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RMB GROUP PTY LTD

Additional Geotechnical Investigation

10-28 Lawrence Street, Freshwater NSW

E25874.G04_Rev1

12 November 2024

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Revision	Details	Date	Amended By
	Original	4 July 2023	
1	Updated architectural details and recommendations	12 November 2024	KX

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1. Introduction

1.1 Background

At the request of Mike Turner on behalf of RMB Group Pty Ltd (the Client), EI Australia (EI) has carried out an Additional Geotechnical Investigation (AGI) for the proposed development at 10-28 Lawrence Street, Freshwater NSW (the Site).

This AGI report has been prepared to provide advice and recommendations to assist in the preparation of designs for the proposed development. The investigation has been carried out in accordance with the agreed scope of works outlined in EI's proposal referenced P20934.1 dated 10 January 2023, and with the Client's signed authorisation to proceed, dated 16/11/2022. A variation on the scope of proposal P20934.1 was made with the clients signed authorisation to proceed (by email), dated 9/02/2023.

EI has also completed the following reports for this site:

- Preliminary Site Investigation (PSI) Report, referenced E25874.E01_Rev0, dated 24 January 2023.
- Geotechnical Site Assessment Report, referenced E25874.G14, dated 7 February 2023.
- Groundwater Monitoring Report No.1, referenced E25874.G11, dated 21 November 2023.
- Groundwater take Assessment referenced E25874.G12_Rev1, dated 12 November 2024.

1.2 Proposed Development

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

- Architectural drawings prepared by CHROFI – Project No. 21053, Drawing Nos. A-DA-000 to A-DA-002, A-DA-097 to A-DA-104, A-DA-201, A-DA-301, A-DA-302, Revision 03-WIP, dated 29 October 2024.
- Site survey plan prepared by Norton Survey Partners – Referenced 53094, dated 25/11/2022. The datum in the survey plan is in Australian Height Datum (AHD), hence all Reduced Levels (RL) mentioned in this report are henceforth in AHD
- Previous Geotechnical Investigation (GI) report prepared by Geotechnique – Ref 12446/1-AA, dated 31 March 2011.

Based on the provided documents, EI understands that the proposed development involves the demolition of the existing site structures and the construction of a four-storey residential development overlying a two-level mixed use basement. The lowest basement level is proposed to have a finished floor level (FFL) of between RL 15.37mAHD. A Bulk Excavation Level (BEL) of RL 15.1mAHD is assumed, which includes allowance for the construction of a concrete basement slab. To achieve the BEL, excavation depths from 5.5m to 12m Below Existing Ground Level (BEGL) have been estimated. Locally deeper excavations may be required for footings, lift overrun pits, crane pads, and service trenches. The basement extends up to the western, southern, northern and eastern boundaries, with no set back.

1.3 Objectives

The objective of the AGI was to assess site surface and subsurface conditions at three borehole locations, and to provide geotechnical advice and recommendations addressing the following:

- Excavation methodologies and monitoring requirements
- Groundwater considerations
- Vibration considerations
- Excavation support requirements, including geotechnical design parameters for retaining walls and shoring systems
- Building foundation options, including;
  - Design parameters
  - Earthquake loading factor in accordance with AS1170.4:2007
- The requirement for additional geotechnical investigation

1.4 Scope of Works

The scope of works for the AGI included:

- Preparation of a Work Health and Safety Plan
- Review of relevant geological maps for the project area
- Site walkover inspection by a Geotechnical Engineer to assess topographical features and site conditions
- Scanning of proposed borehole locations for buried conductive services using a licensed service locator with reference to Dial Before You Dig (DBYD) plans
- Auger drilling of three boreholes (BH101M, BH102, and BH103M) by a track-mounted drill rig using solid flight augers equipped with a 'Tungsten-Carbide' (T-C) bit. The boreholes were auger drilled (or excavated using Non-destructive digging techniques) to depths as shown in **Table1-1** below.
- Continuation of the boreholes using NMLC diamond coring techniques to termination depths shown above in **Table 1-1**. The rock core photographs are presented in **Appendix A**

Table 1-1 Auger Drilling and Rock Coring Depths

Borehole ID	Auger Drilling		Rock Coring	
	Depth (m)	RL (m AHD)	Depth (m)	RL (m AHD)
BH101M	3.93	16.07	17.83	2.17
BH102M	1.42	22.58	20.36	3.64
BH103M	1.02	28.78	23.70	6.10

    - Standard Penetration Testing (SPT) was carried out (as per AS 1289.6.3.1-2004), where possible, during auger drilling of the boreholes to assess soil strength/relative densities
    - Measurements of groundwater seepage/levels where possible, in the augered sections of the boreholes during and shortly after completion of auger drilling
    - The strength of the bedrock in the augered sections of the boreholes was assessed by observation of the auger penetration resistance using a T-C drill bit and examination of the recovered rock cuttings. It should be noted that rock strengths assessed from augered boreholes are approximate and strength variances can be expected
    - The approximate surface levels shown on the borehole logs were interpolated from spot levels shown on the supplied survey plan. Approximate borehole locations are shown on **Figure 2**
- Borehole BH101M, BH102M, and BH103M were converted into groundwater monitoring wells to allow for long-term groundwater monitoring
- Soil and rock samples were sent to STS Geotechnics Pty Ltd (STS) and SGS Australia (SGS), which are National Australian Testing Authority (NATA) accredited laboratories, for testing and storage
- Preparation of this AGI report

EI's Geotechnical Engineer was present full-time onsite to set out the borehole locations, direct the testing and sampling, log the subsurface conditions and record groundwater levels.

1.5 Constraints

The AGI was limited by the intent of the investigation and the presence of existing site structures. The discussions and advice presented in this report are intended to assist in the preparation of final designs for the proposed development. Further geotechnical inspections should be carried out during construction to confirm the geotechnical and groundwater models, and the preliminary design parameters provided in this report.

2. Site Description

2.1 Site Description and Identification

The site identification details and associated information are presented in **Table 2-1** below while the site locality is shown on **Figure 1.** An aerial photograph of the site is presented in **Plate 1** below.

Table 2-1 Summary of Site Information

Information	Detail
Street Address	10-28 Lawrence Street, Freshwater NSW
Lot and Deposited Plan (DP) Identification	Lot 1 DP900061, Lot 1 DP100563, Lot 1 DP578401, Lot 45 DP974653, Lot 1 DP595422
Brief Site Description	The site is currently occupied by commercial structures sharing common boundary lines and a driveway access constructed across the rear boundary of the properties. This driveway is constructed across the roof of the properties along the southern site alignment. The commercial structures are constructed of mixed concrete and masonry materials. Across the site evidence of minor structural settlement was evident with considerable cracking along the entrance to the driveway off Dowling Street. The cracking extends from the entrance off Dowling street, across the concrete slab into the ramp/slab. Differential settlement is evident along the exposed brick work ramp between Lot 45 DP974653 and Lot 1 DP595422 with bricks showing significant spalling and diagonal cracking.
Site Area	The site area is approximately 2,581 m^2 (based on an assessment of the provided survey plan referenced above).

Plate 1: Aerial photograph of the site (source: SixMap, accessed 20/02/2023)

2.2 Local Land Use

The site is situated within an area of mixed commercial and residential use. Current uses on surrounding land at the time of our presence on site are described in **Table 2-2** below. For the sake of this report, the site boundary adjacent to Lawrence Street shall be adopted as the Northern site boundary.

Table 2-2 Summary of Local Land Use

Direction Relative to Site	Land Use Description
North	Lawrence Street, a single lane asphalt paved road with parking lanes. Buried beneath this roadway is a major electrical transmission asset operated by Ausgrid the asset extends from the nearby sub-station down the laneway access to 27 Lawrence street around the curve of Lawrence Street and Dowling Street along the western site boundary. Beyond Lawrence Street lie one to two-storey commercial buildings. Sydney Water Assets also run below Lawrence Street.
East	Adjacent to the eastern boundary with no offset from the Site is a mixed use Commercial/Residential building at 6 - 8 Lawrence Street. The structure at 6 - 8 Lawrence Street appears to be a reinforced concrete structure with at least a single level basement carpark. Beyond this is Albert Street, a single lane asphalt paved road.
South	Along the southern site boundary are a series of residential buildings, these structures are offset between 6m and 16m from the site boundary. 14 Undercliff Road hosts a pool at less than a 1m offset from the site boundary. The main structure at 14 Undercliff is located less then 7m from the site boundary. Beyond this the landscape slopes uphill.
West	Along the western boundary the site adjoins a shared pedestrian-cycleway. This easement is utilised to encase an Ausgrid transmission line. Inside the easement at the corner of Dowling Street and Lawrence Street is an electrical substation. Beyond this easement is Dowling street, which is a single lane asphalt paved road with parking lanes.

2.3 Regional Setting

The site topography and geological information for the locality is summarised in **Table 2-3** below**.**

Table 2-3 Topographic and Geological Information

Attribute	Description
Topography	The site is located on the high south side of Lawrence Street within gently (5° to 9°) North-East dipping topography with site levels varying from R.L. 30.0mAHD at the South-West site corner to R.L. 21.0mAHD at the North-East site corner.
Regional Geology	Information on regional sub-surface conditions, referenced from the Department of Mineral Resources Geological Map Sydney 1:100 000 Geological Series Sheet 9130 (DMR 1983) indicates the site to be underlain by Hawkesbury Sandstone, which consists of medium to coarse-grained quartz sandstone with very minor shale and laminite lenses. Outcrops of in-situ sandstone bedrock were observed at the surface of the existing ground level adjacent to Dowling Street, in the nearby Moore Lane pedestrian walkway and at numerous residences along Undercliff Road.

Plate 2: Excerpt of geological map showing location of site.

3. Investigation Results

3.1 Stratigraphy

For the development of a site-specific geotechnical model, the stratigraphy observed in the GI (Geotechnique) and AGI (EI) has been grouped into three geotechnical units. A summary of the subsurface conditions across the site interpreted from the assessment results is presented in **Table 3-1** below. More detailed descriptions of subsurface conditions at each borehole location are available on the borehole logs presented in **Appendix A**. The details of the methods of soil and rock classifications, explanatory notes and abbreviations adopted on the borehole logs are also presented in **Appendix A.**

Table 3-1 Summary of Subsurface Conditions

Unit	Material[2]	Depth to Top of Unit (m BEGL)[1]	RL of Top of Unit (m AHD)[1]	Observed Thickness (m)	Comments
1a	**Pavement**	Surface	20.0 to 29.8	0.02 to 0.28	Asphalt pavements of 20mm to 50mm thickness, or a concrete slab of 80mm to 280mm thickness (Geotechnique).
1b	**Fill**	0.02 to 0.28	19.9 to29.8	0.2 to 1.5	Sandy Gravel fill; fine to coarse grained sand and fine to medium sandstone gravels, trace cobbles.
2	**Aeolian/ Residual Soil**	1.5	18.5	2.43	Encountered in BH101M only. Fine to medium grained Aeolian sand, overlying high plasticity, very stiff residual silty clay.
3	**Sandstone Bedrock**	0.3 to 3.9	16.1 to 29.1	- [3]	Sandstone bedrock of generally medium to high strength, slightly weathered to fresh. Bedrock quality varies across the site, with various classes encountered in each borehole (summarised in **Table 3-2**). Ocassional bands of very low to low strength sandstone/shale were present in some boreholes. Bedding spacing is generally medium to thickly bedded, and occasional massive bedrock. Defects include crushed/weathered seams, bedding partings, and joints which are sub-vertical. Core loss was observed in BH1, BH2, BH101M and BH102M.

Note 1 Approximate depth and level at the time of our assessment. Depths and levels may vary across the site.
Note 2 For more detailed descriptions of the subsurface conditions reference should be made to the borehole logs attached to **Appendix A.**
Note 3 Observed up to termination depth in all boreholes.

