REPORT

TO
FRASERS PROPERTY

ON
GEOTECHNICAL INVESTIGATION

FOR
PROPOSED DEVELOPMENT AT BLOCK 8

AT
CORNER OF ABERCROMBIE STREET AND
O'CONNOR STREET, CHIPPENDALE, NSW

22 January 2014
Ref: 22905SDrpt8rev1

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Davis Langdon Certification Services

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TABLE OF CONTENTS

1 INTRODUCTION

This report presents the results of a geotechnical investigation for the proposed development at Block 8 of the Frasers Broadway site, at the corner of Abercrombie Street and O'Connor Street, Chippendale, NSW. The geotechnical investigation was commissioned by Craig Elgie, of Frasers Property, by signed Acceptance of Proposal dated 9 September 2013. The geotechnical investigation was carried out in accordance with our proposal (Ref: 22905SDprop8REV1) dated 6 September 2013.

Based on the supplied architectural drawings prepared by Smart Design Studio (Project: 1260 – Central Park 8, Dwg No. DA000, DA001, DA100 to DA112, DA300 to DA303, DA400, DA401 and DA550 to DA557, Revision C, dated 13/12/13) we understand that the proposed development will comprise a 13 storey commercial and retail building with three levels of basement. Each of the basements are split level and referred to as North and South. The lowest basement level (B3 North) will have a Finished Floor Level (FFL) of RL 2.4m. Excavation depths will typically be to about 10m. Detailed excavation for the formation of the lift core will extend down to a reduced level of ~RL0.5m, within the centre of the development area.

This report has been prepared on behalf of Frasers Broadway Pty Ltd to accompany a State Significant Development Application for a mixed use development known as Block 8 at Central Park, Chippendale. Frasers prides itself on delivering high quality and environmentally responsible development projects and Block 8 demonstrates the Frasers ethos.

Block 8 is located at the south western corner of the Central Park site and is bound by Irivng Street and proposed student housing to the north, Central Park Avenue and Chippendale Green to the east, O'Connor Street and existing commercial and industrial development to the south, and Abercrombie Street and existing residential and mixed use development to the west.

The current Block 8 proposal is consistent with the Central Park approved Concept Plan (as modified) and comprises the following:

- 13 storey mixed use building including residential and retail uses;
- 178 apartments;
- Terraces, balconies and/or loggias to all apartments;
- Residents' lounge;
- Ground floor retail tenancies;
- Basement car parking; and

- Public domain works.

Block 8 will provide a mix of much needed residential accommodation in an area well serviced by public transport, and in close proximity to the retail, work and education opportunities offered by the Sydney Central Business District and surrounds.

We have not been provided with column loads and have assumed typical loadings for this type of development will apply.

The purpose of the investigation was to obtain geotechnical information on subsurface conditions and to use this as a basis for comments and recommendations on geotechnical issues relevant to the proposed development including excavation conditions, retention, groundwater, and footing design. The information presented in this report provides a basis to conclude that the site is capable of supporting the proposed development providing the comments and recommendations are embodied in the design.

Environmental and contamination testing of the site soils has not been carried out as this was outside the agreed scope for this geotechnical investigation.

The groundwater seepage analysis is covered in out report (ref: 22905SDrpt8_Seep, dated December 2013).

2 PREVIOUS INVESTIGATION

Previous geotechnical investigations were carried out by ourselves at the nearby Block 4S, which is directly to the north of the subject site and the Detention Tank construction directly to the east of the subject site. The results of these investigations are presented in our geotechnical reports; 22905SDrpt4S dated 20 February 2013 and 22905Srpt DET TANK dated 11 June 2009. Four boreholes drilled during these previous investigations, JK2, JK4, BH205 and BH207 have been referenced within this report to aid in our assessment of subsurface conditions. We have shown the relevant approximate borehole locations on the attached Figure 1 and copies of the relevant borehole logs are attached with this report.

3 INVESTIGATION PROCEDURE

Prior to commencement of fieldwork, a ‘Dial Before You Dig’ search was carried out and each borehole location was electromagnetically scanned for buried services by a specialist subcontractor.

