AU Pty Ltd
Northing (m)	: 0.0	Logged By	: KT	Project	: Proposed Development
Ground Elevation	: Not Surveyed	Reviewed By	:	Location	: 20 Heradale Pde, Batemans Bay
Total Depth	: 6 m BGL	Date	: 13/10/2023	Loc Comment	:

Drilling Method	Depth (m)	Water	Soil Origin	Graphic Log	Classification Code	Material Description	Moisture	Testing SPT	Consistency/Density	Well Diagram
100mm SFA	0.2		Top Soil		ML	Top soil Sandy SILT (ML) : soft, low plasticity, brown yellow, fine grained sand, organic, w < pl.	w < PL		S	
	1.3		Marine Deposit		SM	Marine deposit Silty SAND (SM) : loose, brown yellow, fine grained, with medium sized gravel, dry.	D	3, 3, 3, (N = 6)	L	
	2.5		Residual		CI	Residual Sandy CLAY (CI) : stiff, medium plasticity, grey brown, fine grained sand, trace medium sized gravel, inorganic, moist.	M	3, 3, 19, (N = 22)	St	
	3.5		Residual		CI	Residual Silty CLAY (CI) : hard, medium plasticity, grey brown, with medium sized gravel, with fine grained sand, inorganic, wet.	W		H	
			Rock		SHL	Extremelyweathered, rock Silty CLAY (SHL) : hard, medium plasticity, brown orange, with medium sized gravel, with fine grained sand, inorganic, wet.				

Depth scale: 1, 2, 3, 4

CEC Geotechnical

U4 83, Grose Street, North Parramatta, NSW 2151

Phone: (02) 9630 0121

Geotechnical Log - Borehole

BH06

UTM	: 56H	Drill Rig	: Truck mounted Rig	Job Number	: GR23206
Easting (m)	: 0.0	Driller Supplier	: Total Drilling	Client	: Place Studio AU Pty Ltd
Northing (m)	: 0.0	Logged By	: KT	Project	: Proposed Development
Ground Elevation	: Not Surveyed	Reviewed By	:	Location	: 20 Heradale Pde, Batemans Bay
Total Depth	: 6 m BGL	Date	: 13/10/2023	Loc Comment	:

Drilling Method	Depth (m)	Water	Soil Origin	Graphic Log	Classification Code	Material Description	Moisture	Testing: SPT	Consistency/Density	Well Diagram
100mm SFA			Rock		SHL	Extremelyweathered, rock Silty CLAY (SHL) : hard, medium plasticity, brown orange, with medium sized gravel, with fine grained sand, inorganic, wet.				
	6					**BH06 refusal at 6 m**				
	7									
	8									
	9									

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EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT LOGS - SOIL DESCRIPTION (AS1726 - 2017)

SOIL CLASSIFICATION SYSTEM

Coarse Grained Soil

GW	Well graded gravels, gravel-sand mixtures, little or no fines
GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines, uniform gravels
GM	Silty gravels, Gravel-sand-silt mixtures
GC	Clayey gravels, gravel-sand-clay mixtures
SW	Well-graded sands, gravelly sands, little or no fines
SP	Poorly-graded sands, gravelly sand, little or no fines
SM	Silty sands, sand-silt mixtures
SC	Clayey sands, sand-clay mixtures

Fine Grained Soils

ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or silts with low plasticity
CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays
OL	Organic silts and organic silty clays or low plasticity
MH	Inorganic silts, micaceous or diatomaceous fine sand for silty soils
CH	Inorganic clays of high plasticity
OH	Organic clays of medium to high plasticity, organic silts
PT	Peat, humus, swamp soils with high organic contents

First Letter: G = Grave, S = Sand, M = Silt, C = Clay; Second Letter: W = Well graded, P = Poorly-graded, M = Mixture, O = Organic, L = Low plasticity, H = High plasticity

