Alliance Geotechnical
ENGINEERING | ENVIRONMENTAL | TESTING
Your On-Site Geotechnical & Environmental Specialists

T: 1800 288 188
E: office@allgeo.com.au
W: www.allgeo.com.au
P: PO Box 275
Seven Hills NSW, 1730

Attn: Jane Hetherington
Penrith City Council

5/11/2019

The following Geotechnical Investigation Report – Report Number: 6515-GR-2-2 was completed on 3rd August 2018 for this Development Application submission.

Alliance Geotechnical confirms that the site condition has not changed since the investigation was conducted and the subsequent findings and information presented remain true.

Alliance Geotechnical have been involved in works on the site including Civil works on the residential portion of the site, Lot 3, DP1248137 and the Civil works for the Villa portion of the site on Lot 1, DP1248137.

The following references are to be noted throughout the report:

- Any reference to Lot 3991, DP1190132 is referring to Lot 1, DP1248137. Lot 3991 was subdivided in June, 2019.

- The proposed yield of the ILA Development is 139 ILAs across 3 x 6 storey buildings

Regards,

Thomas Dale
BE (Civil) Hon. MIEAust
Lead Geotechnical Engineer
Alliance Geotechnical Pty Ltd

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Geotechnical Investigation Report

Prepared for Lendlease

Proposed Apartment Developments
Jordan Springs Boulevard, Jordan Springs, NSW 2747

Project Number: 6715
Report Number: 6715-GR-2-2
Report Date: 3rd August 2018

We give you the right information to make the right decisions

Alliance Geotechnical Pty Ltd - Phone: 1800 288 188 - Web: www.allgeo.com.au

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Attachments

- Site Photographs
- Drawing: 6715-GR-2-A
- Borehole Logs (BH4 to BH6, BH201 & BH202) – AG's Previous Investigation
- Borehole Logs (BH501 & BH502)

1. INTRODUCTION

This report presents the findings of a geotechnical investigation undertaken by Alliance Geotechnical Pty Ltd (AG) at Jordan Springs Boulevard (Lot 3991 DP 1190132), Jordan Springs, NSW 2747 at the client's (Lendlease) request in accordance with AG's fee proposal, No. 1254, dated 20th July 2018. The aim of this report is to provide geotechnical information to assist with the development application (DA) process, project planning, and preliminary design estimates for the proposed development.

It is understood that the Lot 3991 is proposed for the new developments including:

- A Retirement Village including 51 villas at the northern side of Lot 3991; and,
- Apartment buildings (See Drawing 6715-GR-2-A) with single level of basement along the southern side of the Lot 3991 (which is referred as site in this report).

This report is prepared only to address the geotechnical conditions and constraints for the proposed apartment developments along the southern side of the site.

Previous geotechnical investigations were undertaken by AG in Lot 3991 as follows:

- December 2016, for the purpose of the construction of multi-storey developments for Investor Property Holdings. The investigation comprised drilled boreholes with Standard Penetration Tests (SPTs) and laboratory testing of subsurface soil & rock samples. The locations of the drilled boreholes (from this investigation and previous investigation) are shown on drawing 6715-GR-2-A;
- February 2018, for proposed apartments along the western side of the site (which have now been relocated to the southern side) for Lendlease, as presented in AG's report No. 6715-GR-2-1, dated 19th February 2018; and,
- March 2018, for the proposed Retirement Village at the northern side of the site, for Lendlease, as presented in AG's report No. 6715-GR-1-2-RevA, dated 30th May 2018.

This report is prepared based on the geotechnical data collected during the previous geotechnical investigations and are additional geotechnical investigation undertaken in the updated location of the proposed apartments. The geotechnical investigation comprised of drilled boreholes and Dynamic Cone Penetrometer (DCP) tests investigation, as described in Section 3.

The objectives of the investigation were to assess the subsurface conditions and provide preliminary geotechnical engineering comments and recommendations relating to:

- Existing geotechnical and groundwater conditions;
- Suitable footings and allowable bearing pressures for design;
- Parameters for retaining structures;
- Excavations;
- Groundwater seepage level and soil permeability.

In order to achieve the project objectives, the following scope of work was carried out for the investigation:

- Review of the site's geological setting, topographic maps and AG's previous geotechnical report for this site;
- Services search (Dial Before You Dig);
- Site walkover inspection and documentation of the existing conditions and features;
- Drilling of three (3) boreholes to the maximum depth of 8m below ground surface (bgs);
- DCP tests to evaluate near surface soil consistency;
- Installing one (1) monitoring well;
- Undertake rising head test in the monitoring well;

- A geotechnical investigation report.

2. SITE SETTING

2.1. Supplied Site Information

Prior to the site investigation, AG were supplied with:

- The site survey plan with reference No. 7202, prepared by Land Development Solutions (SDG), dated 15/01/2018; [1]

- Jordan Springs CID Site, drawing No. AND-28405, Sheet 1 & 2, prepared by A&N Design Group, dated 15/01/2018.

2.2. Site Description

Lot 3991 is located in Jordan Springs, approximately 40m west and 90m south of an existing man-made lake on its closest edge. It is a section of a vacant land, which is bounded by Jordan Springs Boulevard to the north and Lakeside Parade to the north and east. There is a sedimentation pond in the eastern portion of the site and a dam along the western side of Lot 3991. Figure 1 shows the general site locality.