The fieldwork for the investigation as carried out over two days between 30 September 2013 and 1 October 2013 and comprised the drilling of four boreholes (601 to 604 inclusive) using our truck mounted JK350 drilling rig. The boreholes were drilled for the new building works and extended to depths ranging from 14.95 (601) to 15.54m (602). These boreholes were initially auger drilled using spiral augers fitted with a tungsten carbide 'TC' bit to depths ranging from 6.09 (603) to 6.79m (602). All four boreholes were extended to their final depths by rotary diamond corning techniques, using an NMLC triple tube coring barrel and water flush.

The borehole locations are shown on the attached Figure 1, and these were set out by taped measurements from the surface features and inferred site boundaries. The approximate surface reduced levels shown on the borehole logs were interpolated from spot levels shown on the supplied survey plan prepared by Degotardi Smith & Partners (Dwg No. 31420A44, Rev C, dated 28/8/13). The survey datum is Australian Height Datum.

The apparent compaction of the fill and strength / relative densities of the subsurface soils were assessed from Standard Penetration Test (SPT) 'N' values and from hand penetrometers on clayey samples recovered in the SPT split tube sampler. The strength of the rock where it was augered using a 'TC' bit was assessed by examination of recovered rock cuttings and from auger penetration resistance. We note that rock strengths estimated in this way are indicative only and variations of at least one strength order should not be unexpected.

Where the bedrock was cored, the recovered core was returned to our NATA registered laboratory (Soil Test Services (STS)) for photographing and Point Load Strength Index (Is_{50}) testing. Using established correlations, the unconfined compressive strength (UCS) of the bedrock was then calculated from the Is_{50} results. These results are presented in the attached Table A.

Groundwater observations were made in the boreholes during drilling, on completion of augering and a short time after completion of drilling. We note that water is introduced into the borehole during coring and therefore the water levels measured at completion of coring may be artificially high as the water level has not had time to stabilise. PVC monitoring wells were installed in BH601 and BH604 to enable observation of groundwater levels over a longer period of time.

The fieldwork was carried out in the full-time presence of our engineering geologist, Ms Dawn Willemsen, who directed the electromagnetic scanning, set out the borehole locations, nominated the sampling and testing locations, and prepared the logs of the strata encountered. The borehole logs are attached to this report together with a set of explanatory notes, which describe the investigation techniques, and their limitations, and define the logging terms and symbols used.

4 RESULTS OF INVESTIGATION

4.1 Site Description

This area of Chippendale has an overall topography grading down to the west at about 2°. The site itself has frontage to Abercrombie Street to the west, Irving Street to the north, Central Park Avenue Street to the east and O'Connor Street to the south. Abercrombie Street slopes slightly down to the north at less than 1°. Irving Street slopes slightly down to the west at less than 1°, Central Park Avenue Street slopes down to the north at about 2-3° and O'Connor Street slopes down to the west at about 1°-2°. At the time of investigation, Irving and Central Park Avenue Street was limited to site vehicles only; however both roads were asphalt covered.

The site itself has been modified by previous earthworks and remediation, understood to have been undertaken by Delta Group, with the surface now relatively level. At the time of investigation the site was occupied by site sheds occupied by Christie Civil and Total Construction, which limited access to some areas of the site. The south-western corner of the site as well as the eastern boundary were defined by low height cut batters (up to 1m high), which has been formed as Central Park Avenue Street and O'Connor Street slope upwards to the south and east, respectively.

4.2 Subsurface Conditions

Reference to the Sydney 1:100,000 Geological Map indicates that the site is underlain by the intersection of three stratigraphic units: Hawkesbury Sandstone, Ashfield Shale, and man-made fill over Quaternary sands.

For continuity with the previous work carried out at this site, the system of defining Geotechnical Units has been maintained as shown in the following table.

GENERALISED GEOTECHNICAL MODEL

Geotechnical Unit Number	Generalised Descriptions	Formation Name
Unit 1	Granular Fill, gravelly sand or silty sand, igneous and sandstone gravel, variably compacted with inclusions of concrete, brick, slag and clay lumps	Fill
Unit 2	Sand, fine to medium grained, yellow and orange-brown, with silt and clay fines, loose to very loose	Recent/ Quaternary Age – Mainly alluvial channel deposits
Unit 3	Silty clay, grey brown, some mottling soft to stiff, some sandy and gravelly clay, locally wet and soft	Recent/ Quaternary Age – Mainly alluvial and colluvial clays
Unit 4a	Sandstone, extremely low to medium strength, extremely to distinctly weathered, commonly red-brown and medium to closely fractured, along bedding planes with core loss and clay seams (Class III-V Sandstone)	Triassic Age – Hawkesbury Sandstone
Unit 4b	Sandstone, medium to high strength slightly weathered, light-brown and grey-brown, some cross-bedding and massive bedding, medium grained, slightly fractured mainly along bed partings, thin near-horizontal seams (Class II Sandstone)	
Unit 4c	Sandstone, high strength, fresh, light-grey, some cross-bedding and massive bedding, medium grained, slightly fractured, mainly along bed partings (Class I Sandstone)	