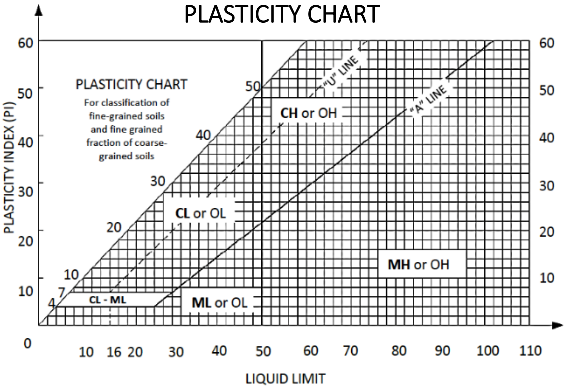
Soils may be a combination of multiple soil classifications where borderline

PARTICLE SIZE

Soil	Major Division	Sub-Division	Particle Size (mm)
Coarse	Boulders		>200
	Cobbles		63 – 200
	Gravel	Coarse	20 – 63
		Medium	6 – 20
		Fine	2.36 – 6
	Sand	Coarse	0.6 – 2.36
		Medium	0.2 – 0.6
		Fine	0.075 – 0.2
Fine	Silt		0.002 – 0.075
	Clay		<0.002

0.075 mm is the approximate minimum particle size discernible by eye

PLASTICITY CHART



MOISTURE CONDITION

Coarse	D	Dry	Sands and gravels are free flowing.
	M	Moist	Soils are darker than in the dry condition and may feel cool. Sands and gravels tend to cohere.
	W	Wet	Soils exude frere water. Sands and gravels tend to cohere
Fine	PL	Plastic Limit	Moisture content of fine grained soils are described; as below plastic limit (<PL), near to plastic limit (=PL), above plastic limit(>PL), near to the liquid limit (=LL), or above the liquid limit (>LL)
	LL	Liquid Limit	

CONSISTENTCY AND DENSITY

Fine Grained Soils

			Pocket Penetrometer Reading (kPa)
VS	Very Soft	Exudes between fingers when squeezed	<25
S	Soft	Can be moulded by light finger pressure	20 – 50
F	Firm	Can be moulded by strong finger pressure	50 – 100
St	Stiff	Cannot be moulded by fingers. Can be indented by thumb	100 – 200
VSt	Very Stiff	Can be indented by thumb nail	200 – 400
H	Hard	Can be indented by thumb nail with difficulty	>400

Coarse Grained Soils

		Density Index %	'N' Value
VL	Very Loose	≤15	0 – 4
L	Loose	15 – 35	4 – 10
MD	Medium Dense	35 – 65	10 – 30
D	Dense	65-85	30 – 50
VD	Very Dense	>85	>50

SECONDARY OR MINOR SOIL COMPONENTS

Designation of Components	In Coarse Grained Soils				In Fine Grained Soils	
	% Fines	Terminology	% Accessory Coarse Fraction	Terminology	% Sand/gravel	Terminology
Minor	≤5	'trace' clay/silt	≤15	'trace' sand/gravel	≤15	'trace' sand/gravel
	5 – 12	'with' clay/silt	15 – 30	'with' sand/gravel	15 – 30	'with' sand/gravel
Secondary	>15	Prefix silty or clayey	>30	Prefix sandy or gravelly	>30	Prefix sandy or gravelly

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EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT LOGS - SOIL DESCRIPTION (AS1726 - 2017)

STRENGTH OF INTACT ROCK

Symbol	Term	Point Load Index, (I_{s50}) MPa	Field Guide to Strength
VL	Very Low	$0.03 \leq I_{s50} < 0.1$	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; pieces up to 30 mm thick can be broken by finger pressure
L	Low	$0.1 \leq I_{s50} < 0.3$	Easily scored with knife; indentations 1 mm to 3 mm after firm blow with pick point; core 150mm long and 50 mm diameter can be broken by hand; sharp edges of core friable
M	Medium	$0.3 \leq I_{s50} < 1.0$	Readily scored with knife; core 150 mm long and 50 mm diameter can be broken by hand with difficulty
H	High	$1.0 \leq I_{s50} < 3$	Core 150 mm long and 50 mm diameter cannot be broken by hand but can be broken by single firm blow of pick; rock rings under hammer
VH	Very High	$3 \leq I_{s50} < 10$	Hand held specimen breaks with pick after more than one blow; rock rings under hammer
EH	Extremely High	$10 \leq I_{s50} <$	Specimen requires many pick blows to break intact rock, rock rings under hammer