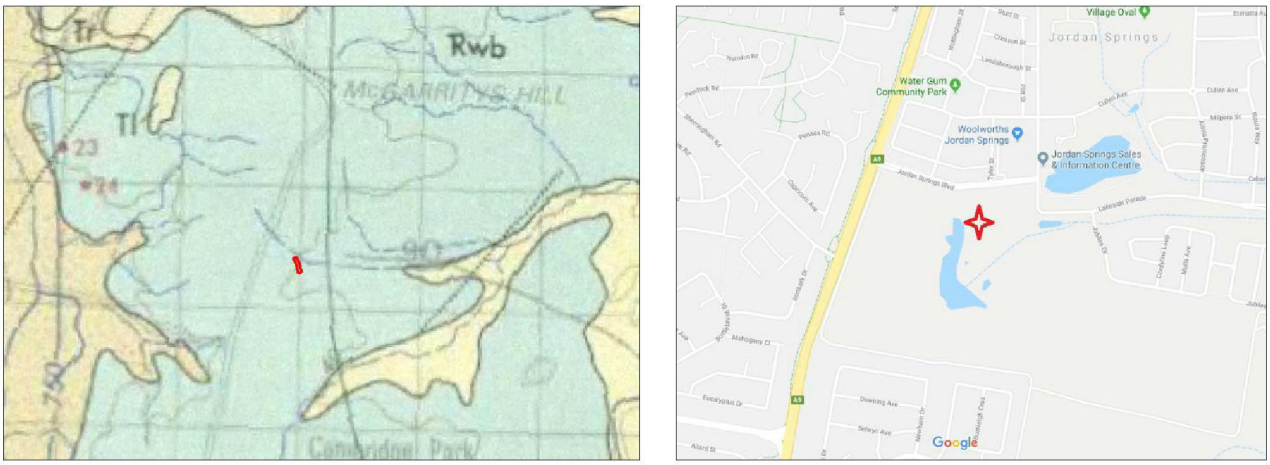


Figure 1- General site locality and geology

The supplied survey plan indicates that the current surface levels over the site (proposed for the apartment development vary by approximately 3m. The higher section of the site is at approximate RL 35.5m on the eastern side of the site and varies to approximate RL 38.5m on the eastern of the site. The site is covered with grass and native trees.

2.3. Regional Geology

The 1:100,000 NSW Department of Mineral Resources Geological Map of the Penrith Region indicates the site is underlain by Bringelly Shale (Rwb) of the Mesozoic dating back to the middle Triassic period. The Bringelly

[1] All levels shown in this report are relative to AHD.

Shale is generally described as *Shale, carbonaceous claystone, Claystone, laminate, fine to medium-grained lithic sandstone, rare coal and tuff.*

3. FIELDWORK

AG's geotechnical site drilling investigation was carried out on 26th July 2018. During the investigation, AG observed the drilling of three (3) boreholes including 2 boreholes (BH501 & BH502) to TC bit refusal and one borehole (BH503) to an approximate depth of 4.1m to install a groundwater monitoring well.

All the boreholes were drilled using a TDL690 drilling rig operated by AG and were advanced with solid flight 100 mm diameter augers with a TC (Tungsten Carbide) drill bit. The approximate locations of the boreholes are shown on the attached sketch plan (refer Drawing No. 6715-GR-2-A).

During the site investigation, the subsurface strata encountered were logged by an AG geotechnical engineer and the in-situ strength of the subsurface soils at the borehole locations were recorded by either visual assessment and/or performing in-situ DCP tests. DCP tests were carried out adjacent to boreholes BH501 & BH502. The DCP tests results are presented in the attachments.

One (1) monitoring well was installed in BH503 to determine the stabilised groundwater level. The slotted screen in BH503 extends approximate depth of 1m to 4m to measure the groundwater seepage through the soil profile to the level of the proposed basement excavation.

Following recording the stabilised groundwater level in the monitoring well on 1st August 2018, a rising head test was undertaken to indicate the inflow rate into the monitoring well.

4. SUBSURFACE CONDITIONS

The site subsurface conditions have been assessed based on AG's previous geotechnical investigations on this site and additional boreholes drilled in this geotechnical investigation. Relevant detailed borehole logs from both the previous and recent fieldworks are used in this report and are provided in the attachments (BH4 to BH6, BH202 and BH501 to BH503). The inferred subsurface soil and rock profiles at the borehole locations are shown in Table 1.

Generally the site is underlain by topsoil material to an approximate depth of 0.2m overlying stiff to very stiff silty clay alluvial material with an approximate depth of 1.8 to 2.6m which is underlain by very stiff residual clayey soils extending to an approximate depth of 4.3m to 6m across the site.

The bedrock comprises very low strength shale with clayey bands, (inferred as Class V shale) was encountered at an approximate depth of 4.3m at the western side (BH502) dipping to an approximate depth of 6m at the eastern side (BH6). BH4, BH5, BH501 and BH502 were terminated due to TC bit refusal on inferred low strength shale (which was not proved with NMLC rock coring) at an approximate depth of 5.4m at BH501 dipping to an approximate depth of 7.5m at the northern and western sides. Medium strength shale was only encountered in BH6 (where the shale bedrock was cored) at an approximate depth of 8.7m below the ground surface.

Table 1 - Summary of Boreholes Subsurface Profile

Borehole (No.)	Borehole Surface Elevation	Topsoil Clayey silt	Fill Moderately to well compacted Silty Clay	Alluvial Stiff silty clay	Residual Soil Stiff to hard silty clay	Shale EW, EL to VL St. (Class V)	Shale HW, L St. (Class IV)	Shale HW, MW, M. to H St. (Class III)	Termination depth
	RL (m)	(m)	(m)	(m)	(m)	(m)		(m)	(m)
BH4	37.7	0.0 – 0.2	-	0.2 – 1.8	1.8 – 5.0	5.0 – 7.2 (RL 32.7 at top)	Below 7.2m (RL 30.5)	-	7.2
BH5	36.5	0.0 – 0.2	-	0.2 – 2.4	2.4 – 4.7	4.7 – 7.6 (RL 31.8 at top)	Below 7.6m (RL 28.9)	-	7.6
BH6	36.2	0.0 – 0.2	0.2 – 2.5	2.5 – 4.0	4.0 – 6.6	6.6 – 8.7 (RL 29.6 at top)	-	8.7 – 12.5 (RL 27.5 at top)	12.5
BH202	38.1	0.0 – 0.1	-	0.1 – 2.6	2.6 – 4.8	4.8 – 6.3 (RL 33.3 at top)	-	-	6.3
BH501	38	0.0- 0.15	-	0.15 – 2.4	2.4 – 4.5	4.5 – 5.4 (RL 33.5 at top)	Below 5.4m (RL 32.6)	-	5.4
BH502	37	0.0 - 0.1	-	0.1 – 1.8	1.8 – 4.3	4.3 – 8.0 (RL 32.7 at top)	Below 8.m (RL 29)	-	8.0
BH503	37	0.0 – 0.1	-	0.1 – 1.8	1.8 – 4.1	-	-	-	4.1
Legend: EL St: Extremely Low Strength VL St.: Very Low Strength L. St.: Low Strength						M to H St.: Medium to High Strength EW: Extremely weathered HW: highly weathered			

