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Geotechnical Investigation Report 39–65 Old Castlereagh Road, Castlereagh NSW

Prepared for: Jacob 4765 Investments Pty Ltd

Reference: P3023_02Rev1

Date: 21 May 2025

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	Full Name & Title	Signature
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Reviewer	Alan Morrow Principal Geotechnical Engineer	

1. Project Background

Morrow Geotechnics Pty Ltd has undertaken a geotechnical investigation to provide geotechnical advice and recommendations for the proposed development at 39–65 Old Castlereagh Road, Castlereagh NSW (the site).

This report has been prepared to provide geotechnical recommendations and address the following requirements of State Environmental Planning Policy (Precincts – Western Parkland City) 2021 Section 4.31 Development on land zoned Tourism, parts:

> (c) whether a stable foundation exists or can be developed for the development; and
>
> (e) whether the proposed development appropriately allows for potential differential settlement given the existing geotechnical conditions and the proposed foundation and for the geotechnical conditions present at the site to prevent excessive total and differential settlement.

1.1 Proposed Development

Preliminary architectural drawings for the proposed development have been provided by Morson Group, including DA06, DA07, and DA15, and dated 20 May 2025. Morrow Geotechnics understands that the proposed development comprises the construction of a seven-storey accommodation building, a three-storey indoor recreation building with drive-through restaurant(s), and a three-storey club, at or near existing grade.

1.2 Investigation Intent

The purpose of the investigation is to provide geotechnical advice and recommendations specific to the ground conditions observed at site for the proposed development. These recommendations include:

- Building foundation options, including design parameters.
- Lot classification in accordance with AS2870.
- Earthquake site classification in accordance with AS1170.4.
- Advice on groundwater level if encountered within the depth of investigation.
- Advice on geotechnical construction constraints.
- Pavement design parameters (subgrade CBR, MDD, OMC and modulus of subgrade reaction).

1.3 Published Geological Mapping

Information on regional sub-surface conditions, referenced from the Department of Mineral Resources Geological Map Penrith 1:100,000 Geological Series Sheet 9030 (DMR 1991), indicates that the site overlies the Cranebrook Formation of the Quaternary Period, which typically comprises gravel, sand, silt and clay.

1.4 Published Soil Landscapes

The Soil Conservation Service of NSW Penrith 1:100,000 Soil Landscapes Series Sheet 9030 (1st Edition) indicates that the alluvial landscape at the site likely comprises the Richmond Landscape. This landscape type typically includes Quaternary terraces of the Nepean and Georges Rivers, with slopes of < 1 %. It generally comprises poorly structured orange to red clay loams, clays and sands. These soils are noted to present localised seasonal waterlogging, localised flood hazard and localised water erosion hazard on terrace edges.

2. Observations

2.1 Investigation Methods

Fieldwork was undertaken by Morrow Geotechnics on 16 March 2023. Work carried out as part of this investigation includes:

- Review of publicly available information from previous reports in the project area, published geological and soil mapping and government agency websites;
- Site walkover inspection by an Experienced Geotechnical Engineer to assess topographical features, condition of surrounding structures and site conditions;
- Dial Before You Dig (DBYD) services search of proposed borehole locations;
- Drilling of one cored borehole (BH1) by a track mounted drill rig. The borehole was drilled using solid flight auger equipped with a tungsten-carbide bit (TC bit) then extended beyond TC bit refusal by NMLC coring techniques to 14.60 metres below ground level (mBGL). Rock core was boxed and photographed and point load tests were undertaken on selected core sample to assess rock strength;
- Drilling of five augered boreholes (BH2, BH3, BH4, BH5 & BH6) using a ute mounted drill rig. Boreholes were drilled using solid flight augers equipped with a tungsten-carbide bit (TC bit) to depths of 5.5, 4.2, 3.3, 3.8, and 3.8m below ground level (mBGL) respectively. Borehole locations are shown on **Figure 1**, and the borehole logs are attached to this report **(Appendix A)**; and
- Standard Penetration Tests (SPT) were undertaken within BH1, and Dynamic Cone Penetrometer (DCP) tests were undertaken adjacent to BH2 to BH6. SPT and DCP test results were used to assess soil consistency/density.

2.2 Subsurface Conditions

The stratigraphy at the site is characterised by topsoil, alluvial sands and cobbles over shale bedrock. Observations taken during the investigation have been used to produce a stratigraphic model of the site. The observed stratigraphy has been divided into four geotechnical units.

A summary of the subsurface conditions across the site, interpreted from the investigation results, is presented in **Table 1** and **Table 2** below. More detailed descriptions of subsurface conditions at the test locations are available in the borehole logs presented in **Appendix A**. The details of the method of soil and rock classification, explanatory notes and abbreviations adopted in the borehole logs are also presented in **Appendix A**.

Table 1 Summary of Inferred Subsurface Conditions

Unit	Material	Generalised Description
1	**Topsoil**	Silty to gravelly SAND, loose, fine grained, fine to coarse sized gravel. Unit 1 is inferred to be uncontrolled and poorly compacted.
2	**Medium Dense Sand**	Alluvial Clayey to Silty SAND, medium dense, low to medium plasticity, fine to medium grained gravels.
3	**Alluvial Cobbles**	COBBLES with coarse gravel, dense to very dense, some fine to medium grained sand, and trace clay.
4	**Shale Bedrock**	SHALE, fine grained, slightly weathered, medium strength.

Table 2 Encountered Geotechnical Conditions

Unit	Material	Approx. Depth Range of Unit [1] mBGL (RL mAHD)					
		BH1	BH2	BH3	BH4	BH5	BH6
1	**Topsoil**	0.0 to 0.5 (24.2 to 23.7)	0.0 to 0.6 (23.8 to 23.2	0.0 to 0.6 (24.0 to 23.4)	0.0 to 0.3 (24.0 to 23.7))	0.0 to 0.6 (24.1 to 23.5)	0.0 to 0.3 (24.1 to 23.8)
2	**Medium Dense Sand**	0.5 to 6.0 (23.7 to 18.2)	0.6 to 5.5 (23.2 to 18.3)	0.6 to 4.2 (23.4 to 20.0)	0.3 to 3.3 (23.7 to 20.7)	0.6 to 3.8 (23.5 to 20.3)	0.3 to 3.8 (23.8 to 20.3)
3	**Alluvial Cobbles**	6.0 to 13.9 (18.2 to 10.3)	5.5 + (sub 18.3)	4.2 + (sub 19.8)	3.3 + (sub 20.7)	3.8 + (20.7 to 20.3)	3.8 + (sub 20.3)
4	**Shale Bedrock**	13.9 to 14.6 (10.3 to 9.6)	-	-	-	-	-

Notes:
1 Depth ranges shown are based on material observed within test locations and will vary across the site.