Material with rock strength less than "Very Low" is to be described using soil properties

DEGREE OF ROCK WEATHERING

<table>
<tr><th colspan="2">Term</th><th colspan="2">Symbol</th><th>Definition</th></tr>
<tr><td colspan="2">Residual Soil</td><td colspan="2">RS</td><td>Soil derived from the weathering of rock; the mass structure and material fabric are no longer evident the soil has not been significantly transported.</td></tr>
<tr><td colspan="2">Extremely Weathered</td><td colspan="2">XW</td><td>Material is weathered to such an extent that it has soil properties, i.e. it either disintegrates or can be remoulded in water. Fabric of original rock still visible.</td></tr>
<tr><td>Highly Weathered</td><td rowspan="2">Distinctly Weathered</td><td>HW</td><td rowspan="2">DW</td><td>Rock strength is changed by weathering. The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognizable. Some minerals are decomposed to clay minerals. Porosity may be increased by leach, or may be decreased due to deposition or weathering products in pores.</td></tr>
<tr><td>Moderately Weathered</td><td>MW</td><td>The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognizable, but shows little or no change of strength from fresh rock.</td></tr>
<tr><td colspan="2">Slightly Weathered</td><td colspan="2">SW</td><td>Rock is slightly discoloured but shows little or no change of strength from fresh rock.</td></tr>
<tr><td colspan="2">Fresh</td><td colspan="2">FR</td><td>Rock shows no sign of decomposition or staining.</td></tr>
</table>

Distinctly Weathered is to be used when it is not possible to differentiate between highly and moderately weathered.

Extremely Weathered material is to be described using soil properties

ROCK MASS PROPERTIES

Term	Separation of Stratification Planes	Term	Description
Thinly laminated	< 6 mm	Fragmented	Primarily fragments < 20 mm length and mostly of width < core diameter
Laminated	6 mm to 20 mm	Highly fractured	Core lengths generally less than 20 mm to 40 mm with occasional fragments
Very thinly bedded	20 mm to 60 mm		
Thinly bedded	60 mm to 200 mm	Fractured	Core lengths mainly 30 mm to 100 mm with occasional shorter and longer pieces
Medium bedded	0.2 m to 0.6 m	Slightly fractured	Core lengths generally 0.3 m to 1.0 m with occasional longer and shorter sections
Thickly bedded	0.6 m to 2.0 m		
Massive	> 2 m	Unbroken	Core has no fractures

DEFECT TYPES AND DESCRIPTIONS

Defect Type

BR	Bedding parting
JT	Joint
SR	Sheared surface
SZ	Sheared zone
SS	Sheared seam
CS	Crushed seam
IS	Infill seam
XS	Extremely Weathered Seam

Defect Shape

PL	Planar
ST	Stepped
CR	Curved
IR	Irregular
UN	Undulating

Surface Roughness

VR	Very rough
RO	Rough
SM	Smooth
PO	Polished
SL	Slickenside

Defect Coatings

CL	Clean
ST	Stained
VN	Veneer
CT	Coating

Vertical Boreholes – The dip of the defect is given from the horizontal

Inclined Boreholes – The angle of the defect is given from the core axis

Appendix C:

Laboratory Test Results

NATA Accredited
Accreditation Number 1261
Site Number 20794

Accredited for compliance with ISO/IEC 17025 – Testing
NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection, proficiency testing scheme providers and reference materials producers reports and certificates.