The pertinent characteristics of the materials encountered subsurface profile are discussed below but for more detailed descriptions reference should be made to the attached borehole logs:

Fill (Unit 1)

Fill was encountered in all four Block 8 boreholes from surface levels to a maximum depth of 2.8m in BH603. The fill generally comprised gravelly sand and silty sand. The apparent compaction of the fill was variable and was assessed to be poorly to well compacted. The fill contained significant inclusions comprising clay fines, igneous and sandstone gravel, plastic, brick and concrete fragments.

In Borehole JK4 a shallow fill layer was encountered (0.4m thick), while no fill was encountered in JK2. BH205 and BH207 both encountered fill to approximately 2m depth. The fill (where encountered) was underlain by natural silty sands or natural sandy clays / clayey sands.

Natural Silty Sands (Unit 2)

Natural silty sands were encountered beneath the fill in all four Block 8 boreholes. The silty sands were assessed to be fine to medium grained and varied in colour between dark grey, grey and brown. The silty sands were generally assessed to be loose to medium dense. In all four boreholes the silty sands extended to depths ranging from 4m (603) to 4.5m (602) at which point the top of residual sandy clay/silty clay was encountered (Unit 3).

Natural Clayey Sands / Sandy Clays/Silty Clays (Unit 3a)

Natural clayey sands and natural sandy clays were encountered beneath silty sands in BH601 to 604. These deposits appeared to be banded in BH602 from 4.5m depth to top of bedrock, while in BH604 this deposit was assessed to contain a high proportion of ironstone gravel.

Silty Clays were encountered in BH205, JK2 and JK4 directly beneath the silty sands, in absence of the clayey sands/sandy clay deposits. This unit was not encountered in BH207.

Weathered Sandstone Bedrock (Unit 4a to 4c)

Weathered sandstone bedrock was encountered in all boreholes at depths ranging between 5.1m (603 and 604) and 5.5m (602) beneath existing surface levels. On first contact, the sandstone was generally assessed to be distinctly weathered and of very low strength. The strength of the sandstone quickly increased to medium to high strength and generally remained so until the termination depth of the boreholes. In general, the initial cored portion of the sandstone was assessed to be distinctly weathered and orange brown, red brown and light grey. At depth, the sandstone improves to slightly weathered and fresh, and becomes light grey with grey laminae, with cross bedding between 0° and 20°. The sandstone contained relatively few defects mostly comprising bedding partings at 0° to 3°, thin clay and extremely weathered seams up to 60mm thickness and joints inclined at 70° and 75°.

Rock Classifications - Depth/RL of Top of Strata

No.	Surface RL	Class V	Class IV	Class III	Class II	Class I	End of Borehole
BH601	~ 12.3	-	5.2 7.1	6.13 6.15	7.0 5.3	8.1 4.2	14.95 -2.65
BH602	~ 12.3	5.5 6.8	6.5 5.8	6.79 5.5	- -	7.5 4.8	15.54 -3.24
BH603	~ 12.3	5.1 7.2	5.9 6.4	6.1 6.2	- -	7.8 4.5	15.15 -2.85
BH604	~ 12.4	-	5.1 7.3	- -	- -	6.3 6.1	15.41 -3.0
BH205	~ 11.2	5.0 6.2	6.2 5.0	-	-	6.7 5.0	12.19 -1.0
BH207	~11.9	-	5.4 6.5	-	6.5 5.4	8.0 5.4	12.08 -0.2
JK2	~14.0	5.75 8.25	-	5.95 8.05	6.3 7.7	-	8.47 5.5
JK4	~11.5	4.2 7.3	4.5 7.0	-	5.0 6.5	-	7.2 4.3

Notes: * Bands of lower class rock occur in some locations below the nominated depths. This table should not be used to assess allowable bearing pressures without reference to the boreholes logs.

Rock classification is based upon the system described by Pells et al, Foundations on Sandstone and Shale in the Sydney Region, Australian Geomechanics, Dec 1998.