2.3 Groundwater Observations

One standpipe piezometer was installed within BH1 as part of the geotechnical investigation with well details found in **Table 3** below. The monitoring well location is shown on the attached plan.

Table 3 Groundwater Levels

Borehole ID	Date of Monitoring	Water Depth Below Ground Level (m)	Water level RL mAHD	Total Well Depth (m)
BH1	25 September 2023	5.55	18.65 mAHD	13.7

2.4 Laboratory Test Results

One soil sample was selected for laboratory pavement testing. A summary of test results is provided in **Table 4.**

Table 4 Pavement Design Laboratory Testing Results

Sample ID	BH2 0.3 to 0.9m	BH3 0.3 to 0.9m
Moisture Content (% w/w)	11.1	14.5
Maximum Dry Density (t/m3)	1.94	1.70
Optimum Moisture Content (%)	11.0	14.50
California Bearing Ratio (%)	3.50	2.50

3. Recommendations

3.1 Excavation Retention

Design of any required excavation retention systems will need to consider both the soil and groundwater conditions encountered within the investigation. For design of flexible shoring systems, a triangular pressure distribution may be employed using the parameters provided in **Table 5**. For design of rigid anchored or braced walls, a trapezoidal earth pressure distribution should be used with a maximum pressure of $0.65.K_a.\gamma.H$ (kPa), where 'H' is the effective vertical height of the wall in metres.

Table 5 Shoring Design Parameters

Material		Unit 1 Topsoil	Unit 2 Medium Dense Sand	Unit 3 Alluvial Cobbles	Unit 4 Shale Bedrock
Unit Weight (kN/m³)		17	18	21	24
Earth Pressure Coefficients	At Rest, K_o	0.58	0.56	0.53	0.47
	Passive, K_p	2.77	2.56	2.77	3.25
	Active, K_a	0.36	0.39	0.36	0.31
Drained Cohesion, c' (kPa)		0	6	15	50
Friction Angle, φ' (°)		28	26	28	32
Elastic Modulus (MPa)		5	20	75	150
Poisson's Ratio		0.30	0.30	0.25	0.22

Notes:
1 Unit Weight is based on visual assessment only and may vary by ±10%.
2 Earth pressures are provided on the assumption that the ground behind the retaining wall is flat and drained.

In addition, design of retaining walls should consider the following:

- Appropriate surcharge loading from construction equipment, vehicular traffic and neighbouring structures at finished surface level should be considered in the retention design. Surcharge loads on retention structures may be calculated using a rectangular stress block with an earth pressure coefficient of 0.5 applied to surcharge loads at ground surface level.
- Anchor design should ignore the contribution of any bonded length within a wedge which extends upwards at 45° from the top of Unit 6 to account for a failure wedge forming behind the shoring system.

3.2 Excavation Vibration Considerations

As a guide, safe working distances for typical items of vibration intensive plant are listed in **Table 6.** The safe working distances are quoted for both "cosmetic" damage (refer British Standard BS 7385:1993) and human comfort (refer NSW Environmental Protection Agency Vibration Guideline). The safe working distances should be complied with at all times, unless otherwise mitigated to the satisfaction of the relevant stakeholders.

Table 6 Recommended Safe Working Distances for Vibration Intensive Plant

Plant Item	Rating/Description	Safe Working Distance	
		Cosmetic Damage (BS 7385:1993) [1]	Human Response (EPA Vibration Guideline)
Vibratory Roller	< 50 kN (typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (typically 2-4 tonnes)	6 m	20 m
	< 200 kN (typically 4-6 tonnes)	12 m	40 m
	< 300 kN (typically 7-13 tonnes)	15 m	100 m
	< 300 kN (typically 13-18 tonnes)	20 m	100 m
	< 300 kN (typically >18 tonnes)	25 m	100 m
Small Hydraulic Hammer	300 kg – 5 to 12 t excavator	2 m	7 m
Med Hydraulic Hammer	900 kg – 12 to 18 t excavator	7 m	23 m
Large Hydraulic Hammer	1600 kg – 18 to 34 t excavator	22 m	73 m
Vibratory Pile Driver	Sheet Piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm	2m (nominal)	N/A
Jackhammer	Handheld	1 m (nominal)	Avoid contact with structure

Notes:
1 More stringent conditions may apply to heritage buildings or other sensitive structures.

In relation to human comfort (response), the safe working distances in **Table 6** relate to continuous vibration and apply to residential receivers. For most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods are permitted, as discussed in British Standard BS 6472-1:2008.

The safe working distances provided in **Table 6** are given for guidance only. Monitoring of vibration levels may be required to ensure vibrations levels remain below threshold values during the construction period.

3.3 Soil and Rock Excavatability

The expected ability of equipment to excavate the soil and rock encountered at the site is summarised **Table 7**. This assessment is based on available site investigation data and guidance on the assessment of excavatability of rock by Pettifer and Fookes (1994). The presence of medium to high strength bands in lower strength rock and the discontinuity spacing may influence the excavatability of the rock mass.

Table 7 Soil and Rock Excavatability

Unit	Material	Excavatability
1	Topsoil	Easy digging by 20t Excavator
2	Alluvial Soil	
3	Alluvial Gravel/Cobbles	Hard ripping by 20t Excavator
4	Shale Bedrock	Hydraulic hammering required where medium strength sandstone is encountered in Unit 4.

The excavation methodology may also be affected by the following factors:

- Scale and geometry of the excavation;
- Availability of suitable construction equipment;
- Potential reuse of material on site; and
- Acceptable excavation methods, noise, ground vibration and other environmental criteria.

3.4 Foundation Design

Due to the potential variability of fill material encountered at the site it is not recommended that any footings found within Unit 1. Footings and slabs on Unit 2 to 4 material should be designed in accordance with AS2870:2011 based on a Site Classification of 'S'.

The parameters given in **Table 8** may be used for the design of pad footings and bored piles. Morrow Geotechnics recommends that a Preliminary Geotechnical Strength Reduction Factor (GSRF) of 0.4 is used for the design of piles in accordance with AS 2159:2009 if no allowance is made for pile testing during construction. Should pile testing be nominated, the GSRF may be reviewed and a value of 0.55 to 0.65 may be expected.