Table 3-2 Summary of Rock Depths

	EI			Geotechnique		
	BH101M	**BH102M**	**BH103M**	**BH1**	**BH2**	**BH3**
Top of Borehole RL (m AHD)	*20.0*	*24.0*	*29.8*	*29.7*	*27.0*	*24.9*
	Depth Range of Sandstone/Shale Class (m BEGL)					
Class V Sandstone	3.93-4.3	1.42-3.42	0.7-1.02	3.4-3.8	0.6-0.75	-
Class IV Sandstone	4.3-7.7 13.9-16.55	-	8.67-9.8	1.0-3.4 3.8-5.0	0.75-3.5	0.3-3.15 9.3-13.8
Class III Sandstone	7.7-11.4	3.42-7.44 9.35-14.39 >18.3	1.02-8.67 13.2-19.68	5.0-9.0	5.5-8.6	3.5-8.0
Class V Shale	-	7.44-9.35	-	9.0-9.25	8.6-11.15	8.2-9.3
Class II Sandstone	11.4-13.9	-	-	>9.5	3.5-5.5 >11.15	>13.8
Class I Sandstone	>16.55	14.39-18.3	9.8-13.2 >19.68	-	-	-

3.2 Groundwater Observations

Groundwater seepage was not observed during auger drilling of any borehole. Following the completion of drilling, groundwater monitoring wells were installed in and bailed dry. The groundwater levels were then measured within the monitoring wells as per **Table 3-2** below:

Table 3-3 Groundwater Levels

Borehole ID	Estimated Ground Level of Well (m AHD)	Measurement Date	Depth to Groundwater (m BEGL)	Groundwater RL (m AHD)
BH101M	20.0	13/04/2023	4.35	15.65
BH102M	24.0	13/04/2023	4.98	19.02
BH103M	29.8	21/04/2023	4.4	25.4
BH3M-Geotechnique	24.6	20/01/2023	1.83	22.77
		13/04/2023	1.84	22.76

Additionally, EI has completed long-term groundwater level monitoring at this site within BH101M, BH102M and BH103M, in the period from 13 April 2023 to 24 October 2023. The summary of long-term groundwater level monitoring data is presented in **Table 3-3** below.

Table 3-4 Summary of Long-Term Groundwater Levels

Borehole ID	Average Groundwater RL (m AHD)	Highest Groundwater RL (mAHD)	Lowest Groundwater RL (mAHD)
BH101M	15.92	16.58	14.8
BH102M	19.83	20.29	19.4
BH103M	25.60	25.94	25.09

3.2.1 Infiltration test

A Rising Head Test was completed on 13 and 21 April 2023 in the monitoring wells installed by EI. The following procedure was adopted:

- The groundwater level within the well was initially recorded;
- The well was purged using an electrical groundwater pump;
- The rising groundwater level within the temporary well was measured at various time intervals for 1 hour.

The results were then used to estimate the permeability of the sandstone bedrock using the Hvorslev Method based on the borehole geometry, and the results are summarised in **Table 3-3** below.

Table 3-5 Hydraulic Conductivity Results

Borehole ID	Measurement Date	Calc. Permeability (m/sec)
BH101M	13/04/2023	3.2E-08
BH102M	13/04/2023	3.1E-08
BH103M	21/04/2023	1.1E-08

3.3 Test Results

No soil samples were assessed due to the location of the boreholes outside of the site boundary. The negligible depth and composition of soil indicates that exposure classification will not be impacted by soil type and composition.

57 selected rock core samples were tested by STS Soil Testing Services to estimate the Point Load Strength Index (Is_{50}) values to assist with rock strength assessment. The results of the testing are summarised on the attached borehole logs. The point load strength index tests correlated reasonably well with our field assessments of rock strength. The approximate Unconfined Compressive Strength (UCS) of the rock core, estimated from correlations with the point load strength index test results, varied from <1 MPa to 80MPa.

4. Recommendations

4.1 Geotechnical Issues

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

- Basement excavation and retention to limit lateral deflections and ground loss as a result of excavations, resulting in damage to nearby structures
- Rock excavation
- Groundwater within the depth of the excavation
- Existing footings of neighbouring properties
- Foundation design for building loads

4.2 Site Preparation

4.2.1 Dilapidation Surveys

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

4.2.2 Existing Footings

Prior to any excavation, we recommend that test pits be excavated adjacent to the existing neighbouring footings for the sheds and pool to the south, and be inspected by the geotechnical and structural engineers to inspect and assess the in-situ ground conditions at the founding level and footing details. The purpose of these test pits is to assess the requirement of underpinning of these neighbouring footings adjoining the site. Should these footings be founded on competent bedrock, shoring may not be required.

4.3 Geotechnical Landslide Assessment

As recommended in the E25874.G14 Site assessment prepared by EI Australia, the Northern Beaches Council DCP/E10-Landslide Risk for Warringah requires a geotechnical assessment for land subject to Hazard Mapping (Landslide Risk). In **Plate 4** below Council's mapping shows part of the land at this site is within Area B (Flanking Slopes from 5 to 25 Degrees).

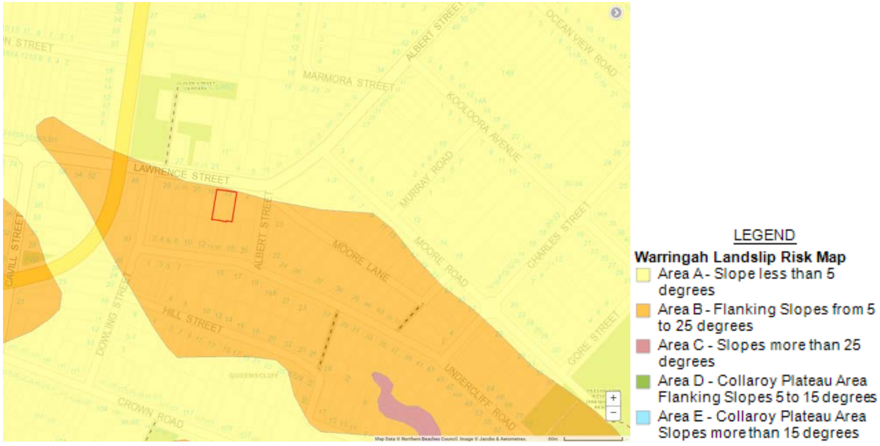

Plate 4 – Landslide Risk mapping

For land in Area B, a Checklist is used to determine whether or not a geotechnical report is required. EI assessed the slope and existing development features within and adjacent to the property.

EI Australia has reviewed the site with reference to this checklist and based on the assessed information, the proposed basement excavation and the adjoining properties. The excavation will be through sandstone bedrock generally of medium to high strength. The basement excavation will be supported by an engineered retention system (where required in soil) and will be subject to geotechnical monitoring during construction. Accordingly, EI considers that with appropriate engineering design, construction controls and monitoring, the landslide risk associated with the proposed basement during excavation and construction will be Low to Very Low.

4.4 Excavation Methodology

4.4.1 Excavation Assessment

Prior to any excavation commencing, we recommend that reference be made to the Safe Work Australia Excavation Work Code of Practice (October 2018) and NSW Government Code of Practice Excavation Work (January 2020).

EI assumes that the proposed development will require a Bulk Excavation Level (BEL) of RL 15.1mAHD for the basement, or an excavation depth of about 5.5m and 12m BEGL. Locally deeper excavations for footings, service trenches, crane pads and lifts overrun pits may be required.

Based on the borehole logs, the proposed basement excavations will therefore extend through all units as outlined in **Table 3-1** above. As such, an engineered retention system must be installed prior to excavation commencing.

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

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

The vibration measurements can be carried out using either an attended or an unattended vibration monitoring system. An unattended vibration monitoring system must be fitted with an alarm in the form of a strobe light or siren or alerts sent directly to the site supervisor to make the plant operator aware immediately when the vibration limit is exceeded. The vibration monitor must be set to trigger the alarm when the overall Peak Particle Velocity (PPV) exceeds set limits outlined by a vibration monitoring plan. Reference should be made to **Appendix C** for a guide to acceptable limits of transmitted vibrations.

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

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

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

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

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

4.4.2 Excavation Monitoring

Consideration should be made to the impact of the proposed development upon neighbouring structures, roadways and services. Basement excavation retention systems should be designed so as to limit lateral deflections. Contractors should also consider the following limits associated with carrying out excavation and construction activities:

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

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

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

4.5 Groundwater Considerations

Groundwater was observed in all monitoring wells as detailed in **Table 3-2**, all of which are above the assumed Bulk excavation level of RL 15.1mAHD.

Based on the results of the Groundwater Take Assessment by EI, due to the low permeability of the bedrock profile any groundwater inflows into the excavation should not have an adverse impact on the proposed development or on the neighbouring sites and should be manageable. However, we expect that some groundwater inflows into the excavation along the soil/rock interface and through any defects within the sandstone bedrock (such as jointing, and bedding planes, etc.) particularly following a period of heavy rainfall. The initial flows into the excavation may be locally high, but would be expected to decrease considerably with time as the bedding seams/joints are drained. We recommend that monitoring of seepage be implemented during the excavation works to confirm the capacity of the drainage system. Dewatering at this site does to have the potential to cause adverse settlement due to the regionally extant sandstone bedrock.

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

In the long term, drainage should be provided behind all basement retaining walls, around the perimeter of the basement and below the basement slab. The completed excavation should be inspected by the hydraulic engineer to confirm that adequate drainage has been allowed for.

Drainage should be connected to the sump-and-pump system and discharging into the stormwater system. The permanent groundwater control system should take into account any possible soluble substances in the groundwater which may dictate whether or not groundwater can be pumped into the stormwater system.

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

4.6 Excavation Retention

4.6.1 Support Systems

From a geotechnical perspective, it is critical to maintain the stability of all adjacent structures and infrastructures during demolition, excavation and construction works.

Based on the provided architectural plans, the proposed basement outline has no offset from any boundary. Based on the depth of the excavation, the encountered subsurface conditions and limited setbacks, temporary batters in soil are not recommended for this site. Unsupported vertical cuts of the soil are not recommended for this site as these carry the risk of potential collapse especially after a period of wet weather. Collapse of the material may result in the injury or death of personnel and/or damage to nearby structures and equipment.

A suitable retention system will be required for the support Units 1 and *2*. However, EI notes that the boreholes within the site (BH1 to BH3) all encountered shallow bedrock (<1m deep), and hence the following temporary shoring systems to support the upper soil may be feasible for this site:

- Reinforced shotcrete with soil nails installed to bedrock, or
- Steel posts installed into the underlying bedrock with timber lagging

Unit 3 sandstone should generally be able to be cut vertically and without support. For vertical cuts, the excavations must be inspected by a geotechnical engineer at regular intervals of no more than 1.5m to check for any inclined joints or weak seams that require stabilisation. Inclined joints and weak seams were identified in all boreholes, particularly the weaker shale layer observed in BH102M, BH1, BH2 and BH3 at depth. If adverse defects are encountered, the stabilisation measures may comprise rock bolts, shotcrete and mesh or dental treatment of thin weak seams using non-shrink grout, and this should be allowed for.

EI recommends that a number of test pits or boreholes be excavated around the perimeter of the site following demolition to determine the depth to bedrock and assess the requirement for a more robust shoring system. Should a deep soil profile be encountered (particularly towards the north-eastern portion of the site), EI recommends a contiguous pile wall with mass concrete in between the piles be founded into Unit 3 sandstone bedrock, with the sandstone excavated vertically below. The piles must allow for an anchor to be installed at the toe to prevent kick-out of the pile toe. Anchors/props and mass concrete must be installed progressively as excavation proceeds based on ongoing geotechnical assessment.

Due to the presence of the basement structures adjacent to the site (to the east), anchors installation may not be possible and internal props may be required. Details of nearby basements, shoring pile walls and anchors must be obtained prior to final design.

The existence of significant horizontal in-situ stresses in bedrock, particularly in the Sydney basin, is well established. The release of such stresses during the basement excavation may cause adverse impact on the stability of the excavation faces and thus increase the movements. Monitoring of several deep excavations within sandstone and shale in the Sydney region indicates that the lateral displacement at the top of the excavation is generally between 0.5mm to 2mm per meter depth of excavation. As the maximum depth of excavation into sandstone is of about 12m, a lateral deflection at the crest of the excavation between 6mm to 24mm can be expected which will reduce in a stepped fashion to zero at the bulk excavation level. Monitoring of the lateral movement as the excavation progresses is recommended. An assessment of such movements and their impact can be carried out using finite element software such as PLAXIS.

Bored piles (where required) are considered to be the most suitable for this site. Tremie pumps may be required where high groundwater seepage inflows are present during the drilling of the bored piles. However, relatively large capacity piling rigs will be required for drilling through the sandstone bedrock. The proposed pile locations should take into account the presence of buried services. Further advice should be sought from prospective piling contractors who should be provided with a copy of this report.

4.6.2 Excavation adjacent to Ausgrid Transmission Lines and Sydney Water assets

Reference should be made to the respective guidelines of Ausgrid and Sydney Water, with regards to excavation/shoring adjacent to these assets. These documents outline the requirements for excavations adjacent to infrastructure, and include the level of geotechnical investigation required, dilapidation surveying, instrumentation and monitoring during construction, trigger levels and contingency plans. A geotechnical monitoring plan may be required by asset owners prior to construction for this site.