CEC Geotechnical
Unit 4 83 Grose Street
North Paramatta
NSW 2151

Attention:	**Kaustuv**
Report	**1038018-S**
Project name	ADDITIONAL - ASS GEOTECH
Project ID	GR23206
Received Date	Oct 25, 2023

Client Sample ID			**BH03-0.5**	**BH3-1.5**	**BH3-3.0**	**BH3-4.5**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**S23-Oc0058745**	**S23-Oc0058746**	**S23-Oc0058747**	**S23-Oc0058748**
Date Sampled			**Oct 14, 2023**	**Oct 14, 2023**	**Oct 14, 2023**	**Oct 14, 2023**
Test/Reference	LOR	Unit				
Actual Acidity (NLM-3.2)						
pH-KCL (NLM-3.1)	0.1	pH Units	9.0	9.6	9.6	9.4
Titratable Actual Acidity (NLM-3.2)	2	mol H+/t	< 2	< 2	< 2	< 2
Titratable Actual Acidity (NLM-3.2)	0.003	% pyrite S	< 0.003	< 0.003	< 0.003	< 0.003
Potential Acidity - Titratable Peroxide						
pH-OX	0.1	pH Units	7.2	8.0	8.0	9.4
Titratable Peroxide Acidity (s-TPA)	0.02	% pyrite S	< 0.02	< 0.02	< 0.02	< 0.02
Titratable Peroxide Acidity (a-TPA)	2	mol H+/t	< 2	< 2	< 2	< 2
Titratable Sulfidic Acidity (a-TSA)	2	mol H+/t	< 2	< 2	< 2	< 2
Titratable Sulfidic Acidity (s-TSA)	0.02	% pyrite S	< 0.02	< 0.02	< 0.02	< 0.02
Extractable Sulfur						
Sulfur - KCl Extractable	0.005	% S	< 0.005	< 0.005	0.017	0.056
Peroxide Extractable Sulfur	0.005	% S	< 0.005	< 0.005	0.021	0.095
HCl Extractable Sulfur	0.005	% S	N/A	N/A	N/A	N/A
Potential Acidity (SPOS)						
Peroxide Oxidisable Sulfur (s-SPOS) (NLM 2.2)	0.005	% S	< 0.005	< 0.005	< 0.005	0.039
Peroxide Oxidisable Sulfur (a-SPOS) (NLM 2.2)	2	mol H+/t	< 2	< 2	< 2	24
Retained Acidity (S-NAS)						
Net Acid soluble sulfur (s-SNAS) NLM-4.1[S02]	0.005	% S	N/A	N/A	N/A	N/A
Net Acid soluble sulfur (a-SNAS) NLM-4.1	2	mol H+/t	N/A	N/A	N/A	N/A
HCl Extractable Sulfur Correction Factor	1	factor	2.0	2.0	2.0	2.0
Extractable Calcium						
Calcium - KCl Extractable	0.005	% Ca	0.15	0.15	0.16	0.19
Calcium - Peroxide	0.005	% Ca	0.33	15	2.3	3.1
Calcium - Acid Reacted	0.005	% Ca	0.17	15	2.1	2.9
Calcium - Acid Reacted (s-aCa)	0.005	% S	0.14	12	1.7	2.3
Calcium - Acid Reacted (a-aCa)	0.005	mol H+/t	85	7500	1100	1400
Extractable Magnesium						
Magnesium - KCl Extractable	0.005	% Mg	< 0.005	0.009	0.023	0.029
Magnesium - Peroxide	0.005	% Mg	< 0.005	0.17	0.086	0.083
Magnesium - Acid Reacted	0.005	% Mg	< 0.005	0.16	0.063	0.054
Magnesium - Acid Reacted (s-aCa)	0.005	% S	< 0.005	0.21	0.084	0.071
Magnesium - Acid Reacted (a-aCa)	0.005	mol H+/t	< 0.005	130	52	44