Selection of footing types and founding depth will need to consider the risk of adverse differential ground movements within the foundation footprint and between high level and deeper footings. Unless an allowance for such movement is included in the design of the proposed development, we recommend that all new structures found on natural materials with comparable end bearing capacities and elastic moduli.

Ultimate geotechnical strengths are provided for use in limit state design. Allowable bearing pressures are provided for serviceability checks. These values have been determined to limit settlements to an acceptable level for conventional building structures, typically less than 1% of the minimum footing dimension.

Table 8 Pad Footing and Pile Design Parameters

Material		Unit 1 Topsoil	Unit 2 Medium-Dense Sand	Unit 3 Alluvial Cobbles	Unit 4 Shale Bedrock
Allowable Bearing Pressure (kPa)		N/A	150	750	3000
Ultimate Vertical End Bearing Pressure (kPa)		N/A	450	2250	9000
Elastic Modulus (MPa)		5	35	80	250
Allowable Shaft Adhesion (kPa)	In Compression	0	20	40	500
	In Tension	0	10	20	250
Susceptibility to Liquefaction during an Earthquake		High	Medium	Low	Low

Notes:

1 Side adhesion values given assume there is intimate contact between the pile and foundation material. Design engineer to check both 'piston' pull-out and 'cone' pull-out mechanics in accordance with AS4678-2002 Earth Retaining Structures.

2 Susceptibility to liquefaction during an earthquake is based on the following definition:
Low - Medium to very dense sands, stiff to hard clays, and rock
Medium - Loose to medium dense sands, soft to firm clays, or uncontrolled fill below the water table
High - Very loose sands or very soft clays below the water table

To adopt these parameters we have assumed that the bases of all pile excavations are cleaned of loose debris and water and inspected by a suitably qualified 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.

3.5 AS1170 Earthquake Site Risk Classification

Assessment of the material encountered during the investigation in accordance with the guidelines provided in AS1170.4-2007 indicates an earthquake subsoil class of Class C_e – Shallow Soil for the site.

3.6 Design Subgrade CBR and Earthworks

The nominated samples for laboratory testing were chosen to be representative of the natural subgrade material which will be encountered beneath pavement areas. Based on the results of soaked CBR testing conducted on the subgrade samples, design CBR values of **2.5 %** for alluvial sand material.

After stripping of topsoil and any loose, unsuitable material, the exposed subgrade should be lightly trimmed and compacted to the required degree of compaction as specified by the civil designer.

To confirm location and lateral extent of Weak Subgrade, in-situ testing should be carried out by both DCP testing and proof rolling. In-situ testing must confirm the strength of all exposed subgrade to a depth of least 1.5m below BEL.

The procedure to determine in-situ subgrade CBR strength should comprise DCP testing in accordance with AS1289 6.3.1. The relationship between DCP rate and in-situ CBR is published by Austroads 2017 "Guide to Pavement Technology" in Figure 5.3 and is replicated below. The formula is also provided which allows interpretation below CBR2%.

The chart is represented by the formula below:

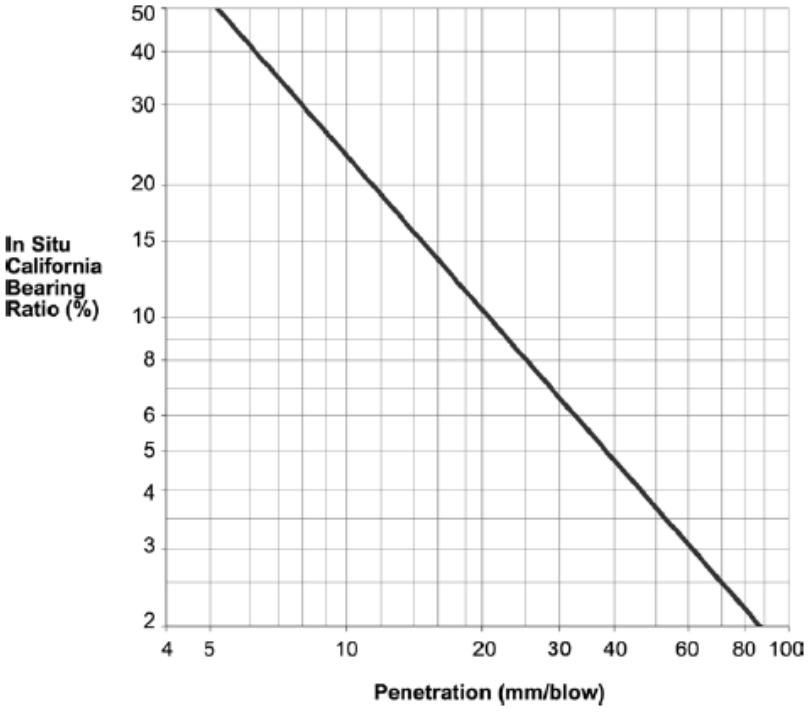
$$\log(CBR) = 2.465 - 1.12\log(DCPI)$$

Where DCPI = DCP Penetration in mm/blow.

After completion of light trimming and compaction of suitable subgrade light subgrade proof rolling shall be undertaken. Light proof rolling of the subgrade should be undertaken with a water tank loaded such that rear axle load does not exceed 4.5 tonnes with tyre inflation pressure of 550 kPa. A 10,000-litre water tanker is acceptable provided the tank has internal baffles to reduce water sloshing. Proof rolling test pattern must sufficiently overlap to ensure the entire subgrade is tested. During testing, the Geotechnical Testing Authority must observe for perceptible movement of the subgrade.

Where perceptible (generally > 2mm) surface deformation is observed, the GTA may require the Contractor to carry out additional testing, localised subgrade replacement or other additional subgrade treatment to ensure the earthworks formation complies with the project design requirements.

Figure 5.3: Correlation between dynamic cone penetration and CBR for fine-grained cohesive soils



4. ADDITIONAL GEOTECHNICAL INPUT

Further input from a geotechnical professional during design and construction is advised in order to ensure a cost-effective design which can be constructed safely and efficiently. Areas for geotechnical input should include:

- All excavated material transported off site should be classified in accordance with NSW EPA 2014 - Waste Classification Guideline Part 1; Classifying Waste.