4.1. Groundwater Seepage

Groundwater seepage had previously been observed at approximate depths of 5.6m to 6.4m (RL 29.6/31m) in boreholes BH5 & BH6 passing through the very low strength shale and an approximate depth of 4.5m in borehole BH202 within the residual clay. It was not observed during drilling BH501 to BH503. Table 2 shows the groundwater seepage levels during the drilling and at the boreholes completion.

Table 2 - Summary of the Groundwater Seepage Depths

Description	BH5	BH6	BH202	BH503
During drilling	5.6 (RL 30.9m)	6.4 (RL 29.8m)	4.5 (RL 33.6m)	-
After 9 days	1.3 (RL 35.2m)	-	-	3.85 (RL 33.15m)

Groundwater may be subject to seasonal/climatic conditions and could fluctuate, particularly at the interface between the soil and bedrock, and may increase following extended rainfall periods.

Groundwater level was measured in the monitoring well (BH503) five (5) days after installation on 1st August 2018 at an approximate depth of 3.85m (RL 33.15m AHD) below the existing ground surface.

The recorded groundwater level before conducting the rising head test is presented in Table 3.

Table 3- Groundwater Water Levels (m)

Monitoring Well	Well Elevation (m)	Well Depth (m)	Water depth (level) before the test 17/07/2018	Solid well length (m)	Screen depth (m)
BH503	RL ~37	4.1	3.85 (RL ~ 33.15m)	0 – 1.0	1.0 – 4.0

A rising head tests was undertaken in monitoring well BH503 to indicate the inflow rate and soil permeability.

The water level in the wells at the end of the test was measured and is as provided in Table 4:

Table 4- The Groundwater Water Levels (m) and Rising Head Test Result

Monitoring Well	Water depth from the surface at the end of the test (m)	Test duration (min)	Discharge rate measured in the monitoring wells (L/S/m2)	Calculated Hydraulic Conductivity (m/day)
BH503	3.95	6	0.003	0.123

The soil permeability value has been calculated using the Hvorslev (1951) method.

5. COMMENTS AND RECOMMENDATIONS

5.1. Proposed Development

At this stage, AG were not provided with any architectural drawings. AG has been advised by the client that the proposed development includes three multi- storey apartment buildings, all with a single level of basement.

For the purpose of this reprot, it is assumed that the maximum excavation depth for the basement will be 4m bgs.

5.2. Basement Excavations

Based on the subsurface ground conditions encountered (refer summary Table 1), excavations to the basement depth (assumed 4m bgs) are expected to encounter to full depth very stiff cohesive material.

Then, the basement will be founded within the very stiff residual soil.

Excavations through the soils are expected to be readily achieved using conventional excavation machines.

5.3. Unsupported Batter Slopes

Temporary batter slopes may be considered appropriate for the proposed excavation if the excavations are set back sufficiently from the site boundaries. The recommended maximum permanent and temporary batter slopes are presented in Table 5 for the soil above the groundwater seepage level.

Table 5-Maximum Excavation Batter Slopes

Material	Maximum Batter Slope (H: V)	
	Permanent	Temporary *
Alluvial silty clay	N/A	1.5: 1
Residual silty clay	N/A	1: 1
*Temporary refers to 10 - 20 days. It is necessary to cover the batters face to retain the moisture.		

In addition to the maximum batter slopes set out in Table 5, it is noted that unsupported excavations in soil should not extend below the 'zone of influence' of any adjacent structures, road and infrastructures (i.e. a 45° line drawn from the foundation level of any adjacent structure).

5.4. Excavation Support

If the setbacks from the boundaries are not sufficient for unsupported batter slopes (considering the zone of influence of the adjacent structures and infrastructures) or unsupported batter slopes are not feasible, continuous shoring support will be required to protect the excavation. If retention is considered, AG recommends soldier piles with reinforced shotcrete infill panels and drainage provided behind the shotcrete panels, or secant pile walls.

Piles would need to extend below the proposed basement excavation and the socket depth should be indicated by the design engineer. A minimum socket depth of 300mm into the bedrock is recommended.

Temporary anchors may be required to support the piled walls until such time as the wall can be braced by the basement slabs. Anchors will need to be installed progressively as the excavation proceeds below existing surface levels and should be inclined sufficiently to allow for penetration through the residual clay soils to anchor into the bedrock at increased depths.

The temporary ground anchors may be designed for a maximum allowable stress as shown in Table 6.

Table 6 - Allowable Bond Stress for Temporary Anchors

Layer Description	Allowable Bond Stress (kPa)
Very low strength Shale (Class V)	70
Low Strength Shale (Class IV)	200

Periodic checks of installed anchors should be carried out during the construction to ensure lock-off load is maintained.

To avoid excavation instability due to water seepage, it is recommended that the seepage be captured by placing strip drains at regular centres on the excavation face (see further comments on excavation support in response below), with the water then drained via weep holes and pipes to a sump & pump-out drainage system. This drainage system should be designed by a qualified and experienced engineer in conjunction with the structural design of the excavation support system.

5.5. Groundwater Seepage Control

As described in Section 4, the monitoring well was installed to an approximate depth of 4m below the existing ground surface next to the existing dam. The stabilised groundwater level was measured at an approximate depth of 3.85m (RL 33.15m) in BH503.