Groundwater

Groundwater seepage observations were made during drilling, on completion of augering, and a short time after drilling. Due to the introduction of water into the boreholes during coring, the groundwater levels measured on completion of drilling may be artificially high as the water level had not had time to stabilise. Relevant groundwater measurements are presented in the table below:

Borehole	Approximate Surface Level (RL mAHD)	Groundwater Depth (m)	Groundwater Level (RL mAHD)	Date
601	~12.3	3.1 / 2.98	9.2 / 9.32	30.09.13 / 30.10.13
602	~12.3	2.8 / (*2.8)*	9.5	30.09.13
603	~12.3	3.3 / 2.75	9.0 / 9.55	01.10.13
604	~12.4	3.0 / 2.9	9.4 / 9.5	01.10.13 / 30.10.13
205	~11.2	2.5 / 2.4	8.7 / 8.8	01.02.13 / 04.02.13
207	~11.9	2.7	9.2	30.01.13
JK2	~14.0	3.45	10.55	25.05.09
JK4	~11.5	1.2	10.3	26.05.09

Notes: (*Depths)* in italics represent collapse depths after completion of drilling.

4.3 Laboratory Test Results

The point load strength index test results correlated well with our field assessment of the weathered bedrock strength. The Unconfined Compressive Strength (UCS) of the sandstone, estimated from the point load strength index test results, ranged from 7MPa to 64MPa.

Three selected samples were sent to Envirolab Services Pty Ltd, an external laboratory, for pH, chloride content and sulphate content testing. The test results are summarised in the attached Envirolab Services Pty Ltd Certificate of Analysis. In accordance with the criteria for concrete and steel piling exposure classification given in Table 6.4.2 (C) and Table 6.5.2 (C) of AS2159-2009 ‘Piling Design and Installation’ the selected samples are assessed as moderately aggressive towards buried concrete and mildly aggressive to buried steel structures.

5 COMMENTS AND RECOMMENDATIONS

5.1 Geotechnical Issues

A summary of some of the main geotechnical issues is presented below. Further details are provided in the following sections of this report.

1. The fill, noted above, must be removed and disposed of appropriately.
2. The water table occurs at relatively shallow depth throughout the site. The sandy alluvial soils form a shallow aquifer and must be carefully considered with regards to shoring design and long term drainage issues to prevent undue disturbance to regional groundwater flows.
3. A perched sandy aquifer was identified during investigation across the majority of the site, in which the water table was generally higher than the water table in the underlying sandstone.
4. Dewatering down to the base of the Class V rock would assist excavation but would not be allowed unless within a cut-off wall.
5. The shoring must form a cut-off through the granular soils and weathered rock and be socketted into sandstone of Class III or better. If the shoring is to form a permanent basement wall, it must be of high quality. Secant walls with misaligned piles may not be acceptable. Cased secant pile walls have been used in nearby excavations with good results. Other wall types such as cutter soil mix (CSM) will not be able to socket effectively to the required depth. Conventional diaphragm walls are likely to be uneconomical.
6. Anchor penetrations in the cut-off wall may leak in the short and long term and must be designed and constructed to minimise leakage accordingly.
7. There are issues immediately outside all four sides of the proposed shoring walls that might prevent or restrict the use of ground anchors to support the shoring. These issues are discussed in Section 5.3 below.
8. Excavation to the lower bulk levels will encounter Class I and II sandstone which will be difficult to remove by ripping and the limited size of the site will make mobilisation of very heavy tractors uneconomical and impractical.

9. Most of the sandstone contains too many bedding laminations to be considered for high quality masonry (yellow block) but nevertheless, may be of some value if the site works could be delayed to allow quarrying by saw cutting.

10. Excavation spoil must be disposed of in accordance with NSW waste classification legislation.

11. The Unit 4b and 4c sandstone that occurs below the proposed shoring system can be cut vertically but in some places stabilisation of wedges formed by the jointing will be necessary. Careful inspection of the sandstone immediately below the toe of piles will be essential.

12. Previous experience from the nearby deep excavations indicates that water seepage and iron staining from through seams and defects in the sandstone and at the toe of the shoring may occur in excavations through the Unit 4b and 4c sandstone and grouting could be considered to reduce inflows.