- Additional cored boreholes at 16/DP793163 and 12/DP793163.
- A suitably qualified geotechnical engineer is to assess the condition of exposed material at foundation or subgrade level to assess the ability of the prepared surface to act as a foundation or as a subgrade.
- Observation of the material within pile excavations should be undertaken at the start of piling works to confirm that material across the site is in accordance with the geotechnical model presented in this report.
- Regular inspections of battered and unsupported excavations, where proposed, to confirm geotechnical conditions and to assess the suitability of design assumptions and to provide further advice with regards to excavation retention/ support and proposed construction methodologies, if required.

5. STATEMENT OF LIMITATIONS

The adopted investigation scope was limited by the investigation intent and the presence of structures onsite at the time of the investigation. Further geotechnical inspections should be carried out during construction to confirm the geotechnical model provided in this report.

Your attention is drawn to the document "Important Information", which is included in **Appendix B** of thisreport. 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 Morrow Geotechnics, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

6. REFERENCES

AS1726:1993, *Geotechnical Site Investigations*, Standards Australia.

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

AS2870:2011, *Residential Slabs and Footings*, Standards Australia.

Chapman, G.A. and Murphy, C.L. (1989), Soil Landscapes of the Sydney 1:100000 sheet. Soil ConservationServices of NSW, Sydney.

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Pells (2004) Substance and Mass Properties for the Design of Engineering Structures in the HawkesburySandstone, Australian Geomechanics Journal, Vol 39 No 3

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P3023 - 2025	
Client No:	Job No: P3023
Client: Jacob 4765 Investments Pty Ltd	
Project: Castlereagh	
Address: 39-65 Old Castlereagh Rd, Castlereagh NSW 2750, Australia	
Legend: Borehole Locations	
Image Source: Google Maps	Viewed: 2025-05-15

Drawn By: Mark Peach	Checked By: Rhiannon McKeon	Date: 2025-05-15	Figure: 1

APPENDIX A
BOREHOLE LOGS AND EXPLANATORY NOTES

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Phone: 0405 843 933

Boring No.: BH1

Easting	**: 285904.9**	**Drill Supplier**	**: GEOSENSE**	**Job Number**	**: P3023**	**Sheet**	**: 1 OF 4**
Northing	**: 6265525.5**	**Driller Company**	**: GEOSENSE**	**Client**	**: Jacob 4765 Investments Pty Ltd**		
Elevation	**: 24.20(m)**	**Logged By**	**: Mahmoud Jangidaryan**	**Project**	**: Castlereagh**		
Total Depth	**: 14.6 m**	**Date**	**: 15/09/2023**	**Location**	**: 47-65 Old Castlereagh Road, Castlereagh NSW**		

Drilling Method	Water	Well Diagram	Testing: SPT	Soil Origin	Graphic Log	Classification Code	Depth (m)	Elevation (m)	Material Description	Consistency/Density	Moisture
ADT		Backfill		Topsoil		SM	0.5	24.2	Topsoil Sandy SILT (SM) : firm to stiff, low plasticity, brown, fine grained sand, trace fine sized gravel, trace low plasticity clay, inorganic, w < pl.	F-St	w < PL
		50mm PVC Solid	10, 17, 16, (N = 33)	Alluvial		SM	1	23.2	Alluvial Silty SAND (SM) : medium dense, brown, fine grained, trace fine sized gravel, trace low plasticity clay, moist to dry.	MD	M-D
		Bentonite	5, 8, 8.98, (N = 16)	Alluvial		SM	1.5		Alluvial Silty to gravelly SAND (SM) : medium dense, brown brown yellow, fine grained, fine to medium sized gravel, trace low plasticity clay, moist.		M
				Alluvial		ML	2	22.2	Alluvial Clayey SILT (ML) : firm, low plasticity, brown red light grey, with fine grained sand, trace fine sized gravel, inorganic, w < pl.	F	w < PL
		50mm PVC Slotted	5, 7, 8, (N = 15)	Alluvial		ML	3	21.2	Alluvial Clayey SILT (ML) : firm to stiff, low plasticity, brown red light grey, with fine grained sand, trace fine sized gravel, inorganic, w < pl.	F-St	
		5mm Graded Sand		Alluvial		SC	3.5		Alluvial Clayey SAND (SC) : medium dense, low plasticity clay, brown orange, fine to medium grained, trace fine sized gravel, moist, (low resistance).	MD	M

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Boring No.: BH1

Easting	**: 285904.9**	**Drill Supplier**	**: GEOSENSE**	**Job Number**	**: P3023**	**Sheet**	**: 2 OF 4**
Northing	**: 6265525.5**	**Driller Company**	**: GEOSENSE**	**Client**	**: Jacob 4765 Investments Pty Ltd**		
Elevation	**: 24.20(m)**	**Logged By**	**: Mahmoud Jangidaryan**	**Project**	**: Castlereagh**		
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Drilling Method	Water	Well Diagram	Testing: SPT	Soil Origin	Graphic Log	Classification Code	Depth (m)	Elevation (m)	Material Description	Consistency/Density	Moisture
ADT				Alluvial		SC		20.2	Alluvial Clayey SAND (SC) : medium dense, low plasticity clay, brown orange, fine to medium grained, trace fine sized gravel, moist, (low resistance).	MD	M
							4.5				
			6, 9/90mm, (N = 30)	Alluvial		SP			Alluvial Gravelly SAND (SP) : dense, light grey brown, fine grained, medium to coarse sized gravel, with low plasticity clay, moist, (with cobbles of varying lithology).	D	
							5	19.2			
		5mm Graded Sand									
		50mm PVC Slotted					6	18.2			
150mm Washbore			4, 6, 10, (N = 16)	Alluvial		GP			Alluvial Sandy GRAVEL sub-rounded (GP) : medium dense, light grey brown, coarse sized, fine to medium grained sand, trace low plasticity clay, wet, (with cobbles of varying lithology).	MD	W
							7	17.2			

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Easting	**: 285904.9**	**Drill Supplier**	**: GEOSENSE**	**Job Number**	**: P3023**	**Sheet**	**: 3 OF 4**
Northing	**: 6265525.5**	**Driller Company**	**: GEOSENSE**	**Client**	**: Jacob 4765 Investments Pty Ltd**		
Elevation	**: 24.20(m)**	**Logged By**	**: Mahmoud Jangidaryan**	**Project**	**: Castlereagh**		
Total Depth	**: 14.6 m**	**Date**	**: 15/09/2023**	**Location**	**: 47-65 Old Castlereagh Road, Castlereagh NSW**		