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Environment Testing

Client Sample ID			BH03-0.5	BH3-1.5	BH3-3.0	BH3-4.5
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			S23-Oc0058745	S23-Oc0058746	S23-Oc0058747	S23-Oc0058748
Date Sampled			Oct 14, 2023	Oct 14, 2023	Oct 14, 2023	Oct 14, 2023
Test/Reference	LOR	Unit				
Acid Neutralising Capacity (ANCE)						
Acid Neutralising Capacity - (ANCE)	0.02	% CaCO3	0.94	35	24	30
Acid Neutralising Capacity - (s-ANCE)	0.02	% S	0.30	11	7.6	9.7
Acid Neutralising Capacity - (a-ANCE)	10	mol H+/t	190	6900	4700	6000
Acid Neutralising Capacity (ANCbt)						
ANC Fineness Factor		factor	1.5	1.5	1.5	1.5
Net Acidity (Including ANC)						
SPOCAS - Net Acidity - ASSMAC (Acidity Units)	10	mol H+/t	< 10	< 10	< 10	< 10
SPOCAS - Net Acidity - ASSMAC (Sulfur Units)	0.02	% S	< 0.02	< 0.02	< 0.02	< 0.02
SPOCAS - Liming rate - ASSMAC	1	kg CaCO3/t	< 1	< 1	< 1	< 1
Extraneous Material						
<2mm Fraction	0.005	g	42	49	45	40
>2mm Fraction	0.005	g	< 0.005	< 0.005	< 0.005	< 0.005
Analysed Material	0.1	%	100	100	100	100
Extraneous Material	0.1	%	< 0.1	< 0.1	< 0.1	< 0.1

Sample History

Where samples are submitted/analysed over several days, the last date of extraction is reported.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
SPOCAS Suite			
SPOCAS Suite	Brisbane	Oct 25, 2023	6 Week
- Method: LTM-GEN-7050			
Extraneous Material	Brisbane	Oct 25, 2023	6 Week
- Method: LTM-GEN-7050/7070			

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ABN: 50 005 085 521

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Site# 1254

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NATA# 1261
Site# 25403

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NATA# 1261
Site# 18217

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Site# 25466

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NATA# 1261
Site# 20794

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Mayfield West NSW 2304
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NATA# 1261
Site# 25079 & 25289

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IANZ# 1402

Company Name:	CEC Geotechnical	**Order No.:**		**Received:**	Oct 25, 2023 12:00 AM
Address:	Unit 4 83 Grose Street North Paramatta NSW 2151	**Report #:**	1038018	**Due:**	Oct 30, 2023
		Phone:	02 9630 0121	**Priority:**	3 Day
		Fax:		**Contact Name:**	Kaustuv
Project Name:	ADDITIONAL - ASS GEOTECH				
Project ID:	GR23206				

Eurofins Analytical Services Manager : Hannah Mawbey

Sample Detail						SPOCAS Suite
Brisbane Laboratory - NATA # 1261 Site # 20794						X
External Laboratory						
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**	
1	BH03-0.5	Oct 14, 2023		Soil	S23-Oc0058745	X
2	BH3-1.5	Oct 14, 2023		Soil	S23-Oc0058746	X
3	BH3-3.0	Oct 14, 2023		Soil	S23-Oc0058747	X
4	BH3-4.5	Oct 14, 2023		Soil	S23-Oc0058748	X
Test Counts						4

Environment Testing

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follow guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013. They are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry weight basis unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion unless otherwise stated.
4. For CEC results where the sample's origin is unknown or environmentally contaminated, the results should be used advisedly.
5. Actual LORs are matrix dependent. Quoted LORs may be raised where sample extracts are diluted due to interferences.
6. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
7. SVOC analysis on waters is performed on homogenised, unfiltered samples unless noted otherwise.
8. Samples were analysed on an 'as received' basis.
9. Information identified in this report with blue colour indicates data provided by customers that may have an impact on the results.
10. This report replaces any interim results previously issued.