4.6.3 Retaining Wall Design Parameters

The following parameters may be used for static design of temporary and permanent retaining walls at the subject site:

- Conventional free-standing cantilever walls which support areas where movement is of little concern (i.e. where only gardens or open areas are to be retained), may be designed using a triangular lateral earth pressure distribution and an ‘active’ earth pressure coefficient, K_a, as shown in **Table 4-1;**
- Cantilevered walls, where the tops of which are restrained by the floor slabs of the permanent structure or which support movement sensitive elements, should be designed using a triangular lateral earth pressure distribution and an ‘at rest’ earth pressure coefficient, K_o, as shown in **Table 4-1** below.
- For progressively anchored or propped walls where minor movements can be tolerated (provided there are no buried movement sensitive services), we recommend the use of a trapezoidal earth pressure distribution of 5H kPa for soil, where H is the retained height in meters. These pressures should be assumed to be uniform over the central 50% of the support system, tapering to nil at top and bottom;
- For progressively anchored or propped walls which support areas which are highly sensitive to movement (such as areas where movement sensitive structures or infrastructures or buried services are located in close proximity), we recommend the use of a trapezoidal earth pressure distribution of 8H kPa for soil, where ‘H’ is the retained height in meters. These pressures should be assumed to be uniform over the central 50% of the support system, tapering to nil at top and bottom;
- All surcharge loading affecting the walls (including from construction equipment, construction loads, adjacent high level footings, etc.) should be adopted in the retaining wall design as an additional surcharge using an ‘at rest’ earth pressure coefficient, K_o.
- The retaining walls should be designed as drained and measures are to be taken to provide complete and permanent drainage behind the walls.

- If temporary anchors extend beyond the site boundaries, then permission from the neighbouring properties would need to be obtained prior to installation. Also, the presence of neighbouring basements and/or services and their levels must be confirmed prior to finalising anchor design**.**
- Anchors should have their bond length within Unit 3 or better. For the design of anchors bonded into Unit 3 or better, the allowable bond stress value outlined in **Table 4-1** below may be used, subject to the following conditions:
  1. Anchor bond lengths of at least 3m behind the ‘active’ zone of the excavation (taken as a 45 degree zone above the base of the excavation) is provided;
  2. Overall stability, including anchor group interaction, is satisfied;
  3. All anchors should be proof loaded to at least 1.33 times the design working load before locked off at working load. Such proof loading is to be witnessed by and engineer independent of the anchoring contractor. We recommend that only experienced contractors be considered for anchor installation with appropriate insurances;
  4. If permanent anchors are to be used, these must have appropriate corrosion provisions for longevity.
- Uncased anchor holes within sands will almost certainly collapse and temporary casing of these holes will be required. It is good practice for anchors to be a “design and construct” sub-contract to avoid disputes should anchors fail to hold their test load;

Table 4-1 Geotechnical Design Parameters

Material [1]		Unit 1a: Pavement	Unit1b: Fill	Unit 2: Alluvial/ Residual Soil	Class V Sandstone	Class IV Sandstone	Class III Sandstone	Class V Shale	Class II Sandstone	Class I Sandstone
Bulk Unit Weight (kN/m³)		-	18	18	24	24	24	24	24	24
Friction Angle, ϕ' (°)		-	25	28	35	40	50	30	50	55
Earth Pressure Coefficients	At rest, K_o [2]	-	0.58	0.53	0.43	-	-	0.50	-	-
	Active, K_a [2]	-	0.41	0.36	0.27	-	-	0.33	-	-
	Passive, K_p [2]	-	2.46	2.77	3.69	-	-	3.00	-	-
Allowable Bearing Pressure (kPa) [4]		-	-	-	700	1500	3500	600	6000	10,000
Allowable Shaft Adhesion (kPa) [3, 4]	in Compression	-	-	-	70	150	350	60	600	1000
	in Uplift	-	-	-	35	75	175	30	300	500
Allowable Toe Resistance [5]		-	-	-	1,000	2,000	5,000	300	7,000	10,000
Earthquake Site Risk Classification		▪ AS 1170.4:2007 indicates an earthquake subsoil class of Class B_e.(Rock) ▪ AS 1170.4:2007 indicates that the hazard factor (z) for Sydney is 0.08								

Notes:

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

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

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

4 To adopt these parameters we have assumed that:

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

5 For footings founded beneath BEL, and no unfavourable defects are present. The upper 0.5m of the rock is ignored.

4.7 Foundations

4.7.1 Shallow Footings in Rock

Following bulk excavation to RL 15.1mAHD, we expect a mixture of Class IV and Class III sandstone to be exposed at BEL.

It is recommended that all footings for the building be founded within the Sandstone bedrock of similar strength to provide uniform support and reduce the potential for differential settlements. Hence, we recommend that all pad and strip footings to be founded within Unit 5 – Class III sandstone, which may be preliminarily designed for an allowable bearing capacity of 3,500 kPa, based on serviceability.

Optimisation of bearing capacities may be feasible, however if bearing capacities higher than 3500kPa is required (such as 6000kPa) EI recommends additional cored boreholes and spoon testing be completed prior to final design to confirm the rock class beneath the footings in greater detail.

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

4.8 Basement Floor Slab

Following bulk excavations for the proposed basement, sandstone bedrock is expected to be exposed at the basement floor BEL.

Following the removal of all loose and softened materials, we recommend that underfloor drainage be provided and should comprise a strong, durable, single sized washed aggregate such as ‘blue metal gravel’. Joints in the concrete floor slab should be designed to accommodate shear forces but not bending moments by using dowelled and keyed joints. The basement floor slab should be isolated from columns. The completed excavation should be inspected by the hydraulic engineer to confirm the extent of the drainage required.

In addition, a system of sub-soil drains comprising a durable single sized aggregate with perforated drains/pipes leading to sumps should be provided. The basement floor slab should be isolated from columns.

Permission may need to be obtained from the NSW Department of Primary Industries (DPI) and possibly Council for any permanent discharge of seepage into the drainage system. Given the subsurface conditions, we expect that seepage volumes would be low and within the DPI limits. However, if permission for discharge is not obtained, the basement may need to be designed as a tanked basement.

5. Further Geotechnical Inputs

Below is a summary of the previously recommended additional work that needs to be carried out:

- Classification of all excavated material transported off site
- Witnessing installation of support measures and proof-testing of anchors (if required)
- Geotechnical inspections of unsupported vertical excavations in bedrock
- Geotechnical assessment of impact of the Bulk Excavation with respect to rock stress relief and associated impacts on adjacent structures
- Geotechnical inspections of all new footings/piles by an experienced geotechnical professional before concrete or steel are placed to verify their bearing capacity and the in-situ nature of the founding strata
- Ongoing monitoring of groundwater inflows into the bulk excavation;

We recommend that a meeting be held after initial structural design has been completed to confirm that our recommendations have been correctly interpreted. We also recommend a meeting at the commencement of construction to discuss the primary geotechnical issues and inspection requirements.

6. Statement of Limitations

This report has been prepared for the exclusive use of RMB Group Pty Ltd who is the only intended beneficiary of EI's work. The scope of the assessment carried out for the purpose of this report is limited to those agreed with RMB Group Pty Ltd

No other party should rely on the document without the prior written consent of EI, and EI undertakes no duty, or accepts any responsibility or liability, to any third party who purports to rely upon this document without EI's approval.

EI has used a degree of care and skill ordinarily exercised in similar investigations by reputable members of the geotechnical industry in Australia as at the date of this document. No other warranty, expressed or implied, is made or intended. Each section of this report must be read in conjunction with the whole of this report, including its appendices and attachments.

The conclusions presented in this report are based on a limited investigation of conditions, with specific sampling and test locations chosen to be as representative as possible under the given circumstances.

EI's professional opinions are reasonable and based on its professional judgment, experience, training and results from analytical data. EI may also have relied upon information provided by the Client and other third parties to prepare this document, some of which may not have been verified by EI.

EI's professional opinions contained in this document are subject to modification if additional information is obtained through further investigation, observations, or validation testing and analysis during construction. In some cases, further testing and analysis may be required, which may result in a further report with different conclusions.

We draw your attention to the document "Important Information", which is included in **Appendix C** of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by EI, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

Should you have any queries regarding this report, please do not hesitate to contact EI.

References

AS1289.6.3.1:2004, *Methods of Testing Soils for Engineering Purposes,* Standards Australia.

AS1726:2017, *Geotechnical Site Investigations*, Standards Australia.

AS2159:2009, *Piling – Design and Installation*, Standards Australia.

AS3600:2009, *Concrete Structures,* Standards Australia

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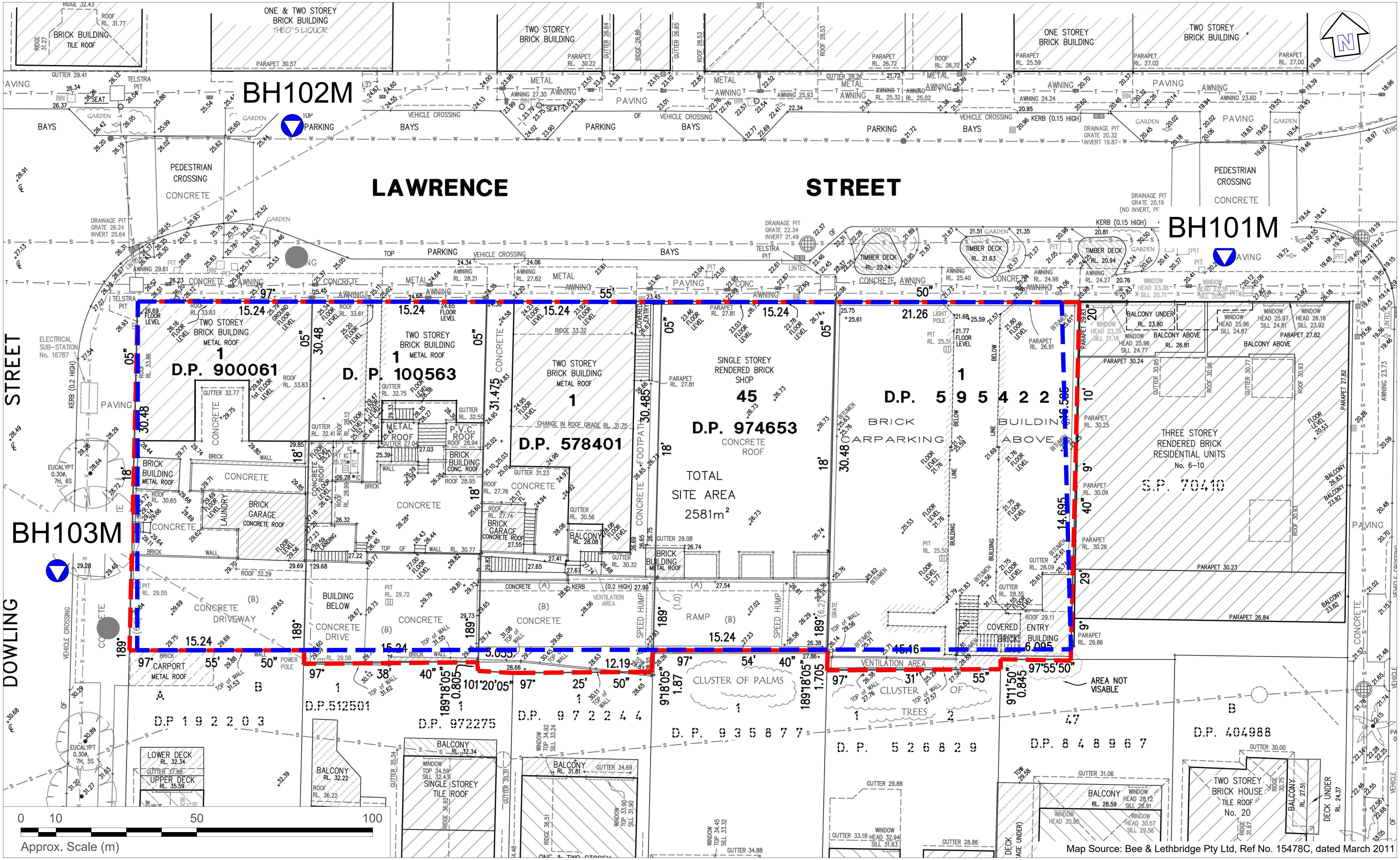
Geoscience Australia and Australian Stratigraphy Commission. (2017). Australian Stratigraphic Units Database.