Dewatering during construction

Groundwater dewatering during the construction can be carried out using the pump-sump method. Groundwater inflow is expected during pile boring. Therefore, pumps may be required to remove seepage from bored pile holes prior to the placement of concrete, if bored piles are adopted. Alternatively, tremie concrete placement method could be adopted for the concrete placement.

Drainage during the building lifetime

Generally, groundwater seepage during the building lifetime can be controlled by a properly designed drainage system. It will be required to design a sub-floor drainage system to create a free drain layer below the base of the concrete slab to release the uplift pressure. As such, this sub-floor drainage system should be designed properly to avoid any water accumulation below the lower basement concrete slab.

5.6. Earth Pressures for the Design of Excavation Support

The earth retaining structure for basement construction should be designed by a structural engineer in accordance with AS 4678 recommendations using the geotechnical parameters set out in Table 7. Earth retention structures should be designed to withstand the applied lateral pressures of the subsurface soil layers, together with the existing live surcharge loads within the zone of influence behind the structure.

For the design of flexible retaining structures, where some lateral movement is acceptable, an active lateral earth pressure coefficient is recommended (k_a). If it is critical to limit the horizontal deformation of a retaining of an earth pressure coefficient "at rest" should be considered (k_o).

It is recommended that the structural engineering drawings for the development provide details of the retaining walls, including foundation bearing capacity, footings, surface drainage and subsoil drainage provisions.

Table 7- Parameters for Retaining Structure Design

Geotechnical Parameter	Fill/Residual/ Alluvial Soils	Very Low to Low Strength Shale
Effective Cohesion c' (kPa)	2	50
Effective Friction Angle (degrees)	26	28
Unit Weight (KN/m^3)	18	22
K_a* (Rankine Method)	0.39	0.36
K_p*(Rankine Method)	2.56	2.77
K_o*(Earth pressure at rest)	0.56	0.53

* These parameters and limits have been assessed for the site based on AG's experience and are considered suitable for the preliminary design of retaining walls proposed as a part of the site development.

5.7. Geotechnical Parameters for Footing Design

Considering the site's subsurface condition, it is recommended to found the buildings on deep footings to take the loads to the bedrock underneath. The recommended design parameters for deep footings are presented in Table 8.

The design of deep footings should consider the capacity and construction requirements. It is recommended that pile footings for this project be designed in accordance with AS 2159-2009 Piling – Design and Installation.

Before pouring concrete, the excavations for the installation of footings should be inspected by a geotechnical engineer to confirm that the bases of the footing excavations are clean and without soft, loose, wet or disturbed soils.

Table 8 – Geotechnical Design Parameters for Deep Footings

Bedrock	Allowable End Bearing Pressure (kPa) *	Ultimate Shaft Adhesion (kPa)	Elastic Modulus (MPa)
Very low strength shale (Class V)	700	70	50
Low strength shale (Class IV)	1000	100	150
* If higher strength is required, further drilling investigation should be undertaken.			

6. LIMITATIONS

Alliance Geotechnical Pty Ltd (AG) has prepared this report for the site located at Jordan Springs Boulevard (Lot 3991 of DP 1190132), Jordan Springs, NSW, in accordance with AG's fee proposal and Terms of Engagement. This geotechnical report has been prepared for Lendlease for this project and for the purposes outlined in this report. This report cannot be relied on for other projects, other parties on this site or any other site. The comments and recommendations provided in this report are based on the assumption that the geotechnical recommendations contained in this report will be fully complied with during the design and construction of the proposed site development.

The borehole investigation and testing results provided in this report are indicative of the subsurface conditions at the site only at the specific sampling and testing locations, and to the depths drilled at the time of the investigation. Subsurface conditions can change significantly due to geological and human processes. Where variations in conditions are encountered further geotechnical advice should be sought from AG.

Reviewed

Sahar Mamouri
BE (Civil) , M.Sc (Geotechnical)
Senior Geotechnical Engineer
Alliance Geotechnical Pty Ltd

Thomas Dale
BE(Hons), MIEAust
Senior Geotechnical Engineer
Alliance Geotechnical Pty Ltd

References

- AS1726-1993 - Geotechnical Site Investigations
- AS 2159-2009 - Piling - Design and Installation
- AS4678 – Earth Retaining Structures
- Pells et al “Foundations on Sandstone and Shale in the Sydney Region” AGJ, 1998
- The 1:100,000 NSW Department of Mineral Resources Geological Map of Penrith