Holding Times

Please refer to the 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours before sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and despite any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling; therefore, compliance with these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether, the holding time is 7 days; however, for all other VOCs, such as BTEX or C6-10 TRH, the holding time is 14 days.

Units

mg/kg: milligrams per kilogram	**mg/L:** milligrams per litre	**µg/L:** micrograms per litre
ppm: parts per million	**ppb:** parts per billion	**%:** Percentage
org/100 mL: Organisms per 100 millilitres	**NTU:** Nephelometric Turbidity Units	**MPN/100 mL:** Most Probable Number of organisms per 100 millilitres
CFU: Colony forming unit		

Terms

APHA	American Public Health Association
CEC	Cation Exchange Capacity
COC	Chain of Custody
CP	Client Parent - QC was performed on samples pertaining to this report
CRM	Certified Reference Material (ISO17034) - reported as percent recovery.
Dry	Where moisture has been determined on a solid sample, the result is expressed on a dry weight basis.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
LOR	Limit of Reporting.
LCS	Laboratory Control Sample - reported as percent recovery.
Method Blank	In the case of solid samples, these are performed on laboratory-certified clean sands and in the case of water samples, these are performed on de-ionised water.
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC represents the sequence or batch that client samples were analysed within.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
SRA	Sample Receipt Advice
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
TBTO	Tributyltin oxide (*bis*-tributyltin oxide) - individual tributyltin compounds cannot be identified separately in the environment; however free tributyltin was measured, and its values were converted stoichiometrically into tributyltin oxide for comparison with regulatory limits.
TCLP	Toxicity Characteristic Leaching Procedure
TEQ	Toxic Equivalency Quotient or Total Equivalence
QSM	US Department of Defense Quality Systems Manual Version 5.4
US EPA	United States Environmental Protection Agency
WA DWER	Sum of PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC - Acceptance Criteria

The acceptance criteria should be used as a guide only and may be different when site-specific Sampling Analysis and Quality Plan (SAQP) have been implemented.

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30%; however the following acceptance guidelines are equally

applicable: Results <10 times the LOR: No Limit

Results between 10-20 times the LOR: RPD must lie between 0-50%

Results >20 times the LOR: RPD must lie between 0-30%

NOTE: pH duplicates are reported as a range, not as RPD

Surrogate Recoveries: Recoveries must lie between 20-130% for Speciated Phenols & 50-150% for PFAS. SVOCs recoveries 20 – 150%

PFAS field samples that contain surrogate recoveries above the QC limit designated in QSM 5.4, where no positive PFAS results have been reported, have been reviewed, and no data was affected.

QC Data General Comments

1. Where a result is reported as less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown are not data from your samples.
3. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling. Therefore, laboratory analysis is unlikely to be completed within holding time.Analysis will begin as soon as possible after sample receipt.
4. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of recovery, the term "INT" appears against that analyte.
5. For Matrix Spikes and LCS results, a dash "-" in the report means that the specific analyte was not added to the QC sample.
6. Duplicate RPDs are calculated from raw analytical data; thus, it is possible to have two sets of data.