Abbreviations

AHD	Australian Height Datum
AS	Australian Standard
BEL	Bulk Excavation Level
BEGL	Below Existing Ground Level
BH	Borehole
DBYD	Dial Before You Dig
DP	Deposited Plan
EI	EI Australia
AGI	Geotechnical Investigation
NATA	National Association of Testing Authorities, Australia
RL	Reduced Level
SPT	Standard Penetration Test
T-C	Tungsten-Carbide
UCS	Unconfined Compressive Strength

Figures

eiaustralia Practical Solutions for Built Environments Suite 6.01, 55 Miller Street, PYRMONT 2009 Ph (02) 9516 0722 Fax (02) 9518 5088	Drawn:	L.T.	**MD Living Pty Ltd** Additional Geotechnical Investigation 10-28 Lawrence Street, Freshwater, NSW	Figure: 1
	Approved:	K.X.		
	Date:	12-04-23		
	Scale:	Not To Scale	Site Locality Plan	Project: E25874.G04.01



LEGEND (All Locations are Approximate)

- Site boundary
- Basement boundary
- Borehole/monitoring well location

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Drawn:	L.T.
Approved:	K.X.
Date:	12-04-23

MD Living Pty Ltd
Additional Geotechnical Investigation
10-28 Lawrence Street, Freshwater, NSW

Borehole/Monitoring Well Location Plan

Figure: 2

Project: E25874.G04.01

Appendix A – Borehole Logs And Explanatory Notes

BOREHOLE LOG

BH ID: BH101M

Location	10-28 Lawrence Street Freshwater	**Started**	24 February 2023		
Client	Mike Turner	**Completed**	24 February 2023		
Job No.	E25874	**Logged By**	LT	**Date**	24 February 2023
Sheets	1 of 3	**Review By**	SK	**Date**	24 May 2023

Drilling Contractor	Geosense Drilling Engineers	**Surface RL**	≈20.00 m (AHD)	**Latitude**	-
Plant	Comacchio Geo 205	**Inclination**	90°	**Longtitude**	-

METHOD	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	RL (m AHD)	MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / REL. DENSITY	MATERIAL ORIGIN & OBSERVATIONS
NDD	GWNE		0.00	20.00	BRICK: 50mm thick	-	-	BRICK
			0.05	19.95	FILL: Sandy GRAVEL: fine to coarse angular to sub-angular sandstone gravel orange-grey and orange-brown, sand is fine to coarse grained, with silt, trace sandstone cobbles	D	-	FILL
			1.50	18.50	SAND: fine to medium grained, orange-brown and grey-orange, with silt	M	-	AEOLIAN SOIL
		BH101M_2.50-2.95 SPT 2.50-2.95 5,7,11 N=18	2.60	17.40	Silty CLAY: high plasticity, grey and red-grey, trace fine sub-angular gravel	M < PL	VSt	RESIDUAL SOIL
			3.93	16.07	*Log continued on next page.*			

BOREHOLE LOG

BH ID: BH101M

Location	10-28 Lawrence Street Freshwater	**Started**	24 February 2023		
Client	Mike Turner	**Completed**	24 February 2023		
Job No.	E25874	**Logged By**	LT	**Date**	24 February 2023
Sheets	2 of 3	**Review By**	SK	**Date**	24 May 2023

Drilling Contractor	Geosense Drilling Engineers	**Surface RL**	≈20.00 m (AHD)	**Latitude**	-
Plant	Comacchio Geo 205	**Inclination**	90°	**Longtitude**	-

METHOD	Flush Return	TCR %	RQD %	DEPTH (m)	RL (m AHD)	MATERIAL DESCRIPTION	WEATHERING	ESTIMATED STRENGTH Is(50) (▼ - Axial, ▽ - Diametral) (VL 0-1, L 0-3, M 1, H 3, VH 10, EH)	DISCONTINUITIES & ADDITIONAL DATA	FRACTURE SPACING (30, 100, 300, 1000, 3000)
				0		*Log continued from previous page.*				
NMLC	90%	100	64	4		SANDSTONE: fine to medium grained, orange-brown and grey, thinly bedded	DW	L–M	4.17-4.22: XWS Clay	
				5			SW	M	5.37-5.38: XWS Clay	
		100	87	6.00	14.00	SANDSTONE: fine to medium grained, grey and pale grey, medium bedded	FR	M	6.55: JT 40° PR RO CN	
				7				M–H	7.71-7.73: IS 8° PR SL Clay VN	
				8				H	8.57-8.61: IS 8° PR SL Clay VN	
				10						

BOREHOLE LOG

BH ID: BH101M

Location	10-28 Lawrence Street Freshwater	**Started**	24 February 2023		
Client	Mike Turner	**Completed**	24 February 2023		
Job No.	E25874	**Logged By**	LT	**Date**	24 February 2023
Sheets	3 of 3	**Review By**	SK	**Date**	24 May 2023

Drilling Contractor	Geosense Drilling Engineers	**Surface RL**	≈20.00 m (AHD)	**Latitude**	-
Plant	Comacchio Geo 205	**Inclination**	90°	**Longtitude**	-

METHOD	Flush Return	TCR %	RQD %	DEPTH (m)	RL (m AHD)	MATERIAL DESCRIPTION	WEATHERING	DISCONTINUITIES & ADDITIONAL DATA
NMLC	90%	100	91	10.00–14.17			FR	10.29-10.39: CS 10.70: JT 20° IR RO CN 11.10-11.20: JT 70° PR RO CN 11.36: JT 70° PR RO CN 11.95: JT 90° PR RO CN 13.95-14.17: XWS Clay
		91	88					
				14.17	5.83	NO CORE: 180mm thick	-	
				14.35	5.65	SANDSTONE: fine to medium grained, grey and pale grey, medium to thickly bedded	FR	15.44: JT 60° PR RO CN 15.72: JT 60° PR RO CN 15.98: Handling Break 16.22: JT 60° PR RO CN 16.95: Handling Break
		100	71					
				17.83	2.17	Terminated at 17.83m. Target Depth Reached.		

ESTIMATED STRENGTH Is(50): ▼ - Axial, ▽ - Diametral; VL 0-1, L 0-3, M 1, H 3, VH 10, EH

FRACTURE SPACING: 30, 100, 300, 1000, 3000

MONITORING WELL LOG

MW NO. BH101M

Project	Proposed Development	**Sheet**	1 of 2
Location	16 Lawrence Street Freshwater	**Date Started**	24/02/2023
Position	See Figure 2	**Date Completed**	24/02/2023
Job No.	E25874	**Logged By** DD	**Date** 24/02/2023
Client	MD Living	**Reviewed By** DD	**Date** 24/02/2023

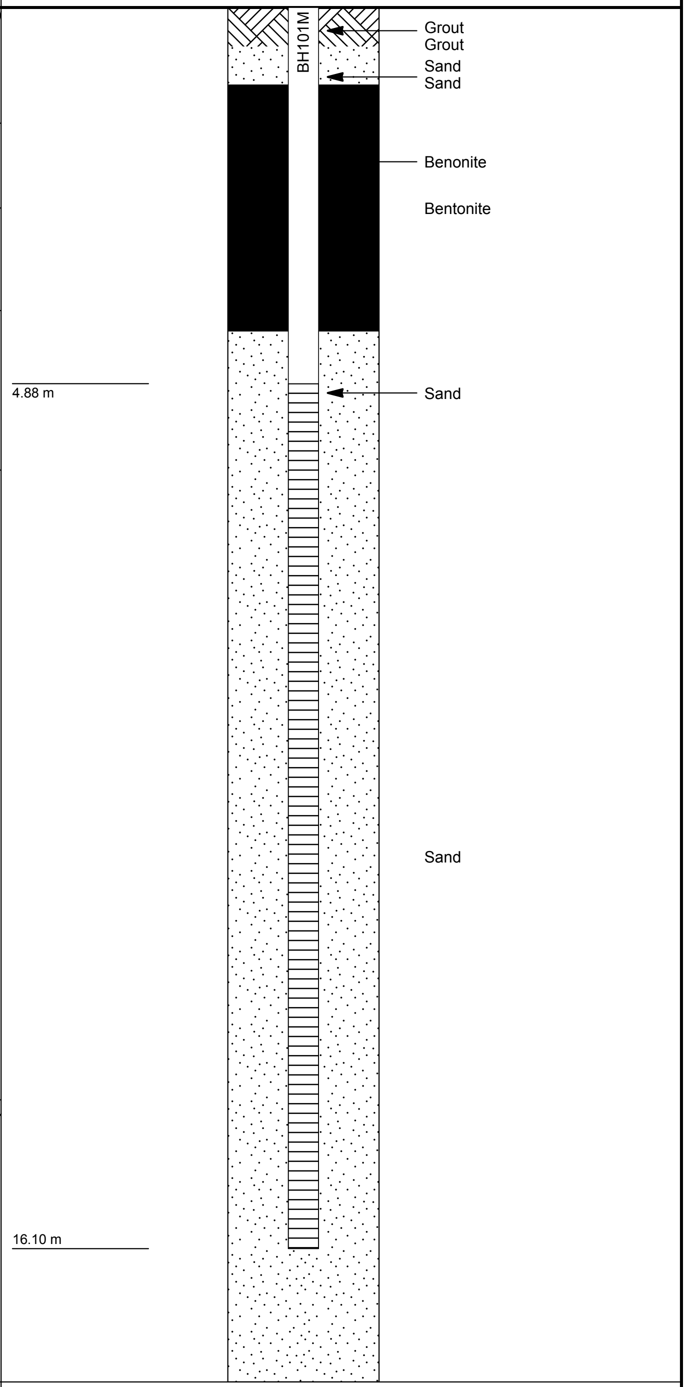
Drilling Contractor	Geosense Drilling Services	**Surface RL**	≈20.00 m
Drill Rig	Geo205	**Inclination**	-90°

PIEZOMETER CONSTRUCTION DETAILS

ID	Type	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
BH101M	Standpipe	-0.07 m 20.07 m	16.10 m 3.90 m	24/02/2023	

METHOD	WATER	SOIL/ROCK MATERIAL DESCRIPTION
AD/T		40mm Pavers/Tiles, 20mm SP fine grained bedding sand, 200mm Concrete,
AD/T		sandy GRAVEL; orange-grey and orange-brown, fine to coarse angular to sub-angular sandstone gravel, sand is fine to coarse grained, with silt, trace sandstone cobbles
AD/T		Sand; fine to medium grained, orange-brown and grey-orange, with silt
AD/T		silty CLAY; high plasticity, grey and red-grey, trace fine grained sub-angular gravel
NMLC		SANDSTONE; fine to medium grained, orange-brown and grey, thinly bedded
NMLC		SANDSTONE; fine to medium grained, grey and pale grey, medium bedded
NMLC		320mm Core Loss
NMLC		SANDSTONE; fine to medium grained, grey and pale grey, medium bedded
		Hole Terminated at 17.83 m Target depth

Depth (m) scale: 0, 2, 4, 6, 8, 10, 12, 14, 16, 18; RL (m) scale: 20, 18, 16, 14, 12, 10, 8, 6, 4, 2



This well log should be read in conjunction with EI Australia's accompanying standard notes.

CORE PHOTOGRAPH OF BOREHOLE: BH101M

Project	Proposed Development			**Depth Range**	3.93m to 17.83m BEGL		
Location	Lawrence Street, Freshwater NSW			**Contractor**	Geosense Drilling Services		
Position	See Figure 2	**Surface RL**	≈ 20.0mAHD	**Drill Rig**	Comacchio Geo205		
Job No.	E25874.G03.02	**Inclination**	-90°	**Logged**	DD	**Date**	24 / 02 / 2023
Client	MD Living Pty Ltd	**Box**	4 of 4	**Checked**	KX	**Date**	0 / 8 / 202

BOREHOLE LOG

BH ID: BH102M

Location	10-28 Lawrence Street Freshwater	**Started**	16 February 2023		
Client	Mike Turner	**Completed**	16 February 2023		
Job No.	E25874	**Logged By**	DD	**Date**	16 February 2023
Sheets	1 of 4	**Review By**	SK	**Date**	24 May 2023

Drilling Contractor	Geosense Drilling Engineers	**Surface RL**	≈24.00 m (AHD)	**Latitude**	-
Plant	Comacchio Geo 205	**Inclination**	90°	**Longtitude**	-

METHOD	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	SAMPLE RECOVERY	DEPTH (m)	RL (m AHD)	MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / REL. DENSITY	MATERIAL ORIGIN & OBSERVATIONS
NDD	GWNE			0.00	24.00	ASPHALT: 20mm thick	-	-	ASPHALT
				0.02	23.98	FILL: Silty GRAVEL: fine to medium, angular basalt and dolerite, brown			FILL
				0.25	23.75	FILL: Sandy GRAVEL: fine to coarse, sub-angular to sub-rounded sandstone, brown and yellow-orange sand fine to coarse grained, trace sandstone cobbles, trace silt, no odour			FILL
				1.42	22.58				

Log continued on next page.