13. The Unit 4c sandstone will provide an excellent foundation of high bearing capacity.

14. Drainage will be required below the basement floor slab.

15. Based on laboratory test results the soils (and groundwater) are assessed as moderately aggressive towards buried concrete and mildly aggressive to buried steel structures.

16. The earthquake site factor is favourable as it is a ‘rock’ site.

These and other issues are described in more detail in the following sections of this report.

5.2 Excavation

Excavation of the fill above the water table is not expected to be problematic provided an allowance is made for removal of concrete service ducting and similar obstructions. The fill encountered will be mainly gravelly sand which can be dug and loaded directly using excavators. Below this will be the sandy alluvial soils.

Below about 2m to 3m depth the granular soils will likely be wet, unless dewatered, and will require special handling and disposal. Subgrade trafficability may be poor as a result. The band of more clayey soils about 1m thick at the base of the soil profile will be of poor quality and will probably have to be taken to the tip.

The upper weathered rock in Unit 4a will comprise a mixture of material that can be excavated, perhaps with lower productivity, using heavy (30 ton plus) excavators. Material ranging up to Class III sandstone will require medium to heavy ripping. In view of the limited size and great depth of the excavation, the ability to rip with very heavy tractors (D10 - D11 or equivalent) will be limited and contractors will have to decide if it is economically and practicably feasible.

The Unit 4b and 4c sandstone will require very hard ripping and the use of impact rippers could be considered. Locally, rock hammers may be needed to assist ripping. Productivity will be very low and equipment wear rates may be high.

Whilst excavation is being undertaken, a number of monitoring procedures must be established and maintained, including:

- Waste classification identification.
- Vibration monitoring at adjacent structures.
- Collection and treatment of water prior to discharge.
- Deflection monitoring of the shoring and surrounding ground and structures.
- Dust and noise monitoring.
- Groundwater monitoring outside the excavation.

Detailed Inspection and Test Plans (ITP) for the above must be prepared, approved and instigated prior to work commencing.

As the shoring system is expected to terminate a little below the base of the Unit 4a sandstone, it will be important to excavate with great care around the toe of the shoring to avoid damage or destabilisation. If possible, the trim line should allow a shoulder inside the face of the shoring. Rock saws should be used to pre-cut the face and these must be used by skilled operators if a good outcome is to be achieved. It should be noted that the greater the socket created in the Unit 4b or 4c sandstone the more effective the groundwater cut-off is likely to be, though some leakage will still occur, particularly along the sub-vertical joints, based on past experience.

5.3 Excavation Support

Due to the existing site geometry, and the fact that the site is bound by existing roads on all four sides, the formation of temporary batters is not feasible. Therefore the excavation will need to be supported by an in-situ shoring system installed prior to excavation.

Construction of piles to depths below the top of the Unit 4b sandstone would be difficult and expensive. Even the most powerful rigs are at their limit using rock augers in Class 1 sandstone and progress is slow with high equipment wear rates. Noise and vibration during drilling are high and must be considered in the detailed inspection and test plans if for any reason such construction is considered.

The high water table with granular sandy fill will necessitate construction of an impermeable cut-off wall. A secant pile wall constructed using a cased auger system appears to be the best option for this project. Conventional secant pile walls (drilled with un-cased augers) suffer from pile misalignment which is difficult or impossible to rectify. Cutter-soil-mix walls produce walls of high quality but would not easily be able to achieve the rock sockets required. Steel sheet piles suffer from the same and other problems. Diaphragm walls are potentially suitable but likely to be much more expensive than any other option.

For stability and long-term waterproofing it will be necessary to socket the shoring walls below the base of Unit 4a, below which the sandstone is of medium to high strength with few defects and should stand vertically without substantial support (local treatment of joint zones and other defects must be expected).

Where possible, the stability of the shoring will be provided by the use of temporary ground anchors, but where anchors are not feasible the shoring walls will need to be propped/braced from inside the excavation.

We are aware of the following:

1. To the north is the basement (and shoring) of building 4S which has a lowest floor level at about RL6.5m. However, as this excavation is about 17m distant it should be feasible to anchor below it.
2. There are ovoid drains on the northern and southern sides of the site and to the west. These drains typically have invert levels at or just below the water table.
3. There is a Transgrid Cable Tunnel in Abercrombie Street which is approximately 3m in diameter. In the vicinity of the site the invert level ranges from about -6.7m to -7.1m. The

tunnel seems to be located below the western carriageway of Abercrombie Street. Details of the tunnel easement must be obtained to determine what restrictions apply to anchor installation.