Site Photographs

Figure 2 – AG's investigation - drilling BH501

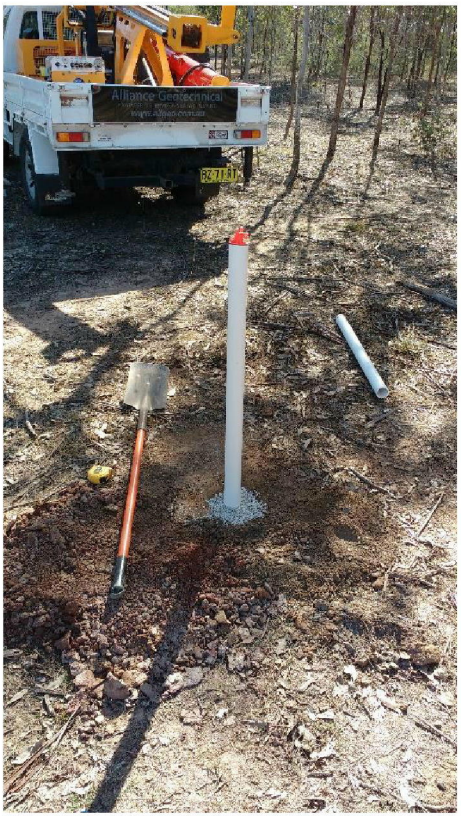
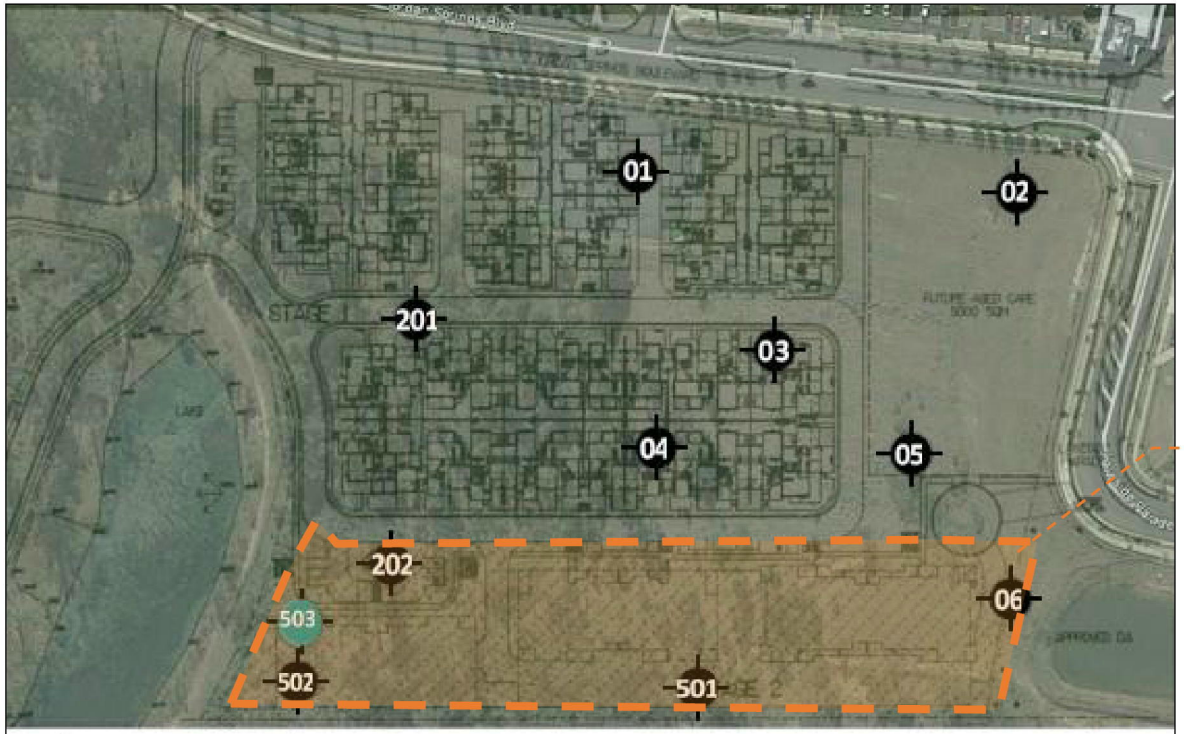


Figure 3 – Installed monitoring well at BH503

Borehole Locations - Drawing Number: 6715-GR-2-A



Not To Scale

Source: Google Map

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Alliance Geotechnical Pty Ltd
T: 1800 288 188
F: 02 9675 1888
E: office@allgeo.com.au
W: www.allgeo.com.au

BH No: BH 4
Sheet: 1 of 1
Job No: 2625

Borehole Log

Client: Investor Property Holdings Pty Ltd
Project: Proposed Mixed-Use Development - Stage 1
Location: Jordan Springs Boulevard, Jordan Springs, NSW 2747

Started: 1/12/16
Finished: 1/12/16
Borehole Size: 110mm

Rig Type: MD300 Drill
Hole Location:
Driller: HD
Logged: LM

RL Surface: 37.7
Contractor: AG P/L
Bearing: ---
Checked: SM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	After 4hrs ~ 3.5m Depth Below Surface					TOPSOIL/FILL: Clayey Silt, grey/brown, with gravel, grass roots		D		TOPSOIL/FILL
						FILL: Mixture of Silty Clay high plasticity with some Gravelly Shaley Clay, brown/red and grey, fine to coarse gravel, with some fine to coarse sand. Appears well compacted	SPT 8, 8, 12 N=20	D		FILL
		36			CH	Silty CLAY, red and orange/brown, high plasticity, with fine to coarse ironstone gravel		M	VSt	ALLUVIUM
			2		CH	Silty CLAY, red/brown and grey, high plasticity	SPT 7, 7, 14 N=21	M	H	RESIDUAL
		34	4		CI	Shaley CLAY/Gravelly Silty CLAY, grey and red/brown, medium plasticity, fine to coarse ironstone and shale gravel		M	H	
	Dry on Completion	32	6			SHALE, grey and brown, extremely to highly weathered, extremely to very low strength, with some fine grained sandstone and clay bands/layers. Extremely low to low TC bit resistance				BEDROCK
						SHALE, grey and dark grey, highly weathered, very low strength, with occasional clay bands. Moderate to high TC bit resistance				
		30	8			Borehole BH 4 terminated at 7.2m				TC Bit Refusal
		28	10							
		26	12							

BOREHOLE / TEST PIT GINT LOGS BH1TOBH6 JORDANSPRINGS.GPJ GINT STD AUSTRALIA.GDT 8/12/16

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Alliance Geotechnical Pty Ltd
T: 1800 288 188
F: 02 9675 1888
E: office@allgeo.com.au
W: www.allgeo.com.au

BH No: BH 5
Sheet: 1 of 1
Job No: 2625

Borehole Log

Client: Investor Property Holdings Pty Ltd
Project: Proposed Mixed-Use Development - Stage 1
Location: Jordan Springs Boulevard, Jordan Springs, NSW 2747