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

BOREHOLE LOG

BH ID: BH102M

Location	10-28 Lawrence Street Freshwater	**Started**	16 February 2023		
Client	Mike Turner	**Completed**	16 February 2023		
Job No.	E25874	**Logged By**	DD	**Date**	16 February 2023
Sheets	2 of 4	**Review By**	SK	**Date**	24 May 2023

Drilling Contractor	Geosense Drilling Engineers	**Surface RL**	≈24.00 m (AHD)	**Latitude**	-
Plant	Comacchio Geo 205	**Inclination**	90°	**Longtitude**	-

METHOD	Flush Return	TCR %	RQD %	DEPTH (m)	RL (m AHD)	MATERIAL DESCRIPTION	WEATHERING	DISCONTINUITIES & ADDITIONAL DATA
				0		*Log continued from previous page.*		
NMLC	90% Water	83	48			SANDSTONE: fine to medium grained, grey, thickly bedded	DW	1.84: JT 85° IR RO Fe SN 1.86-1.88: XWS clay 1.93-1.95: XWS clay
NMLC	90% Water			2.47	21.53	NO CORE: 320mm thick		
NMLC	90% Water			2.79	21.21	SANDSTONE: fine to medium grained, grey and pale grey	DW	3.01-3.05: XWS clay 3.13-3.25: XWS clay 3.27: JT IR RO CN 3.41-3.42: XWS sand
NMLC	90% Water	100	84	3.42	20.58	SANDSTONE: fine to medium grained, pale grey, thickly bedded	FR	4.70-4.72: XWS clay 4.87: JT IR SL CN 4.98: Handling Break
NMLC	90% Water	76	62	7.44	16.56	NO CORE: 720mm thick		
NMLC	90% Water			8.16	15.84	CLAYSTONE: dark brown and grey-brown, thinly bedded	DW	8.19-8.50: XWS SL clay
NMLC	90% Water	100	91	9.35	14.65	SANDSTONE: fine grained, pale grey, interbedded with siltstone, dark grey, thickly bedded		
				10				

ESTIMATED STRENGTH Is(50): ▼ - Axial, ▽ - Diametral; VL 0-1, L 0-3, M 1, H 3, VH 10, EH

FRACTURE SPACING: 30, 100, 300, 1000, 3000

BOREHOLE LOG

BH ID: BH102M

Location	10-28 Lawrence Street Freshwater	**Started**	16 February 2023		
Client	Mike Turner	**Completed**	16 February 2023		
Job No.	E25874	**Logged By**	DD	**Date**	16 February 2023
Sheets	3 of 4	**Review By**	SK	**Date**	24 May 2023

Drilling Contractor	Geosense Drilling Engineers	**Surface RL**	≈24.00 m (AHD)	**Latitude**	-
Plant	Comacchio Geo 205	**Inclination**	90°	**Longtitude**	-

METHOD	Flush Return	TCR %	RQD %	DEPTH (m)	RL (m AHD)	MATERIAL DESCRIPTION	WEATHERING	DISCONTINUITIES & ADDITIONAL DATA
NMLC	90% Water	100	99			SANDSTONE: fine grained, pale grey, interbedded with siltstone, dark grey, thickly bedded	FR	
		100	100	14.39	9.61	SANDSTONE: fine grained, pale grey, with occasional siltstone laminations, massive	FR	14.88: Handling Break 15.95: Handling Break 16.80: JT IR CN
		100	85					19.36: IS SL 2mm Clay VN 19.42-19.43: XWS clay 19.52: JT UN RO CN 19.59-19.61: CS 20mm 19.64: JT 80° IR RO CN

ESTIMATED STRENGTH Is(50): ▼ - Axial, ▽ - Diametral; VL 0-1, L 0-3, M 1, H 3, VH 10, EH

FRACTURE SPACING: 30, 100, 300, 1000, 3000

Depth scale: 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

BOREHOLE LOG

BH ID: BH102M

Location	10-28 Lawrence Street Freshwater	**Started**	16 February 2023		
Client	Mike Turner	**Completed**	16 February 2023		
Job No.	E25874	**Logged By**	DD	**Date**	16 February 2023
Sheets	4 of 4	**Review By**	SK	**Date**	24 May 2023

Drilling Contractor	Geosense Drilling Engineers	**Surface RL**	≈24.00 m (AHD)	**Latitude**	-
Plant	Comacchio Geo 205	**Inclination**	90°	**Longtitude**	-

METHOD	Flush Return	TCR %	RQD %	DEPTH (m)	GRAPHIC LOG	RL (m AHD)	MATERIAL DESCRIPTION	WEATHERING	ESTIMATED STRENGTH Is(50) ▼ - Axial ▽ - Diametral (VL 0-1, L 0-3, M 1, H 3, VH 10, EH)	DISCONTINUITIES & ADDITIONAL DATA	FRACTURE SPACING (30, 100, 300, 1000, 3000)
	90% Water					3.64	SANDSTONE: fine grained, pale grey, with occasional siltstone laminations, massive		▼ (H)		
				21, 22, 23, 24, 25, 26, 27, 28, 29, 30			Terminated at 20.36m. Target Depth Reached.				

This log should be read in conjunction with EI Australia's accompanying explanatory notes.

MONITORING WELL LOG

MW NO. BH102M

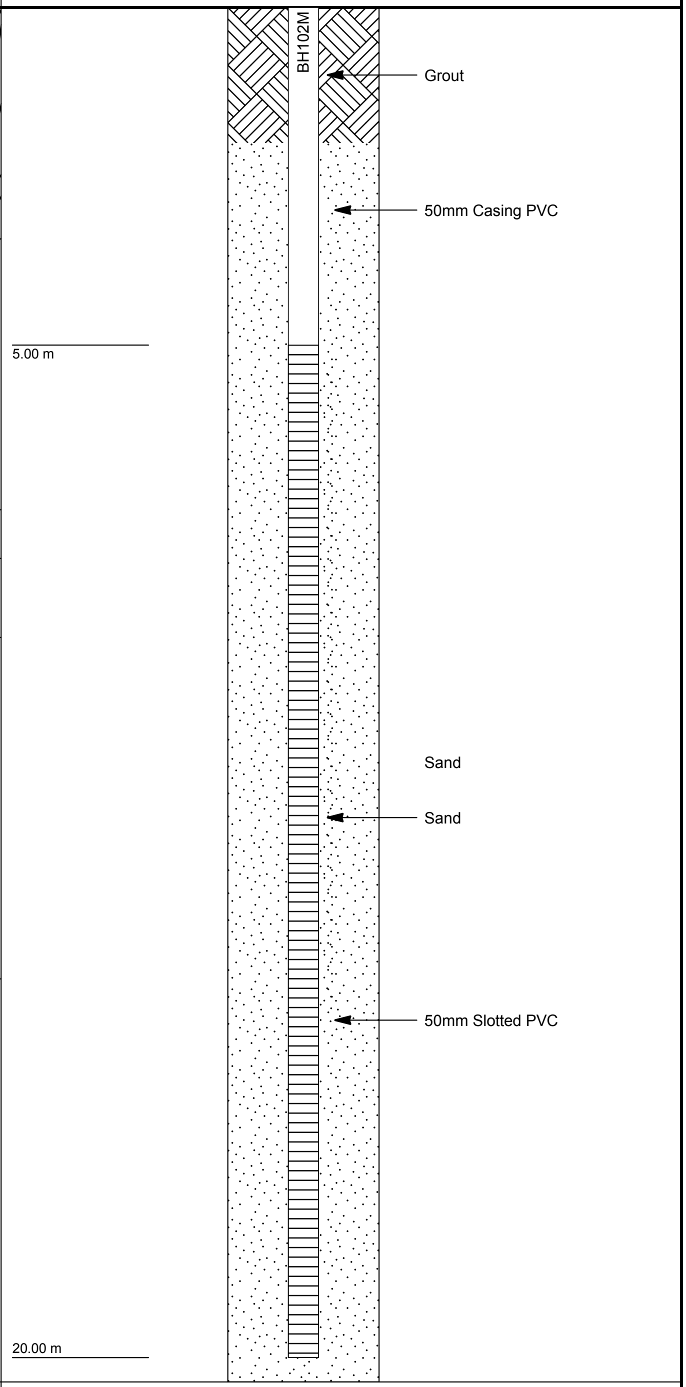
Project	Proposed Development	**Sheet**	1 of 2
Location	16 Lawrence Street Freshwater	**Date Started**	16/02/2023
Position	See Figure 2	**Date Completed**	16/02/2023
Job No.	E25874	**Logged By** DD	**Date** 16/02/2023
Client	MD Living	**Reviewed By** DD	**Date** 22/02/2023

Drilling Contractor	Geosense Drilling Services	**Surface RL**	≈24.00 m
Drill Rig	Geo205	**Inclination**	-90°

PIEZOMETER CONSTRUCTION DETAILS

ID	Type	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
BH102M	Standpipe	-0.07 m 24.07 m	20.00 m 4.00 m		

METHOD	WATER	DEPTH (m)	RL (m)	SOIL/ROCK MATERIAL DESCRIPTION
AD/T		0	24	20mm Asphalt Pavement
AD/T				silty sandy GRAVEL; dark brown, fine to medium angular to sub-angular basalt and dolerite gravel, sand is fine to coarse grained
NMLC	90% RETURN	2	22	sandy GRAVEL; orange-grey and orange-brown, fine to coarse angular to sub-angular sandstone gravel, sand is fine to coarse grained, with silt, trace sandstone cobbles
NMLC	90% RETURN			SANDSTONE; fine to medium grained, orange-grey and grey, thinly bedded
NMLC	90% RETURN			320mm Core Loss
NMLC	90% RETURN			SANDSTONE; fine to medium grained, orange-grey and grey, thinly bedded
NMLC	90% RETURN	4	20	thickly bedded
NMLC	90% RETURN	6	18	
NMLC	90% RETURN			720mm Core Loss
NMLC	90% RETURN	8	16	CLAYSTONE; dark brown, thinly bedded
NMLC	90% RETURN	10	14	Interbedded; SILTSTONE [80%] dark grey, SANDSTONE [20%] fine grained, grey, Medium bedded
NMLC	90% RETURN	12	12	
NMLC	90% RETURN	14	10	SANDSTONE; fine to medium grained, grey and pale grey, with minor quartz inclusions, massively bedded
NMLC	90% RETURN	16	8	
NMLC	90% RETURN	18	6	
NMLC	90% RETURN	20	4	
				Hole Terminated at 20.36 m Target depth
		22	2	



This well log should be read in conjunction with EI Australia's accompanying standard notes.

CORE PHOTOGRAPH OF BOREHOLE: BH102M

Project	Proposed Development			**Depth Range**	1.42m to 11.0m BEGL		
Location	Lawrence Street, Freshwater NSW			**Contractor**	Geosense Drilling Services		
Position	See Figure 2	**Surface RL**	24.0	**Drill Rig**	Comacchio Geo205		
Job No.	E25874.G03.02	**Inclination**	-90°	**Logged**	DD	**Date**	16 / 02 / 2023
Client	MD Living Pty Ltd	**Box**	1 of 2	**Checked**	SK	**Date**	27/ 02 / 2023

CORE PHOTOGRAPH OF BOREHOLE: BH102M

Project	Proposed Development			**Depth Range**	11.00m to 20.36m BEGL		
Location	Lawrence Street, Freshwater NSW			**Contractor**	Geosense Drilling Services		
Position	See Figure 2	**Surface RL**	24.0	**Drill Rig**	Comacchio Geo205		
Job No.	E25874.G03.02	**Inclination**	-90°	**Logged**	DD	**Date**	16 / 02 / 2023
Client	MD Living Pty Ltd	**Box**	2 of 2	**Checked**		**Date**	28 / 082/ 2023

BOREHOLE LOG

BH ID: BH103M

Location	10-28 Lawrence Street Freshwater	**Started**	17 February 2023		
Client	Mike Turner	**Completed**	17 February 2023		
Job No.	E25874	**Logged By**	LT	**Date**	17 February 2023
Sheets	1 of 4	**Review By**	SK	**Date**	24 May 2023

Drilling Contractor	Geosense Drilling Engineers	**Surface RL**	≈29.80 m (AHD)	**Latitude**	-
Plant	Comacchio Geo 205	**Inclination**	90°	**Longtitude**	-

METHOD	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	SAMPLE RECOVERY	DEPTH (m)	GRAPHIC LOG	RL (m AHD)	MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY / REL. DENSITY	MATERIAL ORIGIN & OBSERVATIONS
NDD	GWNE			0.00		29.80	ASPHALT: 20mm thick			ASPHALT
				0.02		29.78	FILL: Silty GRAVEL: fine to medium angular to sub-angular basalt and dolerite gravel, dark brown, sand is fine to coarse grained	D	-	FILL
				0.40		29.40	FILL: Sandy GRAVEL: fine to coarse angular to sub-angular sandstone gravel, orange-grey and orange-brown, sand is fine to coarse grained	D	-	FILL
				0.70		29.10	Sandy GRAVEL: extremely weathered sandstone material	D	-	EXTREMELY WEATHERED MATERIAL
				1.02		28.78	*Log continued on next page.*			

Log continued on next page.