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Environment Testing

Quality Control Results

Test			Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
LCS - % Recovery									
Actual Acidity (NLM-3.2)									
pH-KCL (NLM-3.1)			%	89			80-120	Pass	
Titratable Actual Acidity (NLM-3.2)			%	102			80-120	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
Actual Acidity (NLM-3.2)				Result 1	Result 2	RPD			
pH-KCL (NLM-3.1)	S23-Oc0058747	CP	pH Units	9.6	9.6	<1	20%	Pass	
Titratable Actual Acidity (NLM-3.2)	S23-Oc0058747	CP	mol H+/t	< 2	< 2	<1	20%	Pass	
Titratable Actual Acidity (NLM-3.2)	S23-Oc0058747	CP	% pyrite S	< 0.003	< 0.003	<1	30%	Pass	
Duplicate									
Potential Acidity - Titratable Peroxide				Result 1	Result 2	RPD			
pH-OX	S23-Oc0058747	CP	pH Units	8.0	8.8	<1	20%	Pass	
Titratable Peroxide Acidity (s-TPA)	S23-Oc0058747	CP	% pyrite S	< 0.02	< 0.02	<1	30%	Pass	
Titratable Peroxide Acidity (a-TPA)	S23-Oc0058747	CP	mol H+/t	< 2	< 2	<1	20%	Pass	
Titratable Sulfidic Acidity (a-TSA)	S23-Oc0058747	CP	mol H+/t	< 2	< 2	<1	30%	Pass	
Titratable Sulfidic Acidity (s-TSA)	S23-Oc0058747	CP	% pyrite S	< 0.02	< 0.02	<1	30%	Pass	
Duplicate									
Extractable Sulfur				Result 1	Result 2	RPD			
Sulfur - KCl Extractable	S23-Oc0058747	CP	% S	0.017	0.016	8.1	30%	Pass	
Peroxide Extractable Sulfur	S23-Oc0058747	CP	% S	0.021	0.021	<1	20%	Pass	
HCl Extractable Sulfur	S23-Oc0058747	CP	% S	N/A	N/A	N/A	20%	Pass	
Duplicate									
Potential Acidity (SPOS)				Result 1	Result 2	RPD			
Peroxide Oxidisable Sulfur (s-SPOS) (NLM 2.2)	S23-Oc0058747	CP	% S	< 0.005	< 0.005	<1	30%	Pass	
Peroxide Oxidisable Sulfur (a-SPOS) (NLM 2.2)	S23-Oc0058747	CP	mol H+/t	< 2	< 2	<1	30%	Pass	
Duplicate									
Retained Acidity (S-NAS)				Result 1	Result 2	RPD			
Net Acid soluble sulfur (s-SNAS) NLM-4.1	S23-Oc0058747	CP	% S	N/A	N/A	N/A	30%	Pass	
Net Acid soluble sulfur (a-SNAS) NLM-4.1	S23-Oc0058747	CP	mol H+/t	N/A	N/A	N/A	30%	Pass	
Duplicate									
Extractable Calcium				Result 1	Result 2	RPD			
Calcium - KCl Extractable	S23-Oc0058747	CP	% Ca	0.16	0.16	1.0	30%	Pass	
Calcium - Peroxide	S23-Oc0058747	CP	% Ca	2.3	2.2	1.2	20%	Pass	
Calcium - Acid Reacted	S23-Oc0058747	CP	% Ca	2.1	2.1	1.4	30%	Pass	
Calcium - Acid Reacted (s-aCa)	S23-Oc0058747	CP	% S	1.7	1.7	1.4	30%	Pass	
Calcium - Acid Reacted (a-aCa)	S23-Oc0058747	CP	mol H+/t	1100	1000	1.4	30%	Pass	
Duplicate									
Extractable Magnesium				Result 1	Result 2	RPD			
Magnesium - KCl Extractable	S23-Oc0058747	CP	% Mg	0.023	0.023	<1	30%	Pass	
Magnesium - Peroxide	S23-Oc0058747	CP	% Mg	0.086	0.086	<1	20%	Pass	
Magnesium - Acid Reacted	S23-Oc0058747	CP	% Mg	0.063	0.063	1.1	30%	Pass	
Magnesium - Acid Reacted (s-aCa)	S23-Oc0058747	CP	% S	0.084	0.083	1.1	30%	Pass	
Magnesium - Acid Reacted (a-aCa)	S23-Oc0058747	CP	mol H+/t	52	52	1.1	30%	Pass	
Duplicate									
Acid Neutralising Capacity (ANCE)				Result 1	Result 2	RPD			
Acid Neutralising Capacity - (ANCE)	S23-Oc0058747	CP	% CaCO3	24	23	5.0	30%	Pass	
Acid Neutralising Capacity - (a-ANCE)	S23-Oc0058747	CP	mol H+/t	4700	4500	5.0	30%	Pass	