Drilling Method	Water	Well Diagram	Testing: SPT	Soil Origin	Graphic Log	Classification Code	Depth (m)	Elevation (m)	Material Description	Consistency/Density	Moisture
150mm Washbore		5mm Graded Sand 50mm PVC Slotted		Alluvial		GP	9 10 11	16.2 15.2 14.2 13.2	Alluvial Sandy GRAVEL sub-rounded (GP) : medium dense, light grey brown, coarse sized, fine to medium grained sand, trace low plasticity clay, wet, (with cobbles of varying lithology).	MD	W

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Easting	**: 285904.9**	**Drill Supplier**	**: GEOSENSE**	**Job Number**	**: P3023**	**Sheet**	**: 4 OF 4**
Northing	**: 6265525.5**	**Driller Company**	**: GEOSENSE**	**Client**	**: Jacob 4765 Investments Pty Ltd**		
Elevation	**: 24.20(m)**	**Logged By**	**: Mahmoud Jangidaryan**	**Project**	**: Castlereagh**		
Total Depth	**: 14.6 m**	**Date**	**: 15/09/2023**	**Location**	**: 47-65 Old Castlereagh Road, Castlereagh NSW**		

Drilling Method	Water	Well Diagram	Testing: SPT	Soil Origin	Graphic Log	Classification Code	Depth (m)	Elevation (m)	Material Description	Consistency/Density	Moisture
150mm Washbore		5mm Graded Sand 50mm PVC Slotted		Alluvial		GP		12.2	Alluvial Sandy GRAVEL sub-rounded (GP) : medium dense, light grey brown, coarse sized, fine to medium grained sand, trace low plasticity clay, wet, (with cobbles of varying lithology).	MD	W
							13	11.2	**13m : Commenced NMLC Coring;**		
							14	10.2			
							15	9.2			

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Easting	**: 285904.9**	**Drill Supplier**	**: GEOSENSE**	**Job Number**	**: P3023**	**Sheet**	**: 4 OF 4**
Northing	**: 6265525.5**	**Driller Company**	**: GEOSENSE**	**Client**	**: Jacob 4765 Investments Pty Ltd**		
Elevation	**: 24.20(m)**	**Logged By**	**: Mahmoud Jangidaryan**	**Project**	**: Castlereagh**		
Total Depth	**: 14.6 m**	**Date**	**: 15/09/2023**	**Location**	**: 47-65 Old Castlereagh Road, Castlereagh NSW**		

Drilling Method	Water	Well Diagram	RQD% and TCR%	Testing Is(50)	Estimated Strength (VLS, LS, MS, HS, VHS, EHS)	Weathering	Depth (m)	Elevation (m)	Graphic Log	Classification Code	Material Description	Defect Spacing (mm) (30, 100, 300, 1000, 3000)	Defect Depth	Defect Description (type, inclination, planarity, roughness, coating, thickness)
		5mm Graded Sand; 50mm PVC Slotted					12.2							
NMLC Coring							13	11.2		GW	alluvial Sandy GRAVEL rounded to sub-rounded (GW) : very dense, light orange brown grey, medium to coarse sized, fine grained sand, (cobbles of varying lithology).		13	
			RQD = 31% TCR = 100%	D:0.53 ; A:1.06		SW-F	13			SHA	rock SHALE: slightly to fresh weathered, medium to high strength, dark grey, fine grained, (sub-horizontal, thinly laminated).		14	14.09, P, 5°, SO, PL, CL, OP 14.11, P, 5°, RO, PL, CL, OP 14.18, P, 5°, RO, PL, CL, OP 14.21, P, SO, PL, CL, OP 14.29, P, 25°, RO, PL, CL, OP 14.52, P, 5°, RO, PL, CL, OP
				D:0.77 ; A:1.06			14	10.2						
											BH1 Terminated at 14.6 m (Terminated in Fresh Shale)			
							15	9.2					15	