4. The outlet pipe from the detention tank passes the north-eastern corner of the site.
5. The detention tank on the eastern side of the site has a FFL at about RL9.5m and is through to be at least 8m distant.
6. There may be other major service ducts or tunnels in the surrounding streets.
7. There are buildings on the southern side of O’Connor Street which may have basements.

The installation of anchors will give rise to groundwater leakage through the wall penetrations. This may be considered acceptable during construction provided the holes can be plugged after the anchors are de-stressed and cut-off once the internal structure is complete.

Design of the shoring system can be carried out either based upon simplified sections and earth pressures or by use of software such as ‘WALLAP’ which allows parameters for individual soil layers to be applied and may result in economies. The latter must be used with caution as the software may use geotechnical parameters in a manner which the user may not appreciate. The use of Plaxis or similar software is preferred if deflections are to be modelled. The following parameters may be used as a guide for the various materials:

Soil Design Parameters for Retaining Walls

Geotech Unit No	**Description**	**Bulk Density of (kN/m^3)**	**Effective Cohesion C' (KPa)**	**Friction Angle, ϕ' (degrees)**	**Elastic Modulus E' (MPa)**	**Earth Pressure Coefficient K_o**	**Earth Pressure Coefficient K_a**
1	Fill #1	18	0-5	28-30	5-20	0.53	0.35
2b	Sand	20	0	30	20	0.5	0.33
3a	Silty Clay	19	3	30	10	0.5	0.33
4a	Class V Sandstone Class IV Sandstone	23 24	10 10	32 35	50 100	0.45 0.4	0.30 0.27
1 Fill parameters will vary across the site depending on composition and compaction. 2 Consideration should also be given to Undrained Strength in Cohesive Soils.							

Alternatively, the earth pressure may be considered as a series of simplified sections where the soil pressure is trapezoidal, being uniform over the central 60% of the loaded section, tapering to zero at the top and bottom. Where there are no movement sensitive structures (including services) within the zone of influence of the wall, the earth pressure may be taken as 6H kPa where H is the depth in metres of soil and Unit 4a rock for an anchored or propped wall. Where movement sensitive structures are present, the assumed earth pressure should be increased to

8H kPa to provide a 'stiff' shoring where deflections are effectively minimised. Surcharge loads, including inclined backfill and hydrostatic pressure are additional to the above. In particular, hydrostatic pressure must be carefully considered where the wall will form a watertight cut-off, producing a water pressure differential across the wall.

Shoring piles socketed into Class III sandstone may be designed for a maximum allowable lateral resistance of 400kPa, where the piles extend below bulk excavation level plus a margin of 300mm to allow for over excavation. In practice this is not likely to arise.

Where rock anchors are used to support the shoring system, it is common practice to allow the contractors to prepare their own designs for various specified loading conditions. The reason for this is to balance economy of design with the risk of failure under test load and the cost of re-installation. If non-conservative design parameters are used and a small proportion of anchors fail, it is difficult to determine whether the failure was due to bond failure or poor construction. Nevertheless, as a guide for designers, the following parameters may be used provisionally:

Unit	Rock Class	Allowable Bond Stress for Anchors
4a – Hawkesbury Sandstone	DW, VL-L Strength IV	150kPa
4a – Hawkesbury Sandstone	DW, L-M Strength III	300kPa
4b – Hawkesbury Sandstone	SW, M-H Strength II	600kPa
4c – Hawkesbury Sandstone	Fr H Strength I	1,000kPa

All anchors should be test loaded to 1.3 times the design working load. A proportion of anchors should be re-tested after a period of 7-14 days to determine whether any relaxation has occurred as a guide to the need to re-stress all or any of the remaining anchors. A detailed specification for rock anchors should form part of the tender documentation.

Whatever shoring system is adopted, inward deflections of the shoring will occur and even for a well-designed and constructed shoring system, deflections may be in the order of 1mm horizontally per metre depth. Additional to this will be inward deflections due to stress relief in the sandstone bedrock. The horizontal stress field in the Hawkesbury Sandstone below the city is several times the vertical stress and results in elastic relaxation of the rock surrounding an excavation. The principal stress axis runs ENE-WSW and so deflections of the eastern and western boundaries will be greatest. As a guide, the deflections range from 0.5mm to 1mm per metre depth of excavation, reducing with distance from the excavation but still quite evident at setbacks of up to twice the excavation depth. More accurate predictions can be made by carrying out in-situ stress measurements in boreholes and using the data in 2D or 3D finite element models using software such as Plaxis or Flac.