BOREHOLE LOG

BH ID: BH103M

Location	10-28 Lawrence Street Freshwater	**Started**	17 February 2023		
Client	Mike Turner	**Completed**	17 February 2023		
Job No.	E25874	**Logged By**	LT	**Date**	17 February 2023
Sheets	2 of 4	**Review By**	SK	**Date**	24 May 2023

Drilling Contractor	Geosense Drilling Engineers	**Surface RL**	≈29.80 m (AHD)	**Latitude**	-
Plant	Comacchio Geo 205	**Inclination**	90°	**Longtitude**	-

METHOD	Flush Return	TCR %	RQD %	DEPTH (m)	RL (m AHD)	MATERIAL DESCRIPTION	WEATHERING	DISCONTINUITIES & ADDITIONAL DATA
				0		*Log continued from previous page.*		
NMLC	90% Water	100	94	1.00		SANDSTONE: fine to medium grained, orange-grey and grey, medium to thickly bedded	FR	1.38: Handling Break 1.45: JT 15° IR RO CN 1.48: JT 80° IR RO CN 2.49-2.57: XWS Clay, 80mm 2.80: JT 30° IR SL Clay VN
				3.10	26.70	From 3.10m, With siltstone laminations		3.26: JT 70° IR RO CN 3.78-3.80: IS 15° SL Clay 4.00: JT 15° RO CN 4.25: Handling Break 4.69: Handling Break 5.56: Handling Break 6.00: JT 80° IR RO CN 6.19: JT IR RO CN 6.41: JT 15° IR RO CN 7.69: JT 20° IR RO CN
		100	94					
		100	92					
				8.67	21.13	SANDSTONE: fine to medium grained, grey, with siltstone clasts, dark grey, very thinly bedded		8.66-8.92: XWS Clay 8.92-9.02: IS Clay, 30mm 9.74: IS 15° RO

Estimated Strength Is(50): ▼ - Axial; ▽ - Diametral (VL 0-1, L 0-3, M 1, H 3, VH 10, EH)

Fracture Spacing: 30, 100, 300, 1000, 3000

BOREHOLE LOG

BH ID: BH103M

Location	10-28 Lawrence Street Freshwater	**Started**	17 February 2023		
Client	Mike Turner	**Completed**	17 February 2023		
Job No.	E25874	**Logged By**	LT	**Date**	17 February 2023
Sheets	3 of 4	**Review By**	SK	**Date**	24 May 2023

Drilling Contractor	Geosense Drilling Engineers	**Surface RL**	≈29.80 m (AHD)	**Latitude**	-
Plant	Comacchio Geo 205	**Inclination**	90°	**Longtitude**	-

Method: NMLC; Flush Return: 90% Water; Weathering: FR

Depth (m)	RL (m AHD)	TCR %	RQD %	Material Description
10.00–10.38		98	84	SANDSTONE: fine to medium grained, grey, with siltstone clasts, dark grey, very thinly bedded
10.38–13.76	19.42	100	90	SANDSTONE: fine to medium grained, grey, massive
13.76–19.68	16.04	100 / 101	100 / 88	LAMINITE: Interbedded: SANDSTONE [80%] fine grained, SILTSTONE [20%], dark grey-grey,thinly bedded
19.68–20.00	10.12			SANDSTONE: fine to medium grained, grey and pale grey, with minor quartz inclusions, thickly bedded

Estimated Strength Is(50) (▼ - Axial, ▽ - Diametral): VL 0-1, L 0-3, M 1, H 3, VH 10, EH

Fracture Spacing: 30, 100, 300, 1000, 3000

DISCONTINUITIES & ADDITIONAL DATA

- 10.04: IS 15° RO
- 10.29: IS 20° SL
- 13.44: IS -10° Clay VN
- 13.76-13.78: XWS Clay
- 14.43: JT 40° IR RO CN
- 14.98: JT 70° IR RO CN
- 15.51: Handling Break
- 15.96: Handling Break
- 17.90: Handling Break
- 18.59: JT 30° IR RO CN
- 18.66: IS 15° RO
- 18.77: JT 15° IR RO
- 18.90: JT 45° IR RO
- 19.67-19.69: Handling Break

BOREHOLE LOG

BH ID: BH103M

Location	10-28 Lawrence Street Freshwater	**Started**	17 February 2023		
Client	Mike Turner	**Completed**	17 February 2023		
Job No.	E25874	**Logged By**	LT	**Date**	17 February 2023
Sheets	4 of 4	**Review By**	SK	**Date**	24 May 2023

Drilling Contractor	Geosense Drilling Engineers	**Surface RL**	≈29.80 m (AHD)	**Latitude**	-
Plant	Comacchio Geo 205	**Inclination**	90°	**Longtitude**	-

METHOD	Flush Return	TCR %	RQD %	DEPTH (m)	GRAPHIC LOG	RL (m AHD)	MATERIAL DESCRIPTION	WEATHERING	ESTIMATED STRENGTH Is(50) ▼ - Axial ▽ - Diametral (VL 0-1, L 0-3, M 1, H 3, VH 10, EH)	DISCONTINUITIES & ADDITIONAL DATA	FRACTURE SPACING (30, 100, 300, 1000, 3000)
	90% Water	100	100	20–23.70			SANDSTONE: fine to medium grained, grey and pale grey, with minor quartz inclusions, thickly bedded	FR	M–H	20.00-20.03: Handling Break 20.10: Handling Break 21.17: Handling Break 22.05: Handling Break 22.49: JT 25° IR RO CN 22.97: Handling Break	
				23.70		6.10	Terminated at 23.70m. Target Depth Reached.				

Depth scale: 21, 22, 23, 24, 25, 26, 27, 28, 29, 30

This log should be read in conjunction with EI Australia's accompanying explanatory notes.

MONITORING WELL LOG

MW NO. BH103M

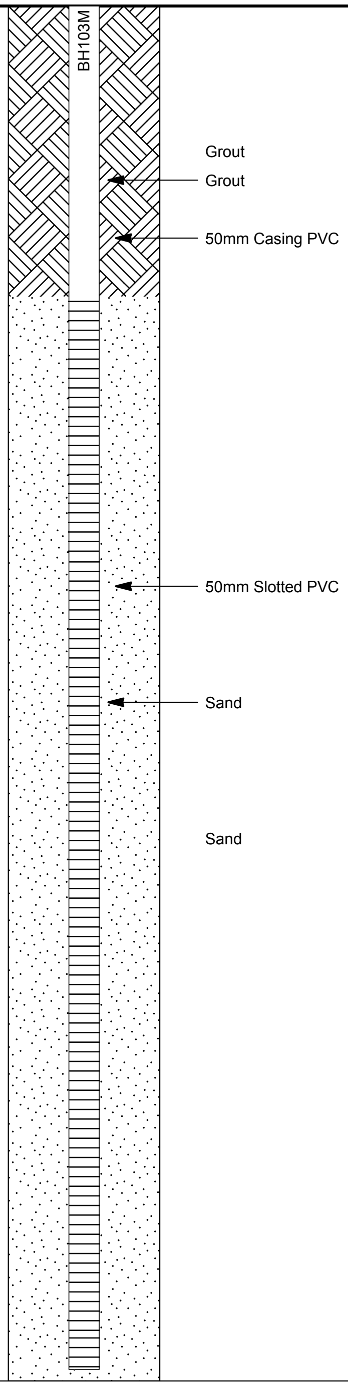
Project	Proposed Development	**Sheet**	1 of 2
Location	16 Lawrence Street Freshwater	**Date Started**	17/02/2023
Position	See Figure 2	**Date Completed**	17/02/2023
Job No.	E25874	**Logged By** DD	**Date** 17/02/2023
Client	MD Living	**Reviewed By** DD	**Date** 22/02/2023

Drilling Contractor	Geosense Drilling Services	**Surface RL**	≈29.80 m
Drill Rig	Geo205	**Inclination**	-90°

PIEZOMETER CONSTRUCTION DETAILS

ID	Type	Stick Up & RL	Tip Depth & RL	Installation Date	Static Water Level
BH103M	Standpipe		23.50 m 6.30 m	24/02/2023	

METHOD	WATER	DEPTH (m)	RL (m)	SOIL/ROCK MATERIAL DESCRIPTION
AD/T		0		20mm Asphalt Pavement
AD/T				silty sandy GRAVEL; dark brown, fine to medium angular to sub-angular basalt and dolerite gravel, sand is fine to coarse grained
NMLC	90% RETURN	2	28	sandy GRAVEL; orange-grey and orange-brown, fine to coarse angular to sub-angular sandstone gravel, sand is fine to coarse grained, with silt, trace sandstone cobbles
NMLC	90% RETURN			Extremely Weathered Sandstone Material; recovered as sandy Gravel
NMLC	90% RETURN			SANDSTONE; fine to medium grained, orange-grey and grey, thinly bedded
NMLC	90% RETURN	4	26	massively bedded
NMLC	90% RETURN	6	24	SANDSTONE; fine to medium grained, orange-grey and grey, thinly bedded
NMLC	90% RETURN	8	22	thickly bedded
NMLC	90% RETURN	10, 12	20, 18	SANDSTONE with Siltstone clasts; fine to medium grained sandstone [grey], siltstone [dark grey], very thinly bedded
NMLC	90% RETURN	14, 16, 18	16, 14, 12	Interbedded; SILTSTONE [20%] dark grey, SANDSTONE [80%] fine grained, grey, thinly bedded
NMLC	90% RETURN	20, 22	10, 8	SANDSTONE; fine to medium grained, grey and pale grey, with minor quartz inclusions, thickly bedded
		24, 26	6, 4	Hole Terminated at 23.70 m Target depth



This well log should be read in conjunction with EI Australia's accompanying standard notes.

CORE PHOTOGRAPH OF BOREHOLE: BH103M

Project	Proposed Development			**Depth Range**	1.02m to 11.0 BEGL		
Location	Lawrence Street, Freshwater NSW			**Contractor**	Geosense Drilling Services		
Position	See Figure 2	**Surface RL**	29.8mAHD	**Drill Rig**	Comacchio Geo205		
Job No.	E25874.G03.02	**Inclination**	-90°	**Logged**	DD	**Date**	17 / 02 / 2023
Client	MD Living Pty Ltd	**Box**	1 of 1	**Checked**		**Date**	

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CORE PHOTOGRAPH OF BOREHOLE: BH103M

Project	Proposed Development			**Depth Range**	11.0m to 18.00m BEGL		
Location	Lawrence Street, Freshwater NSW			**Contractor**	Geosense Drilling Services		
Position	See Figure 2	**Surface RL**	29.8mAHD	**Drill Rig**	Comacchio Geo205		
Job No.	E25874.G03.02	**Inclination**	-90°	**Logged**	DD	**Date**	07 / 07 / 2021
Client	MD Living Pty Ltd	**Box**	2 of 2	**Checked**		**Date**	00 / 00 / 2000

EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT LOGS

DRILLING/EXCAVATION METHOD

HA	Hand Auger	**ADH**	Hollow Auger	**NQ**	Diamond Core - 47 mm
DT	Diatube Coring	**RT**	Rotary Tricone bit	**NMLC**	Diamond Core - 52 mm
NDD	Non-destructive digging	**RAB**	Rotary Air Blast	**HQ**	Diamond Core - 63 mm
AD*	Auger Drilling	**RC**	Reverse Circulation	**HMLC**	Diamond Core - 63 mm
***V**	V-Bit	**PT**	Push Tube	**EX**	Tracked Hydraulic Excavator
***T**	TC-Bit, e.g. AD/T	**WB**	Washbore	**HAND**	Excavated by Hand Methods

PENETRATION RESISTANCE

L	**Low Resistance**	Rapid penetration/ excavation possible with little effort from equipment used.
M	**Medium Resistance**	Penetration/ excavation possible at an acceptable rate with moderate effort from equipment used.
H	**High Resistance**	Penetration/ excavation is possible but at a slow rate and requires significant effort from equipment used.
R	**Refusal/Practical Refusal**	No further progress possible without risk of damage or unacceptable wear to equipment used.

These assessments are subjective and are dependent on many factors, including equipment power and weight, condition of excavation or drilling tools and experience of the operator.

WATER

Standing Water Level

Partial water loss

Water Seepage

Complete Water Loss

GWNO GROUNDWATER NOT OBSERVED - Observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave-in of the borehole/ test pit.

GWNE GROUNDWATER NOT ENCOUNTERED - Borehole/ test pit was dry soon after excavation. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/ test pit been left open for a longer period.