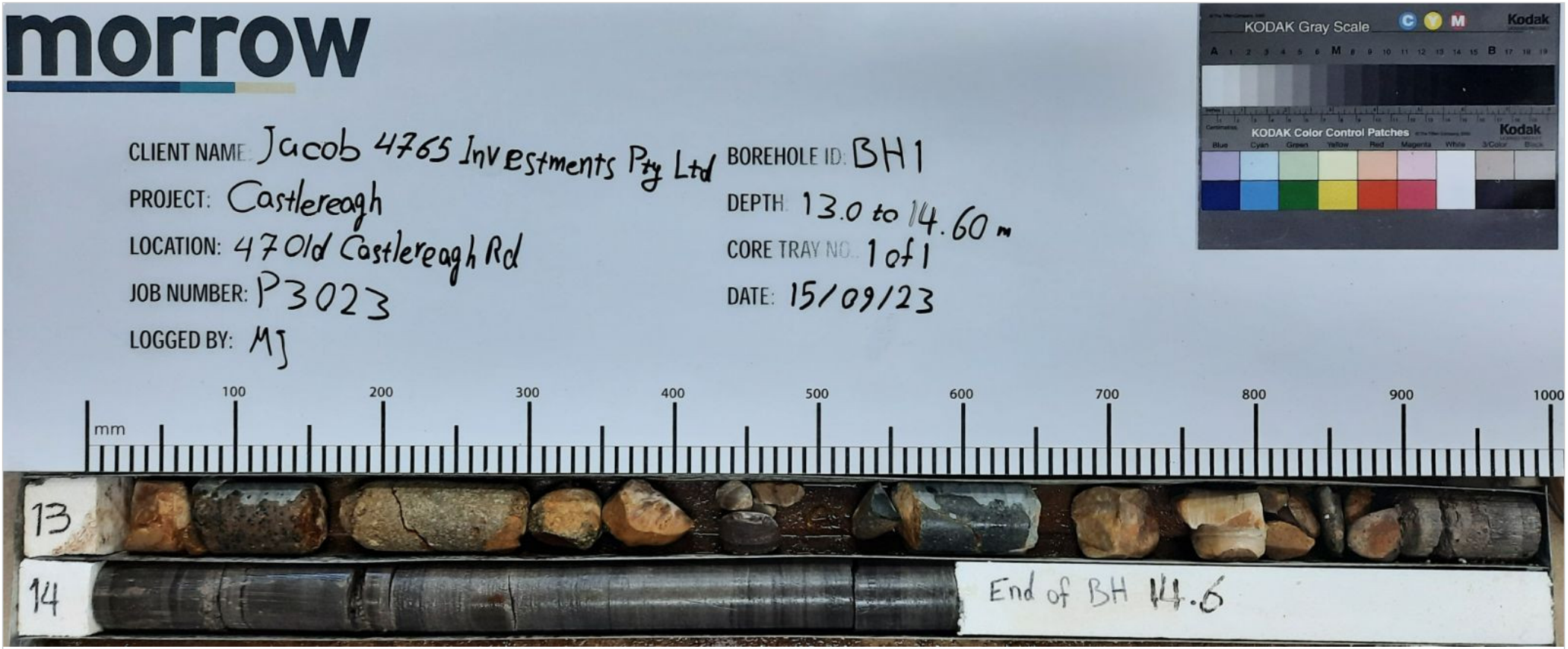

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Photo description	BH1 - Tray 1 of 1		
Client	Jacob 4765 Investments Pty Ltd		
Location	47-65 Old Castlereagh Road, Castlereagh NSW		
Project name	Castlereagh		
Project No	P3023	**Scale**	Not to Scale
BH No	BH1	**BH Depth**	13.0 to 14.6m

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Boring No.: BH2

Easting	: 285947.8	**Drill Supplier**	: HartGeo	**Job Number**	: P3023	**Sheet**	: 1 OF 2
Northing	: 6265500.1	**Driller Company**	: HartGeo	**Client**	: Jacob 4765 Investments Pty Ltd		
Elevation	: 23.8(m)	**Logged By**	: Mark Peach	**Project**	: Castlereagh		
Total Depth	: 5.5 m	**Date**	: 15/09/2023	**Location**	: 47-65 Old Castlereagh Road, Castlereagh NSW		

Drilling Method	Water	DCP graph	Soil Origin	Graphic Log	Classification Code	Depth (m)	Elevation (m)	Material Description	Consistency/Density	Moisture	Observations
ADT		4 8 8 18 21 25+	Alluvial		SM	0.6	23.8	Alluvial Silty SAND (SM) : loose, brown grey, fine grained, moist to dry, (low resistance).	L	M-D	
			Alluvial		SC	1.3	22.8	Alluvial Clayey to silty SAND (SC) : inferred medium dense, low plasticity clay, brown grey orange, fine grained, moist, (low resistance).	D-VD	M	
			Alluvial		SC	2.8	21.8	As above, but medium dense, red grey.	MD		
			Alluvial		CL	3.3	20.8	Alluvial Sandy CLAY (CL) : stiff, low plasticity, red grey, fine to medium grained sand, with fine sized gravel, w ≈ pl, (low resistance).	St	w ≈ PL	
			Alluvial		CI	3.6		Alluvial Sandy to gravelly CLAY (CI) : stiff, medium plasticity, grey red, coarse sized gravel, fine to medium grained sand, w ≈ pl, (medium to high resistance, cobbles).			
			Alluvial		SC			Alluvial Clayey SAND (SC) : medium dense, low plasticity clay, medium plasticity, grey brown, coarse grained, trace fine sized gravel, moist, (low resistance, with some high plasticity clay bands).	MD	M	

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Boring No.: BH2

Easting	**: 285947.8**	**Drill Supplier**	**: HartGeo**	**Job Number**	**: P3023**	**Sheet**	**: 2 OF 2**
Northing	**: 6265500.1**	**Driller Company**	**: HartGeo**	**Client**	**: Jacob 4765 Investments Pty Ltd**		
Elevation	**: 23.8(m)**	**Logged By**	**: Mark Peach**	**Project**	**: Castlereagh**		
Total Depth	**: 5.5 m**	**Date**	**: 15/09/2023**	**Location**	**: 47-65 Old Castlereagh Road, Castlereagh NSW**		

Drilling Method	Water	DCP graph	Soil Origin	Graphic Log	Classification Code	Depth (m)	Elevation (m)	Material Description	Consistency/Density	Moisture	Observations
ADT			Alluvial		SC		19.8	Alluvial Clayey SAND (SC) : medium dense, low plasticity clay, medium plasticity, grey brown, coarse grained, trace fine sized gravel, moist, (low resistance, with some high plasticity clay bands).	MD	M	
			Alluvial		SC	4.3		Alluvial Clayey to gravelly SAND (SC) : medium dense, low plasticity clay, medium plasticity, grey brown, coarse grained, coarse sized gravel, moist, (high resistance, with cobbles).			
			Alluvial		SC	4.8		Alluvial Clayey SAND (SC) : medium dense, low plasticity clay, medium plasticity, grey brown, coarse grained, trace fine sized gravel, moist, (low resistance, with some high plasticity clay bands).			
						5	18.8				
						6	17.8	**BH2 Terminated at 5.5 m (Target Depth Reached)**			
						7	16.8				

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Boring No.: BH3

Easting	**: 285909.7**	**Drill Supplier**	**: HartGeo**	**Job Number**	**: P3023**	**Sheet**	**: 1 OF 2**
Northing	**: 6265478.7**	**Driller Company**	**: HartGeo**	**Client**	**: Jacob 4765 Investments Pty Ltd**		
Elevation	**: 24(m)**	**Logged By**	**: Mark Peach**	**Project**	**: Castlereagh**		
Total Depth	**: 4.2 m**	**Date**	**: 15/09/2023**	**Location**	**: 47-65 Old Castlereagh Road, Castlereagh NSW**		

Drilling Method	Water	DCP graph	Soil Origin	Graphic Log	Classification Code	Depth (m)	Elevation (m)	Material Description	Consistency/Density	Moisture	Observations
ADT		3 10 16 16 25+	Alluvial		SM	0.6	24	Alluvial Silty SAND (SM) : medium dense, brown grey, fine grained, moist to dry, (low resistance).	MD	M-D	
			Alluvial		SM	1 1.1	23	Alluvial Silty SAND (SM) : inferred medium dense, brown grey orange, fine grained, with low plasticity clay, moist, (low resistance).	D-VD	M	
			Alluvial		SC	2 3	22 21	As above, but Clayey (SC) : medium dense, low plasticity clay, low plasticity, red grey, medium grained, (low resistance, very sandy clay bands).	MD		

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Boring No.: BH3

Easting	: 285909.7	**Drill Supplier**	: HartGeo	**Job Number**	: P3023	**Sheet**	: 2 OF 2
Northing	: 6265478.7	**Driller Company**	: HartGeo	**Client**	: Jacob 4765 Investments Pty Ltd		
Elevation	: 24(m)	**Logged By**	: Mark Peach	**Project**	: Castlereagh		
Total Depth	: 4.2 m	**Date**	: 15/09/2023	**Location**	: 47-65 Old Castlereagh Road, Castlereagh NSW		