Started: 30/11/16
Finished: 30/11/16
Borehole Size: 110mm

Rig Type: MD300 Drill
Hole Location:
Driller: HD
Logged: LM

RL Surface: 36.5
Contractor: AG P/L
Bearing: ---
Checked: SM

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	After 24hrs & After 24hrs		36				TOPSOIL/FILL: Clayey Silt, brown, with gravel, grass roots				TOPSOIL/FILL
							FILL: Mixed Silty Clay high plasticity with Gravelly Sandy Clay medium plasticity, brown/red and grey, with fine to coarse sand. Appears well compacted	CBR Sample SPT 7, 12, 11 N=23	D - M		FILL
				2		CH	Silty CLAY, red and orange/brown, high plasticity, with fine to coarse ironstone gravel		M	Vst	ALLUVIUM
			34			CH	Silty CLAY, red/brown and grey, high plasticity, with fine to coarse ironstone gravel	SPT 6, 6, 7 N=13	M	VSt	RESIDUAL
				4		CI	Gravelly Shaley CLAY/Shale and Sandstone layers, medium plasticity, with some red ironstone gravel bands	SPT 5, 5, 14 N=19	M	VSt - H	RESIDUAL/ROCK
			32				SHALE, grey and brown, extremely weathered, extremely low strength, with frequent clay bands. Extremely low TC bit resistance	Aggressivity Sample Aggressivity Sample			BEDROCK
	Slight Seepage			6							
			30				SHALE, grey and brown, highly weathered, very low strength, with occasional shaley clay bands. Moderate TC bit resistance				
				8			Borehole BH 5 terminated at 7.6m				TC Bit Refusal
			28								
				10							
			26								
				12							
			24								

BOREHOLE / TEST PIT GINT LOGS BH1TOBH6 JORDANSPRINGS.GPJ GINT STD AUSTRALIA.GDT 8/12/16

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T: 1800 288 188
F: 02 9675 1888
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W: www.allgeo.com.au

Borehole Log

Client: Investor Property Holdings Pty Ltd
Project: Proposed Mixed-Use Development - Stage 1
Location: Jordan Springs Boulevard, Jordan Springs, NSW 2747

Started: 30/11/16
Finished: 30/11/16
Borehole Size: 110mm

Rig Type: MD300 Drill | **Hole Location:** | **Driller:** HD | **Logged:** LM
RL Surface: 36.2 | **Contractor:** AG P/L | **Bearing:** --- | **Checked:** SM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT		36				TOPSOIL/FILL: Clayey Silt, brown, with gravel, grass roots		D		TOPSOIL/FILL
						FILL: Mixed Silty Clay of medium to high plasticity with Silty Sandy Clay, high plasticity, brown/red and grey, with fine to coarse sand. Appears well compacted	CBR Sample	D - M		FILL
							SPT 6, 8, 8 N=16			
						FILL: Silty Clay of high plasticity, mixed with some gravel, red and grey, trace of sand. Appears well compacted		M		
		34	2							
					CI	Silty CLAY, orange/grey mottled brown, medium to high plasticity, with fine to coarse ironstone gravel		M	VSt	ALLUVIUM
							SPT 3, 5, 8 N=13			
			4							
		32			CH	Silty CLAY, red/brown and grey, high plasticity, with some fine to coarse ironstone and shale gravel		M	H	RESIDUAL
							SPT 6, 8, 12 N=20			
					CI	Gravelly Silty CLAY/Shaley CLAY, grey and brown/red, medium plasticity, fine to coarse ironstone and shale gravel		M	H	
	▼ Slight Seepage		6							
		30				SHALE, grey and brown, extremely weathered, extremely low strength, with frequent clay bands. Low TC bit resistance				BEDROCK
			8			SHALE, grey and brown, highly weathered, very low strength, interlayered with shaley clay bands of medium plasticity. Extremely low to moderate TC bit resistance				
		28								
						Borehole BH 6 continued as cored hole				
			10							
		26								
			12							
		24								

BOREHOLE / TEST PIT GINT LOGS BH1TOBH6 JORDANSPRINGS.GPJ GINT STD AUSTRALIA.GDT 8/12/16

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BH No: BH 6
PAGE 2 OF 2
Job No: 2625

Cored Borehole Log

Client: Investor Property Holdings Pty Ltd
Project: Proposed Mixed-Use Development - Stage 1
Location: Jordan Springs Boulevard, Jordan Springs, NSW 2747

Started: 30/11/16
Finished: 30/11/16
Borehole Size: 110mm

Rig Type: MD300 Drill
Hole Location:
Driller: HD
Logged: LM

RL Surface: 36.2
Contractor: AG P/L
Bearing: ---
Checked: SM

Method	Water	RL (m)	Depth (m)	Graphic Log	Material Description	Weathering	Estimated Strength (EL -0.03, VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	$Is_{(50)}$ MPa D- diametral A- axial	RQD %	Defect Spacing mm (30, 100, 300, 1000, 3000)	Additional Data
		36									
			2								
		34									
			4								
		32									
			6								
		30									
			8								
		28									
					Continued from non-cored borehole						
NMLC	Full Return				SHALE, grey and dark grey, with brown bands	HW/MW		A 0.77			0.00m, Fragmented core, 130mm with 2 clay seems 22mm and 24mm 9.00m, EW Seam, 28mm 9.16m, Joint, 35°, Curved
								A 0.32			
			10					D 0.27 A 1.24	81		9.83m, Joint, 30°, Curved 9.95m, Joint, 45°, Curved
		26			SANDSTONE, fine grained, light grey	MW		D 1.05 A 1.95			10.25-10.38m, SANDSTONE Band (fine grained)
					SHALE, grey and dark grey, with brown bands	HW/MW					
								D 0.11 A 0.29			10.97m, Fragmented core, 80mm with clay seam
					SHALE, grey and dark grey	HW		D 0.21 A 0.31			11.24m, Joint, 45°, Planar 11.34m, EW Seam, 28mm
			12								11.65m, EW Seam, 14mm 11.70m, EW Seam, 12mm
					SHALE, dark grey with grey laminations	HW/MW		D 0.15 A 0.2	89		
		24						D 0.42 A 0.27			
					BH 6 terminated at 12.53m			D 0.45 A 0.49			End of BH6

CORED BOREHOLE GINT LOGS BH1TOBH6 JORDANSPRINGS.GPJ GINT STD AUSTRALIA.GDT 8/12/16

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BH No: BH 201
Sheet: 1 of 1
Job No: 6715

Borehole Log

Client: Lendlease Pty Ltd
Project: Proposed Community Living
Location: Jordan Springs Boulevard, Jordan Springs NSW