SAMPLING AND TESTING

SPT	Standard Penetration Test to AS1289.6.3.1-2004
4,7,11 N=18	4,7,11 = Blows per 150mm. N = Blows per 300mm penetration following a 150mm seating drive
30/80mm	Where practical refusal occurs, the blows and penetration for that interval are reported, N is not reported
RW	Penetration occurred under the rod weight only, N<1
HW	Penetration occurred under the hammer and rod weight only, N<1
HB	Hammer double bouncing on anvil, N is not reported
Sampling	
DS	Disturbed Sample
ES	Sample for environmental testing
BDS	Bulk disturbed Sample
GS	Gas Sample
WS	Water Sample
U50	Thin walled tube sample - number indicates nominal sample diameter in millimetres
Testing	
FP	Field Permeability test over section noted
FVS	Field Vane Shear test expressed as uncorrected shear strength (sv= peak value, sr= residual value)
PID	Photoionisation Detector reading in ppm
PM	Pressuremeter test over section noted
PP	Pocket Penetrometer test expressed as instrument reading in kPa
WPT	Water Pressure tests
DCP	Dynamic Cone Penetrometer test
CPT	Static Cone Penetration test
CPTu	Static Cone Penetration test with pore pressure (u) measurement

GEOLOGICAL BOUNDARIES

———————— = Observed Boundary (position known)

– – – – – – – – – – – = Observed Boundary (position approximate)

– –?– –?– –?– – = Boundary (interpreted or inferred)

ROCK CORE RECOVERY

TCR=Total Core Recovery (%)

$$= \frac{Length\ of\ core\ recovered}{Length\ of\ core\ run} \times 100$$

RQD = Rock Quality Designation (%)

$$= \frac{\sum Axial\ lengths\ of\ core > 100mm}{Length\ of\ core\ run} \times 100$$

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METHOD OF SOIL DESCRIPTION USED ON BOREHOLE AND TEST PIT LOGS

FILL	ORGANIC SOILS (OL, OH or Pt)	CLAY (CL, CI or CH)
COUBLES or BOULDERS	SILT (ML or MH)	SAND (SP or SW)
GRAVEL (GP or GW)	Combinations of these basic symbols may be used to indicate mixed materials such as sandy clay	

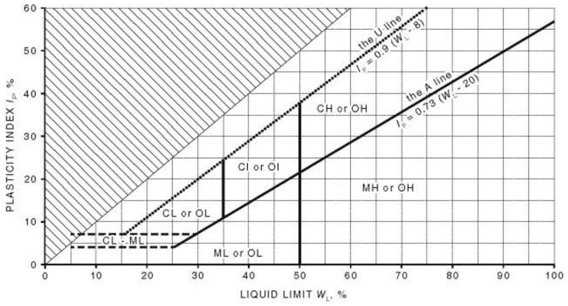
CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil is broadly classified and described in Borehole and Test Pit Logs using the preferred method given in AS 1726:2017, Section 6.1 – Soil description and classification.

PARTICLE SIZE CHARACTERISTICS

Fraction	Components	Sub Division	Size mm
Oversize	BOULDERS		>200
	COBBLES		63 to 200
Coarse grained soil	GRAVEL	Coarse	19 to 63
		Medium	6.7 to 19
		Fine	2.36 to 6.7
	SAND	Coarse	0.6 to 2.36
		Medium	0.21 to 0.6
		Fine	0.075 to 0.21
Fine grained soil	SILT		0.002 to 0.075
	CLAY		<0.002

PLASTICITY PROPERTIES



GROUP SYMBOLS

Major Divisions		Symbol	Description
COARSE GRAINED SOILS More than 65% of soil excluding oversize fraction is greater than 0.075mm	**GRAVEL** More than 50% of coarse fraction is >2.36mm	GW	Well graded gravel and gravel-sand mixtures, little or no fines, no dry strength.
		GP	Poorly graded gravel and gravel-sand mixtures, little or no fines, no dry strength.
		GM	Silty gravel, gravel-sand-silt mixtures, zero to medium dry strength.
		GC	Clayey gravel, gravel-sand-clay mixtures, medium to high dry strength.
	SAND More than 50% of coarse fraction is <2.36 mm	SW	Well graded sand and gravelly sand, little or no fines, no dry strength.
		SP	Poorly graded sand and gravelly sand, little or no fines, no dry strength.
		SM	Silty sand, sand-silt mixtures, zero to medium dry strength.
		SC	Clayey sand, sandy-clay mixtures, medium to high dry strength.
FINE GRAINED SOILS More than 35% of soil excluding oversized fraction is less than 0.075mm	Liquid Limit less < 50%	ML	Inorganic silts of low plasticity, very fine sands, rock flour, silty or clayey fine sands, zero to medium dry strength.
		CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, medium to high dry strength.
		OL	Organic silts and organic silty clays of low plasticity, low to medium dry strength.
	Liquid Limit > than 50%	MH	Inorganic silts of high plasticity, high to very high dry strength.
		CH	Inorganic clays of high plasticity, high to very high dry strength.
		OH	Organic clays of medium to high plasticity, medium to high dry strength.
Highly Organic soil		PT	Peat muck and other highly organic soils.

MOISTURE CONDITION

Symbol	Term	Description
D	Dry	Non- cohesive and free-running.
M	Moist	Soils feel cool, darkened in colour. Soil tends to stick together.
W	Wet	Soils feel cool, darkened in colour. Soil tends to stick together, free water forms when handling.

Moisture content of cohesive soils shall be described in relation to plastic limit (PL) or liquid limit (LL) for soils with higher moisture content as follows: Moist, dry of plastic limit (w < PL); Moist, near plastic limit (w ≈ PL); Moist, wet of plastic limit (w < PL); Wet, near liquid limit (w ≈ LL), Wet, wet of liquid limit (w > LL),

CONSISTENCY

Symbol	Term	Undrained Shear Strength (kPa)	SPT "N" #
VS	Very Soft	≤ 12	≤ 2
S	Soft	>12 to ≤ 25	>2 to ≤ 4
F	Firm	>25 to ≤ 50	>4 to 8
St	Stiff	>50 to ≤ 100	>8 to 15
VSt	Very Stiff	>100 to ≤ 200	>15 to 30
H	Hard	>200	>30
Fr	Friable	-	

DENSITY

Symbol	Term	Density Index %	SPT "N" #
VL	Very Loose	≤ 15	0 to 4
L	Loose	>15 to ≤ 35	4 to 10
MD	Medium Dense	>35 to ≤ 65	10 to 30
D	Dense	>65 to ≤ 85	30 to 50
VD	Very Dense	>85	Above 50

In the absence of test results, consistency and density may be assessed from correlations with the observed behaviour of the material.
SPT correlations are not stated in AS1726:2017, and may be subject to corrections for overburden pressure, moisture content of the soil, and equipment type.

MINOR COMPONENTS

Term	Assessment Guide	Proportion by Mass
Add 'Trace'	Presence just detectable by feel or eye but soil properties little or no different to general properties of primary component	Coarse grained soils: ≤ 5% Fine grained soil: ≤ 15%
Add 'With'	Presence easily detectable by feel or eye but soil properties little or no different to general properties of primary component	Coarse grained soils: 5 - 12% Fine grained soil: 15 - 30%
Prefix soil name	Presence easily detectable by feel or eye in conjunction with the general properties of primary component	Coarse grained soils: >12% Fine grained soil: >30%

TERMS FOR ROCK MATERIAL STRENGTH AND WEATHERING

CLASSIFICATION AND INFERRED STRATIGRAPHY

Rock is broadly classified and described in Borehole and Test Pit Logs using the preferred method given in AS1726 – 2017, Section 6.2 – Rock identification, description and classification.

ROCK MATERIAL STRENGTH CLASSIFICATION

Symbol	Term	Point Load Index, $Is_{(50)}$ (MPa) #	Field Guide
VL	Very Low	0.03 to 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 30 mm can be broken by finger pressure.
L	Low	0.1 to 0.3	Easily scored with a knife; indentations 1 mm to 3 mm show in the specimen with firm blows of pick point; has dull sound under hammer. A piece of core 150 mm long by 50 mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
M	Medium	0.3 to 1	Readily scored with a knife; a piece of core 150 mm long by 50 mm diameter can be broken by hand with difficulty.
H	High	1 to 3	A piece of core 150 mm long by 50 mm diameter cannot be broken by hand but can be broken with pick with a single firm blow; rock rings under hammer.
VH	Very High	3 to 10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
EH	Extremely High	>10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

Rock Strength Test Results

▼ Point Load Strength Index, $Is_{(50)}$, Axial test (MPa)

● Point Load Strength Index, $Is_{(50)}$, Diametral test (MPa)

Relationship between rock strength test result ($Is_{(50)}$) and unconfined compressive strength (UCS) will vary with rock type and strength, and should be determined on a site-specific basis. However UCS is typically 20 x $Is_{(50)}$.

ROCK MATERIAL WEATHERING CLASSIFICATION

Symbol		Term	Field Guide
RS		Residual Soil	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
XW		Extremely Weathered	Rock is weathered to such an extent that it has soil properties - i.e. it either disintegrates or can be remoulded, in water.
DW	HW MW	Distinctly Weathered	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores. In some environments it is convenient to subdivide into Highly Weathered and Moderately Weathered, with the degree of alteration typically less for MW.
SW		Slightly Weathered	Rock slightly discoloured but shows little or no change of strength relative to fresh rock.
FR		Fresh	Rock shows no sign of decomposition or staining.

ABBREVIATIONS AND DESCRIPTIONS FOR ROCK MATERIAL AND DEFECTS

eiaustralia
Contamination | Remediation | Geotechnical

CLASSIFICATION AND INFERRED STRATIGRAPHY
Rock is broadly classified and described in Borehole and Test Pit Logs using the preferred method given in AS1726 – 2017, Section 6.2 – Rock identification, description and classification.

DETAILED ROCK DEFECT SPACING

Defect Spacing

Term	Description
Massive	No layering apparent
Indistinct	Layering just visible; little effect on properties
Distinct	Layering (bedding, foliation, cleavage) distinct; rock breaks more easily parallel to layering

Bedding Thickness (Stratification)

Term	Spacing (mm)
Thinly laminated	<6
Laminated	6 – 20
Very thinly bedded	20 – 60
Thinly bedded	60 – 200
Medium bedded	200 – 600
Thickly bedded	600 – 2,000
Very thickly bedded	> 2,000

ABBREVIATIONS AND DESCRIPTIONS FOR DEFECT TYPES

Defect Type	Abbr.	Description
Joint	JT	Surface of a fracture or parting, formed without displacement, across which the rock has little or no tensile strength. May be closed or filled by air, water or soil or rock substance, which acts as cement.
Bedding Parting	BP	Surface of fracture or parting, across which the rock has little or no tensile strength, parallel or sub-parallel to layering/ bedding. Bedding refers to the layering or stratification of a rock, indicating orientation during deposition, resulting in planar anisotropy in the rock material.
Contact	CO	The surface between two types or ages of rock.
Sheared Surface	SSU	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.
Sheared Seam/ Zone (Fault)	SS/SZ	Seam or zone with roughly parallel almost planar boundaries of rock substance cut by closely spaced (often <50 mm) parallel and usually smooth or slickensided joints or cleavage planes.
Crushed Seam/ Zone (Fault)	CS/CZ	Seam or zone composed of disoriented usually angular fragments of the host rock substance, with roughly parallel near-planar boundaries. The brecciated fragments may be of clay, silt, sand or gravel sizes or mixtures of these.
Extremely Weathered Seam/ Zone	XWS/XWZ	Seam of soil substance, often with gradational boundaries, formed by weathering of the rock material in places.
Infilled Seam	IS	Seam of soil substance, usually clay or clayey, with very distinct roughly parallel boundaries, formed by soil migrating into joint or open cavity.
Vein	VN	Distinct sheet-like body of minerals crystallised within rock through typically open-space filling or crack-seal growth.

NOTE: Defects size of <100mm SS, CS and XWS. Defects size of >100mm SZ, CZ and XWZ.

ABBREVIATIONS AND DESCRIPTIONS FOR DEFECT SHAPE AND ROUGHNESS

Shape	Abbr.	Description	Roughness	Abbr.	Description
Planar	PR	Consistent orientation	Polished	POL	Shiny smooth surface
Curved	CU	Gradual change in orientation	Slickensided	SL	Grooved or striated surface, usually polished
Undulating	UN	Wavy surface	Smooth	SM	Smooth to touch. Few or no surface irregularities
Stepped	ST	One or more well defined steps	Rough	RO	Many small surface irregularities (amplitude generally <1mm). Feels like fine to coarse sandpaper
Irregular	IR	Many sharp changes in orientation	Very Rough	VR	Many large surface irregularities, amplitude generally >1mm. Feels like very coarse sandpaper

Orientation: **Vertical Boreholes –** The dip (inclination from horizontal) of the defect.
Inclined Boreholes – The inclination is measured as the acute angle to the core axis.

ABBREVIATIONS AND DESCRIPTIONS FOR DEFECT COATING

Coating	Abbr.	Description
Clean	CN	No visible coating or infilling
Stain	SN	No visible coating but surfaces are discoloured by staining, often limonite (orange-brown)
Veneer	VNR	A visible coating of soil or mineral substance, usually too thin to measure (< 1 mm); may be patchy

DEFECT APERTURE

Aperture	Abbr.	Description
Closed	CL	Closed.
Open	OP	Without any infill material.
Infilled	-	Soil or rock i.e. clay, silt, talc, pyrite, quartz, etc.