Duplicate									
Acid Neutralising Capacity (ANCbt)				Result 1	Result 2	RPD			
ANC Fineness Factor	S23-Oc0058747	CP	factor	1.5	1.5	<1	30%	Pass	
Duplicate									
Net Acidity (Including ANC)				Result 1	Result 2	RPD			
SPOCAS - Net Acidity - ASSMAC (Acidity Units)	S23-Oc0058747	CP	mol H+/t	< 10	< 10	<1	30%	Pass	
SPOCAS - Net Acidity - ASSMAC (Sulfur Units)	S23-Oc0058747	CP	% S	< 0.02	< 0.02	<1	30%	Pass	
SPOCAS - Liming rate - ASSMAC	S23-Oc0058747	CP	kg CaCO3/t	< 1	< 1	<1	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
S02	Retained Acidity is Reported when the pHKCl is less than pH 4.5

Authorised by:

Adam Bateup	Analytical Services Manager
Jonathon Angell	Senior Analyst-SPOCAS

Glenn Jackson
Managing Director

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

Appendix D:

Site Classification General Information

(CSIRO Document – BTF18)

Foundation Maintenance and Footing Performance: A Homeowner's Guide

BTF 18 replaces Information Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

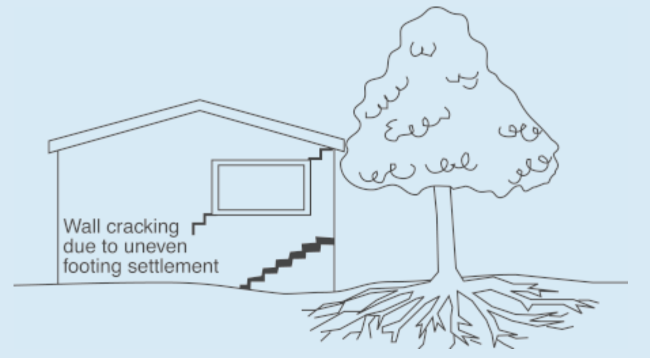
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures
Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

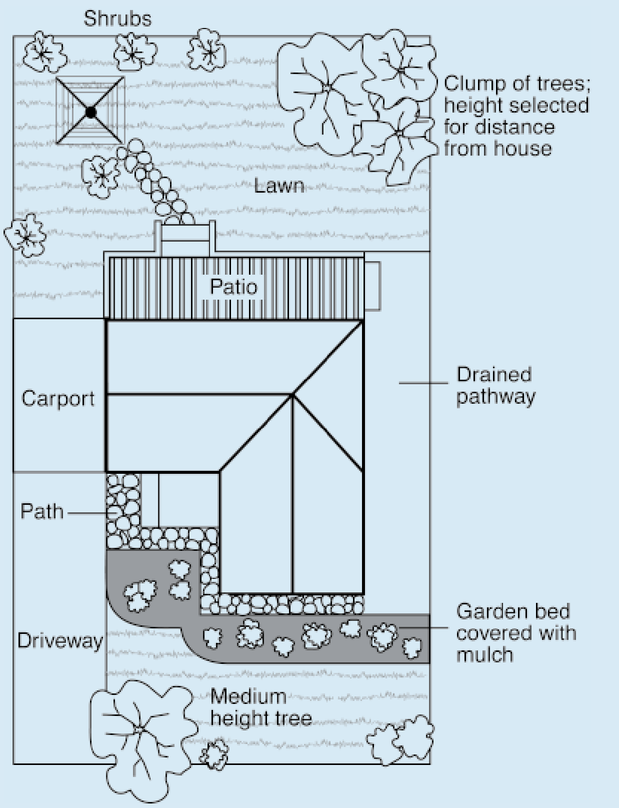
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4

Gardens for a reactive site



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

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