Started: 9/2/18
Finished: 9/2/18
Borehole Size: 125mm

Rig Type: Hanjin D&B
Hole Location: Refer Drawing 6715-GR-1-A
Northing
Logged: DJ

RL Surface: 38.72
Contractor: Rockwell P/L
Easting:
Checked: LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	None Observed	38	1		CL	CLAY with some silt, low to medium plasticity, brown to red-brown, trace fine to medium grained sand, trace fine to medium grained subrounded gravel, organics (plant fibres, rootlets etc.)		D	St - VSt	ALLUVIUM
		37	2		CL	CLAY with some silt, low to medium plasticity, grey brown to grey, trace fine to medium grained sand.	SPT 3, 6, 7 N=13	D	VSt	
		36	3		CH	CLAY, medium to high plasticity, red-brown to brown, trace fine to medium grained sand. Very stiff becoming hard below 3.5m depth.	SPT 4, 10, 12 N=22	D	VSt - H	RESIDUAL
		35	4							
		34	5			Interbedded CLAY/ SILTSTONE, extremely weathered, extremely low strength to very low strength, brown, very thinly bedded, fine grained and highly fragmented, clay is low plasticity.	SPT 20, 50+ Hammer Bounce for 10mm penetration.			BEDROCK
		33	6							
		32	7				SPT 50+ 20mm penetration.			
						Borehole BH 201 terminated at 7m				

BOREHOLE / TEST PIT 6715-BOREHOLE LOGS.GPJ GINT STD AUSTRALIA.GDT 14/2/18

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BH No: BH 202
Sheet: 1 of 1
Job No: 6715

Borehole Log

Client: Lendlease Pty Ltd
Project: Proposed Community Living
Location: Jordan Springs Boulevard, Jordan Springs NSW
Started: 9/2/18
Finished: 9/2/18
Borehole Size: 125mm

Rig Type: Hanjin D&B
Hole Location: Refer Drawing 6715-GR-1-A
Northing
Logged: DJ
RL Surface: 38.18
Contractor: Rockwell P/L
Easting:
Checked: LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT		38	1		CL	CLAY, medium to high plasticity, brown to dark brown, trace fine to medium grained sand, trace fine to medium grained subrounded gravel, organics (plant fibres, rootlets etc.)		D	St	ALLUVIUM
		37	2		CL	CLAY, medium to high plasticity, grey brown to red brown, trace fine to medium grained sand, trace ironstone inclusions.	SPT 3, 4, 5 N=9	D	St - VSt	
		36	3		CH	As above, grey to grey-brown transitioning to grey from 3.1m onwards, trace fine to medium grained sand.	SPT 1, 7, 13 N=20	D	VSt - H	RESIDUAL
	Strong Inflow	35	4							
		34			CL	As above, but medium plasticity, grey, possible trace siltstone fragments, extremely weathered, extremely low to very low strength, very thinly bedded.	SPT 9, 50+ 140mm penetration.	D	H	
		33	5			Interbedded CLAY/ SILTSTONE, extremely weathered, extremely low strength to very low strength, grey, very thinly bedded, fine grained and highly fragmented, clay is low plasticity.				BEDROCK
		32	6							
		31	7			Borehole BH 202 terminated at 6.3m				

BOREHOLE / TEST PIT 6715-BOREHOLE LOGS.GPJ GINT STD AUSTRALIA.GDT 14/2/18

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BH No: BH 501
Sheet: 1 of 1
Job No: 6715

Borehole Log

Client: Lendlease Pty Ltd
Project: Proposed Apartments Development
Location: Lot 3991, Jordan Springs Boulevard, Jordan Springs, NSW

Started: 26/7/18
Finished: 26/7/18
Borehole Size: 100mm

Rig Type: TDLR690 Drill
Hole Location: Refer Drawing 6715-GR-3-A
Driller: US
Logged: DJ

RL Surface: 36.9
Contractor: AG P/L
Bearing: ---
Checked: LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Groundwater Not Observed	36	0			TOPSOIL: Clay, low plasticity, light brown to brown, organics (leaves, twigs, rootlets), trace fine to medium grained sand.		D		TOPSOIL
			1		CI - CH	CLAY, medium to high plasticity, red-brown mottled grey, trace fine grained sand, highly indurated, stratification layers are well defined.		D	VSt - H	ALLUVIUM
		35	2							
					CI - CH	CLAY, medium to high plasticity, with silt, red-brown to brown, trace ironstone gravel observed from 2.6m depth.		D - M	VSt - H	RESIDUAL
		34	3							
					CI - CH	As above, but brown mottled grey to light brown mottled grey, some friable clay/silty clay grey particles.		D - M	VSt - H	
		33	4							
					CI	CLAY, low to medium plasticity, with silt, brown-grey, trace siltstone fragments (<5%) which are highly weathered, very low to low strength, brown, fine grained.		D	VSt - H	
		32	5							
						SHALE/CLAYSTONE, highly weathered, very low strength, grey, with Shaley Clay low plasticity, brown-grey, very thinly bedded and highly fragmented, fine grained, calcite deposits.				BEDROCK
						Borehole BH 501 terminated at 5.4m				TC bit refusal
		31	6							
		30	7							
		29	8							
		28	9							

BOREHOLE / TEST PIT 6715-501-502.GPJ GINT STD AUSTRALIA.GDT 2/8/18

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BH No: BH 502
Sheet: 1 of 1
Job No: 6715

Borehole Log

Client: Lendlease Pty Ltd
Project: Proposed Apartments Development
Location: Lot 3991, Jordan Springs Boulevard, Jordan Springs, NSW

Started: 26/7/18
Finished: 26/7/18
Borehole Size: 100mm

Rig Type: TDLR690 Drill
Hole Location: Refer Drawing 6715-GR-3-A
Driller: US
Logged: DJ