Appendix B – Laboratory Certificates

STS GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

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

NATA Accredited for Compliance with ISO/IEC 17025 - Testing No. 2750

Point Load Strength Index Report

Project: E25874| 10 - 16 Lawrence Street, FRESHWATER, NSW — Project No.: 31380/7405D-L
Client: EI AUSTRALIA — Report No.: 23/0492
Address: Suite 6.01, 55 Miller St. PYRMONT — Report Date: 03/03/2023
Test Method: AS 4133.4.1 — Page: 1 OF 2
Sampling Procedure: Samples Supplied By Client (Not covered under NATA Scope of Accreditation)

Borehole / Sample No.	Depth (m)	Date Sampled	Date Tested	Test Type	**Is (MPa)**	**$Is_{(50)}$ (MPa)**	Rock Type	Failure Type	Moisture
BH101M	4.07	24/02/2023	02/03/2023	A	**0.37**	**0.38**	SS	3	M
BH101M	5.31	24/02/2023	02/03/2023	A	**1.1**	**1.1**	SS	3	M
BH101M	6.68	24/02/2023	02/03/2023	A	**0.84**	**0.87**	SS	3	M
BH101M	7.35	24/02/2023	02/03/2023	A	**1.1**	**1.1**	SS	3	M
BH101M	8.66	24/02/2023	02/03/2023	A	**2.3**	**2.4**	SS	3	M
BH101M	9.73	24/02/2023	02/03/2023	A	**1.60**	**1.6**	SS	3	M
BH101M	10.86	24/02/2023	03/03/2023	A	**0.98**	**1**	SS	3	M
BH101M	11.73	24/02/2023	03/03/2023	A	**1.6**	**1.7**	SS	3	M
BH101M	12.45	24/02/2023	03/03/2023	A	**1.7**	**1.6**	SS	3	M
BH101M	13.86	24/02/2023	03/03/2023	A	**1.4**	**1.3**	SS	3	M
BH101M	14.40	24/02/2023	03/03/2023	A	**1.8**	**1.8**	SS	3	M
BH101M	15.38	24/02/2023	03/03/2023	A	**0.11**	**0.11**	SS	3	M
BH101M	16.55	24/02/2023	03/03/2023	A	**2.1**	**2**	SS	3	M
BH101M	17.68	24/02/2023	03/03/2023	A	**1.7**	**1.6**	SS	3	M
BH102M	1.50	16/02/2023	03/03/2023	A	**0.2**	**0.2**	SS	3	M
BH102M	2.29	16/02/2023	03/03/2023	A	**0.4**	**0.4**	SS	3	M
BH102M	3.45	16/02/2023	03/03/2023	A	**0.37**	**0.37**	SS	3	M
BH102M	4.57	16/02/2023	03/03/2023	A	**0.33**	**0.35**	SS	3	M
BH102M	5.32	16/02/2023	03/03/2023	A	**0.5**	**0.53**	SS	3	M
BH102M	6.52	16/02/2023	03/03/2023	A	**0.88**	**0.91**	SS	3	M
BH102M	7.27	16/02/2023	03/03/2023	A	**0.66**	**0.7**	SS	3	M
BH102M	8.72	16/02/2023	03/03/2023	A	**0.052**	**0.054**	SH	3	M
BH102M	9.47	16/02/2023	03/03/2023	A	**0.51**	**0.53**	SS	3	M
BH102M	10.78	16/02/2023	03/03/2023	A	**0.6**	**0.62**	SS	3	D
BH102M	11.56	16/02/2023	03/03/2023	A	**0.6**	**0.61**	SS	3	D
BH102M	12.71	16/02/2023	03/03/2023	A	**0.61**	**0.62**	SS	3	D
BH102M	13.52	16/02/2023	03/03/2023	A	**0.35**	**0.34**	SS	3	D
BH102M	14.65	16/02/2023	03/03/2023	A	**0.96**	**0.99**	SS	3	D
BH102M	15.47	16/02/2023	03/03/2023	A	**1.4**	**1.4**	SS	3	D

Failure Type
1 = Fracture through bedding or weak plane
2 = Fracture along bedding
3 = Fracture through rock mass
4 = Fracture influenced by natural defect or drilling
5 = Partial fracture or chip (invalid result)

Test Type
A = Axial
D = Diametrial
I = Irregular
C = Cube

Moisure Condition
W = Wet
M = Moist
D = Dry

Rock Type
SS = Sandstone
ST = Siltstone
SH = Shale
YS = Claystone
IG = Igneous

Remarks:

Approved Signatory...

Technician: FV

Orlando Mendoza - Laboratory Manager

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

Point Load Strength Index Report

Project: E25874 |10 - 16 Lawrence Street, FRESHWATER, NSW
Client: EI AUSTRALIA
Address: Suite 6.01, 55 Miller St. PYRMONT
Test Method: AS 4133.4.1
Sampling Procedure: Samples Supplied By Client (Not covered under NATA Scope of Accreditation)

Project No.: 31380/7405D-L
Report No.: 23/03/23
Report Date: 03/03/2023

Borehole / Sample No.	Depth (m)	Date Sampled	Date Tested	Test Type	Is (MPa)	$Is_{(50)}$ (MPa)	Rock Type	Failure Type	Moisture
BH102M	16.45	16/02/2023	03/03/2023	A	**2.5**	**2.6**	SS	3	D
BH102M	17.59	16/02/2023	03/03/2023	A	**3**	**3**	SS	3	D
BH102M	18.49	16/02/2023	03/03/2023	A	**1.7**	**1.7**	SS	3	D
BH102M	19.76	16/02/2023	03/03/2023	A	**3.8**	**4**	SS	3	D
BH102M	20.30	16/02/2023	03/03/2023	A	**1.8**	**1.8**	SS	3	D
							SS		
BH103M	1.17	17/02/2023	03/03/2023	A	**1.2**	**1.2**	SS	3	D
BH103M	2.66	17/02/2023	03/03/2023	A	**0.68**	**0.7**	SS	3	D
BH103M	3.53	17/02/2023	03/03/2023	A	**1.3**	**1.3**	SS	3	D
BH103M	4.73	17/02/2023	03/03/2023	A	**2**	**2**	SS	3	D
BH103M	5.85	17/02/2023	03/03/2023	A	**1.3**	**1.4**	SS	3	D
BH103M	6.55	17/02/2023	03/03/2023	A	**0.9**	**0.94**	SS	3	D
BH103M	7.59	17/02/2023	03/03/2023	A	**0.57**	**0.59**	SS	3	D
BH103M	8.57	17/02/2023	03/03/2023	A	**0.37**	**0.38**	SS	3	D
BH103M	9.31	17/02/2023	03/03/2023	A	**0.67**	**0.67**	SS	3	D
BH103M	10.76	17/02/2023	03/03/2023	A	**1.1**	**1.1**	SS	3	D
BH103M	11.25	17/02/2023	03/03/2023	A	**1.7**	**1.7**	SS	3	D
BH103M	12.54	17/02/2023	03/03/2023	A	**1.2**	**1.2**	SS	3	D
BH103M	13.82	17/02/2023	03/03/2023	A	**0.31**	**0.31**	SS	3	D
BH103M	14.66	17/02/2023	03/03/2023	A	**0.75**	**0.76**	SS	3	D
BH103M	15.78	17/02/2023	03/03/2023	A	**0.64**	**0.67**	SS	3	D
BH103M	16.42	17/02/2023	03/03/2023	A	**0.69**	**0.7**	3SS	3	D
BH103M	17.68	17/02/2023	03/03/2023	A	**0.86**	**0.9**	SS	3	D
BH103M	18.28	17/02/2023	03/03/2023	A	**0.77**	**0.76**	SS	3	D
BH103M	19.39	17/02/2023	03/03/2023	A	**0.49**	**0.49**	SS	3	D
BH103M	20.67	17/02/2023	03/03/2023	A	**1.2**	**1.2**	SS	3	D
BH103M	21.26	17/02/2023	03/03/2023	A	**1.1**	**1.1**	SS	3	D
BH103M	22.73	17/02/2023	03/03/2023	A	**1.8**	**1.9**	SS	3	M
BH103M	23.57	17/02/2023	03/03/2023	A	**2.5**	**2.6**	SS	3	M

Failure Type
1 = Fracture through bedding or weak plane
2 = Fracture along bedding
3 = Fracture through rock mass
4 = Fracture influenced by natural defect or drilling
5 = Partial fracture or chip (invalid result)

Test Type
A = Axial
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Moisture Condition
W = Wet
M = Moist
D = Dry

Rock Type
SS = Sandstone
ST = Siltstone
SH = Shale
YS = Claystone
IG = Igneous

Remarks:

Approved Signatory..

Technician: FV

Orlando Mendoza - Laboratory Manager

Appendix C – Vibration Limits

German Standard DIN 4150 – Part 3: 1999 provides guideline levels of vibration velocity for evaluating the effects of vibration in structures. The limits presented in this standard are generally considered to be conservative.

The DIN 4150 values (maximum levels measured in any direction at the foundation, OR, maximum levels measured in (x) or (y) directions, in the plane of the uppermost floor), are summarised in **Table A** below.

It should be noted that peak vibration velocities higher than the minimum figures in **Table A** for low frequencies may be quite 'safe', depending on the frequency content of the vibration and the actual conditions of the structures.

It should also be noted that these levels are 'safe limits', up to which no damage due to vibration effects has been observed for the particular class of building. 'Damage' is defined by DIN 4150 to include even minor non-structural cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls. Should damage be observed at vibration levels lower than the 'safe limits', then it may be attributed to other causes. DIN 4150 also states that when vibration levels higher than the 'safe limits' are present, it does not necessarily follow that damage will occur. Values given are only a broad guide.

Table A DIN 4150 – Structural Damage – Safe Limits for Building Vibration

Group	Type of Structure	Peak Vibration Velocity (mm/s)			
		At Foundation Level at a Frequency of:			Plane of Floor of Uppermost Storey
		Less than 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 and 2 and have intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

Note: For frequencies above 100 Hz, the higher values in the 50 Hz to 100 Hz column should be used.

Appendix D – Important Information

Important Information

SCOPE OF SERVICES

The geotechnical report ("the report") has been prepared in accordance with the scope of services as set out in the contract, or as otherwise agreed, between the Client And EI Australia ("EI"). The scope of work may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

RELIANCE ON DATA

EI has relied on data provided by the Client and other individuals and organizations, to prepare the report. Such data may include surveys, analyses, designs, maps and plans. EI has not verified the accuracy or completeness of the data except as stated in the report. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations ("conclusions") are based in whole or part on the data, EI will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to EI.

GEOTECHNICAL ENGINEERING

Geotechnical engineering is based extensively on judgment and opinion. It is far less exact than other engineering disciplines. Geotechnical engineering reports are prepared for a specific client, for a specific project and to meet specific needs, and may not be adequate for other clients or other purposes (e.g. a report prepared for a consulting civil engineer may not be adequate for a construction contractor). The report should not be used for other than its intended purpose without seeking additional geotechnical advice. Also, unless further geotechnical advice is obtained, the report cannot be used where the nature and/or details of the proposed development are changed.

LIMITATIONS OF SITE INVESTIGATION

The investigation programme undertaken is a professional estimate of the scope of investigation required to provide a general profile of subsurface conditions. The data derived from the site investigation programme and subsequent laboratory testing are extrapolated across the site to form an inferred geological model, and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. Despite investigation, the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies. The engineering logs are the subjective interpretation of subsurface conditions at a particular location and time, made by trained personnel. The actual interface between materials may be more gradual or abrupt than a report indicates.

SUBSURFACE CONDITIONS ARE TIME DEPENDENT

Subsurface conditions can be modified by changing natural forces or man-made influences. The report is based on conditions that existed at the time of subsurface exploration. Construction operations adjacent to the site, and natural events such as floods, or ground water fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report. EI should be kept appraised of any such events, and should be consulted to determine if any additional tests are necessary.

VERIFICATION OF SITE CONDITIONS

Where ground conditions encountered at the site differ significantly from those anticipated in the report, either due to natural variability of subsurface conditions or construction activities, it is a condition of the report that EI be notified of any variations and be provided with an opportunity to review the recommendations of this report. Recognition of change of soil and rock conditions requires experience and it is recommended that a suitably experienced geotechnical engineer be engaged to visit the site with sufficient frequency to detect if conditions have changed significantly.

REPRODUCTION OF REPORTS

This report is the subject of copyright and shall not be reproduced either totally or in part without the express permission of this Company. Where information from the accompanying report is to be included in contract documents or engineering specification for the project, the entire report should be included in order to minimize the likelihood of misinterpretation from logs.

REPORT FOR BENEFIT OF CLIENT

The report has been prepared for the benefit of the Client and no other party. EI assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of EI or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own inquiries and obtain independent advice in relation to such matters.

OTHER LIMITATIONS

EI will not be liable to update or revise the report to take into account any events or emergent circumstances or fact occurring or becoming apparent after the date of the report.