Drilling Method	Water	DCP graph	Soil Origin	Graphic Log	Classification Code	Depth (m)	Elevation (m)	Material Description	Consistency/Density	Moisture	Observations
						4					
ADT			Alluvial		SC		20	As above, but grey red brown, coarse grained, with low plasticity clay, (high resistance, cobbles).			
						5	19	**BH3 refusal at 4.2 m (Refusal on Cobbles)**			
						6	18				
						7	17				

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Boring No.: BH4

Easting	**: 285872.1**	**Drill Supplier**	**: HartGeo**	**Job Number**	**: P3023**	**Sheet**	**: 1 OF 1**
Northing	**: 6265513.9**	**Driller Company**	**: HartGeo**	**Client**	**: Jacob 4765 Investments Pty Ltd**		
Elevation	**: 24.0(m)**	**Logged By**	**: Mark Peach**	**Project**	**: Castlereagh**		
Total Depth	**: 3.3 m**	**Date**	**: 15/09/2023**	**Location**	**: 47-65 Old Castlereagh Road, Castlereagh NSW**		

Drilling Method	Water	DCP graph	Soil Origin	Graphic Log	Classification Code	Depth (m)	Elevation (m)	Material Description	Consistency/Density	Moisture	Observations
ADT		1 3 3	Topsoil		SC	0.3	24	Topsoil Clayey to silty SAND (SC) : loose, low plasticity clay, brown, fine to medium grained, moist to dry, (low resistance).	L	M-D	
		4 18 25+	Alluvial		SM	0.6		Alluvial Silty SAND (SM) : dense to very dense, brown grey, fine grained, moist to dry, (low resistance).	D-VD		
			Alluvial		SC	1	23	Alluvial Clayey to silty SAND (SC) : loose, low plasticity clay, orange grey brown, fine grained, moist, (low resistance).	L	M	
			Alluvial		SC	1.3		Alluvial Clayey SAND (SC) : loose to medium dense, low plasticity clay, red grey, medium grained, trace fine sized gravel, moist, (low resistance).	L-MD		
			Alluvial		SC	2	22				
						2.9					
			Alluvial		SC	3	21	Alluvial Clayey to gravelly SAND (SC) : medium dense, low plasticity clay, red grey brown, medium to coarse grained, coarse sized gravel, moist, (medium to high resistance, cobbles).	MD		
								BH4 refusal at 3.3 m (Refusal on Cobbles)			

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Boring No.: BH5

Easting	**: 285882.8**	**Drill Supplier**	**: HartGeo**	**Job Number**	**: P3023**	**Sheet**	**: 1 OF 1**
Northing	**: 6265556.4**	**Driller Company**	**: HartGeo**	**Client**	**: Jacob 4765 Investments Pty Ltd**		
Elevation	**: 24.1(m)**	**Logged By**	**: Mark Peach**	**Project**	**: Castlereagh**		
Total Depth	**: 3.8 m**	**Date**	**: 15/09/2023**	**Location**	**: 47-65 Old Castlereagh Road, Castlereagh NSW**		

Drilling Method	Water	DCP graph	Soil Origin	Graphic Log	Classification Code	Depth (m)	Elevation (m)	Material Description	Consistency/Density	Moisture	Observations
ADT		3 5 8 17 17 25+	Alluvial		SM	0.6	24.1	Alluvial Silty SAND (SM) : loose to medium dense, grey brown, fine grained, moist to dry, (low resistance).	L-MD	M-D	
			Alluvial		SC	1 1.3	23.1	Alluvial Clayey to silty SAND (SC) : medium dense, low plasticity clay, orange brown, fine grained, moist, (low resistance).	D-VD	M	
			Alluvial		SC	2 3 3.4	22.1 21.1	As above, but Clayey loose to medium dense, red grey, trace fine sized gravel.	L-MD		
			Alluvial		SC			As above, but medium dense, grey red brown, medium to coarse grained, (high resistance, cobbles).	MD		
								BH5 refusal at 3.8 m (Refusal in Cobbles)			

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Boring No.: BH6

Easting	: 285939.0	**Drill Supplier**	: HartGeo	**Job Number**	: P3023	**Sheet**	: 1 OF 1
Northing	: 6265537.1	**Driller Company**	: HartGeo	**Client**	: Jacob 4765 Investments Pty Ltd		
Elevation	: 24.1(m)	**Logged By**	: Mark Peach	**Project**	: Castlereagh		
Total Depth	: 3.8 m	**Date**	: 15/09/2023	**Location**	: 47-65 Old Castlereagh Road, Castlereagh NSW		

Drilling Method	Water	DCP graph	Soil Origin	Graphic Log	Classification Code	Depth (m)	Elevation (m)	Material Description	Consistency/Density	Moisture	Observations
		3 7 8	Alluvial		SM		24.	Alluvial Silty SAND (SM) : loose to medium dense, grey brown, fine grained, moist to dry, (low resistance).	L-MD	M-D	
		8 20 25+	Alluvial		SC	0.3		Alluvial Clayey to silty SAND (SC) : dense to very dense, low plasticity clay, orange, fine to medium grained, trace fine sized gravel, moist, (low resistance).	D-VD	M	
			Alluvial		SC	1 1.3	23.	As above, but loose to medium dense.	L-MD		
			Alluvial		SC	2 3 3.4	22. 21.	As above, but Clayey to gravelly medium dense, brown orange grey, medium to coarse grained, coarse sized gravel, (high resistance, cobbles).	MD		
								BH6 refusal at 3.8 m (Refusal on Cobbles)			

GENERAL

Information obtained from site investigations is recorded on log sheets. The "Cored Drill Hole Log" presents data from an operation where a core barrel has been used to recover material - commonly rock. The "Non-Core Drill Hole - Geological Log" presents data from an operation where coring has not been used and information is based on a combination of regular sampling and insitu testing. The material penetrated in non-core drilling is commonly soil but may include rock. The "Excavation - Geological Log" presents data and drawings from exposures of soil and rock resulting from excavation of pits, trenches, etc.

The heading of the log sheets contains information on Project Identification, Hole or Pit Identification, Location and Elevation. The main section of the logs contains information on methods and conditions, material substance description and structure presented as a series of columns in relation to depth below the ground surface which is plotted on the left side of the log sheet. The common depth scale is 8m per drill log sheet and about 3-5m for excavation logs sheets.