RL Surface: 38.1
Contractor: AG P/L
Bearing: ---
Checked: LM

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Groundwater Not Observed	38			CI - CH	TOPSOIL: Clay, low plasticity, light brown to brown, organics (grass, rootlets etc), trace fine to medium grained sand.		D		TOPSOIL
						CLAY, medium to high plasticity, brown to red-brown mottled grey, trace silt, trace fine grained sand.		D	VSt - H	ALLUVIUM
		37	1							
			2		CI	CLAY, low to medium plasticity, with silt, grey mottled brown to red, trace ironstone inclusions.		D	VSt - H	RESIDUAL
		36								
			3							
		35			CI	CLAY, low to medium plasticity, with silt, grey to red-grey, trace ironstone inclusions.		D	VSt - H	
			4							
		34			CL	CLAY with shale, low plasticity, grey to grey-brown, shale/siltstone fragments extremely to highly weathered, very low to low strength, grey, very thinly bedded and highly fragmented.		D	VSt - H	
			5			SHALE/SILTSTONE, extremely to highly weathered, grey to dark grey, very thinly bedded, fine grained, trace calcilte deposits in bedding planes, highly fragmented.				BEDROCK
		33								
			6							
		32								
			7			SHALE/SILTSTONE, extremely weathered, very low to low strength, light grey, very thinly bedded, fine grained, highly fragmented.				
		31								
			8							
		30				Borehole BH 502 terminated at 8m				TC bit refusal
			9							

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BH No: BH 503
Sheet: 1 of 1
Job No: 6715

Borehole Log

Client: Lendlease Pty Ltd
Project: Proposed Apartments Development
Location: Lot 3991, Jordan Springs Boulevard, Jordan Springs, NSW
Started: 26/7/18
Finished: 26/7/18
Borehole Size: 100mm

Rig Type: TDLR690 Drill
Hole Location: Refer Drawing 6715-GR-3-A
Driller: US
Logged: DJ
RL Surface: 38.1
Contractor: AG P/L
Bearing: ---
Checked: LM

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Moisture Condition	Consistency/ Density Index	Additional Observations
ADT	Groundwater Not Observed		38				TOPSOIL: Clay, low plasticity, light brown to brown, organics (grass, rootlets etc), trace fine to medium grained sand.		D		TOPSOIL
						CI - CH	CLAY, medium to high plasticity, brown to red-brown mottled grey, trace silt, trace fine grained sand.		D	VSt - H	ALLUVIUM
			37	1							
			36	2		CI	CLAY, low to medium plasticity, with silt, grey mottled brown to red, trace ironstone inclusions.		D	VSt - H	RESIDUAL
			35	3		CI	CLAY, low to medium plasticity, with silt, grey to red-grey, trace ironstone inclusions.		D	VSt - H	
			34	4		CL	CLAY with shale, low plasticity, grey to grey-brown, shale/siltstone fragments extremely to highly weathered, very low to low strength, grey, very thinly bedded and highly fragmented.		D	VSt - H	
							Borehole BH 503 terminated at 4.5m				
			33	5							
			32	6							
			31	7							
			30	8							
				9							

BOREHOLE / TEST PIT 6715-501-502.GPJ GINT STD AUSTRALIA.GDT 2/8/18

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Dynamic Cone Penetrometer Test Report

Client:	Lendlease	Report Number:	6715-GR-2-2
Project Name:	Proposed Apartment Developments	Job No.:	6715
Project Location:	Lot 3991 of DP 1190132, Jordan Springs Boulevard, Jordan Springs, NSW 2747	Date Tested:	26/07/2018
Test Method:	AS 1289 6.3.2		

Test Number	DCP-1	DCP-2
Test Location	Next to BH501	Next to BH502
R.L (AHD)		
Depth (meters)		
0.00 – 0.15	13	18
0.15 – 0.30	22	25
0.30 – 0.45	25	23
0.45 – 0.60	25	19
0.60 – 0.75	>25	20
0.75 – 0.90		>25
0.90 – 1.05		
1.05 – 1.20		
1.20 – 1.35		
1.35 – 1.50		
1.50 – 1.65		
1.65 – 1.80		

EXPLANATORY NOTES - DRILL & EXCAVATION LOGS

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 excavtion 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

AS	Auger Screwing
AD/V	Auger Drilling with V-Bit
AD/T	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
F	Firm
H	Hard
VH	Very Hard

Groundwater Levels

Date of measurement is shown.

Standing water level measured in completed borehole

Level taken during or immediately after drilling

Samples/Tests

D	Disturbed
U	Undisturbed
C	Core Sample
SPT	Standard Penetration Test
N	Result of SPT (*sample taken)
VS	Vane Shear Test
IMP	Borehole Impression Device
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	< 25kPa
S	Soft	25 - 50kPa
F	Firm	50 - 100kPa
St	Stiff	100 - 200kPa
VSt	Very Stiff	200 - 400kPa
H	Hard	≥ 400kPa

Strength figures quoted are the approximate range of Unconfined Compressive Strength for each class.

Density Index. (%) is estimated or is based on SPT results. Approximate N Value correlation is shown in right column.

VL	Very Loose	< 15%	0 - 4
L	Loose	15 - 35%	4 - 10
MD	Medium Dense	35 - 65%	10 - 30
D	Dense	65 - 85%	30 - 50
VD	Very Dense	> 85%	> 50

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

Description	Spacing (mm)
Thinly Laminated	< 6
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.

Type	BP	Bedding Parting
	JT	Joint
	SM	Seam
	FZ	Fracture Zone
	SZ	Shear Zone
	VN	Vein
	FL	Foliation
	CL	Cleavage
	DL	Drill Lift
	HB	Handling break
	DB	Drilling break

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

Infilling	CN	Clean
	X	Carbonaceous
	Clay	Clay
	KT	Chlorite
	CA	Calcite
	Fe	Iron Oxide
	Qz	Quartz
	MS	Secondary Mineral
	MU	Unidentified Mineral
Shape	PR	Planar
	CU	Curved
	UN	Undulose
	ST	Stepped
	IR	Irregular
	DIS	Discontinuous
Roughness	POL	Polished
	SL	Slickensided
	S	Smooth
	RF	Rough
	VR	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.