As far as is practicable the data contained on the log sheets is factual. Some interpretation is inevitable in the identification of material boundaries in areas of partial sampling, the location of areas of core loss, description and classification of material, estimation of strength and identification of drilling induced fractures. Material description and classifications are based on SAA Site Investigation Code AS 1726 - 1993 with some modifications as defined below.

These notes contain an explanation of the terms and abbreviations commonly used on the log sheets.

DRILLING

Drilling & Casing

ADV	Auger Drilling with V-Bit
ADT	Auger Drilling with TC Bit
WB	Wash-bore drilling
RR	Rock Roller
NMLC	NMLC core barrel
NQ	NQ core barrel
HMLC	HMLC core barrel
HQ	HQ core barrel

Drilling Fluid/Water

The drilling fluid used is identified and loss of return to the surface estimated as a percentage.

Drilling Penetration/Drill Depth

Core lifts are identified by a line and depth with core loss per run as a percentage. Ease of penetration in non-core drilling is abbreviated as follows:

VE	Very Easy
E	Easy
M	Medium
H	High
VH	Very High

Groundwater Levels

Date of measurement is shown.

Standing water level measured in completed borehole Level taken during or immediately after drilling

D	Disturbed
B	Bulk
U	Undisturbed
SPT	Standard Penetration Test
N	Result of SPT (sample taken)
PBT	Plate Bearing Test
PZ	Piezometer Installation
HP	Hand Penetrometer Test

EXCAVATION LOGS

Explanatory notes are provided at the bottom of drill log sheets. Information about the origin, geology and pedology may be entered in the "Structure and other Observations" column. The depth of the base of excavation (for the logged section) at the appropriate depth in the "Material Description" column. Refusal of excavation plant is noted should it occur. A sketch of the exposure may be added.

MATERIAL DESCRIPTION – SOIL

Classification Symbol - In accordance with the Unified Classification System (AS 1726-1993, Appendix A, Table A1)

Material Description - In accordance with AS 1726-1993, Appendix A2.3

Moisture Condition

D	Dry, looks and feels dry
M	Moist, No free water on remoulding
W	Wet, free water on remoulding

Consistency - In accordance with AS 1726-1993, Appendix A2.5

VS	Very Soft	< 12.5 kPa
S	Soft	12.5 – 25 kPa
F	Firm	25 – 50 kPa
St	Stiff	50 – 100 kPa
VSt	Very Stiff	100 – 200 kPa
H	Hard	> 200 kPa

Strength figures quoted are the approximate range of undrained shear strength for each class.

Density Index. (%) is estimated or is based on SPT results.

VL	Very Loose	< 15 %
L	Loose	15 – 35 %
MD	Medium Dense	35 – 65 %
D	Dense	65 – 85 %
VD	Very Dense	> 85 %

MATERIAL DESCRIPTION -ROCK

Material Description

Identification of rock type, composition and texture based on visual features in accordance with AS 1726-1993, Appendix A3.1-A3.3 and Tables A6a, A6b and A7.

Core Loss

Is shown at the bottom of the run unless otherwise indicated.

Bedding

Thinly Laminated	< 6 mm
Laminated	6 - 20
Very Thinly Bedded	20 - 60
Thinly Bedded	60 - 200
Medium Bedded	200 – 600
Thickly Bedded	600 – 2000
Very Thickly Bedded	> 2000

Weathering - No distinction is made between weathering and alteration. Weathering classification assists in identification but does not imply engineering properties.

Fresh (F)	Rock substance unaffected by weathering
Slightly Weathered(SW)	Rock substance partly stained or discoloured. Colour and texture of fresh rock recognisable.
Moderately Weathered (MW)	Staining or discolouration extends throughout rock substance. Fresh rock colour not recognisable.
Highly Weathered(HW)	Stained or discoloured throughout. Signs of chemical or physical alteration. Rock texture retained.
Extremely Weathered (EW)	Rock texture evident but material has soil properties and can be remoulded.

Strength - The following terms are used to described rock strength:

Rock Strength Class	Abbreviation	Point Load Strength Index, Is(50) (MPa)
Extremely Low	EL	< 0.03
Very Low	VL	0.03 to 0.1
Low	L	0.1 to 0.3
Medium	M	0.3 to 1
High	H	1 to 3
Very High	VH	3 to 10
Extremely High	EH	≥ 10

Strengths are estimated and where possible supported by Point Load Index Testing of representative samples. Test results are plotted on the graphical estimated strength by using:

Diametral Point Load Test

Axial Point Load Test

Where the estimated strength log covers more than one range it indicates the rock strength varies between the limits shown.

MATERIALS STRUCTURE/FRACTURES

ROCK

Natural Fracture Spacing - A plot of average fracture spacing excluding defects known or suspected to be due to drilling, core boxing or testing. Closed or cemented joints, drilling breaks and handling breaks are not included in the Natural Fracture Spacing.

Visual Log - A diagrammatic plot of defects showing type, spacing and orientation in relation to core axis.

Defects	---------- ..... ————	Defects open in-situ or clay sealed Defects closed in-situ Breaks through rock substance

Additional Data - Description of individual defects by type, orientation, in-filling, shape and roughness in accordance with AS 1726-1993, Appendix A Table A10, notes and Figure A2.

Orientation - angle relative to the plane normal to the core axis.

Type	BP JT SM FZ SZ VN FL CL DL HB DB	Bedding Parting Joint Seam Fracture Zone Shear Zone Vein Foliation Cleavage Drill Lift Handling Break Drilling Break
Infilling	CN X Clay KT CA Fe Qz MS MU	Clean Carbonaceous Clay Chlorite Calcite Iron Oxide Quartz Secondary Mineral Unidentified Mineral
Shape	PR CU UN ST IR DIS	Planar Curved Undulose Stepped Irregular Discontinuous
Rougness	POL SL S RF VR	Polished Slickensided Smooth Rough Very Rough

SOIL

Structures - Fissuring and other defects are described in accordance with AS 1726-1993, Appendix A2.6, using the terminology for rock defects.

Origin - Where practicable an assessment is provided of the probable origin of the soil, eg fill, topsoil, alluvium, colluvium, residual soil.

APPENDIX B
IMPORTANT INFORMATION

This Document has been provided by Morrow Geotechnics Pty Ltd subject to the following limitations:

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