Inclined joints and other geological features may result in potential instability of excavation in the Unit 4b and 4c bedrock. Such problems are usually solved by means of rock bolts or stressed anchors for larger features. Where permanent bolts and anchors are not permitted to extend beyond the boundaries, it is necessary to install permanent support by propping from the internal structure or by underpinning, which may be quite straightforward for smaller features but occasionally large blocks or wedges occur which are difficult to manage without stressed anchors. It is partly due to this possibility that we advise against using the shoring to support significant structural loads. It is a far better approach to use internal columns to transfer building loads to the base of the excavation. If perimeter columns founded above bulk excavation are used for primary structural support, consideration should be given to designing the structure with sufficient redundancy that should one column fail the load could be supported by adjacent columns, at least in the short term.

5.4 Foundations

Foundation conditions at the site are very favourable as the excavation will be taken to a bulk level of RL 2.4m which will likely encounter sandstone ranging from Class II to Class I. We recommend that all major structural loads be transferred to the sandstone bedrock of at least Class II by means of pad and strip footings when encountered at bulk level.

The design Allowable Bearing Pressure (ABP) for footings on Class I sandstone may range up to 12 MPa based on serviceability criteria where settlements of 1% of the footing width are acceptable. For such high bearing pressures however, good practice requires that there be cored boreholes at 50% (or more) of footings and jackhammer holes and spoon testing at the remainder. If a lower allowable bearing pressure of (say) 6 MPa were adopted, there would need to be only localised additional cored boreholes where weaker conditions are identified and spoon testing at (say) one third of the footings and geotechnical inspection of the remainder.

With any excavation, it must be recognised that some geological anomalies may be present, such as faults, joint swarms and igneous intrusions (commonly dykes in Sydney). The majority of these anomalies are vertical or near-vertical features and so are difficult to identify with vertical boreholes.

The allowable bearing pressure of shoring piles which extend to the base of Unit 4a and bear upon a vertical face cut in Unit 4b or 4c sandstone could be taken as 2MPa if there are no adverse defects and the sandstone is of adequate strength. Some vertical load on the shoring is unavoidable but we strongly advise against using the shoring to support major structural elements.

5.5 Dewatering

Dewatering may be necessary to some degree to enable excavation as the water table occurs within the Unit 1 and Unit 2 soils. Such dewatering would most probably involve a planned sequence of excavation to encourage gravity drainage, supplemented with some pumped sumps or crude wells formed by installation of perforated casing in gravel filled pits. Provided that the shoring/cut-off wall works effectively, inflows/recharge will be relatively low. Nevertheless, over time there may be a significant drawdown effect outside the shoring due to leakage below and through the shoring. If the shoring system were to form a perfect cut-off there is a potential for some build-up of water externally. This issue is dealt with in more detail in the hydrogeological report by Jeffery and Katauskas (Ref 22905SWHrpt) dated 26 November 2009 and our seepage analysis report (Ref 22905SDrpt8_Seep) dated December 2013.

5.6 Drainage

The secant pile cut-off wall should permit excavation to be carried out without any substantial effect on groundwater levels in the surrounding area in the short term.

The exposed rock faces will be damp and locally wet to a greater or lesser extent and locally seepage will flow or ‘weep’ from bedding partings and other defects. Any such flows may cause deposition of iron due to chemical changes to the groundwater on exposure and other undesirable effects. These flows can be managed in a variety of ways, or may simply be covered by 'dry' walls built clear from the rock face. If groundwater levels outside the excavation are being drawn down by leakage into the excavation, a recharge system in which the collected water is returned to the ground via infiltration trenches or wells may be considered. Such recharge systems are likely to require some maintenance over their lifetime and thus need to be accessible as required.

Drainage will be required below floor slabs in the lower basement and this normally comprises a grid of gravel drains flowing to sumps from which pumping occurs or a blanket drain below the whole of the floor. The spacing of subfloor drains varies with the nature of the flows - as a guide, a grid or herringbone pattern with a spacing of about 6m is a reasonable starting point, but this may be varied on site when conditions can be observed directly. An alternative to reduce the risk of dampness is to place a gravel blanket about 100mm in thickness below the slabs, with a vapour barrier above the gravel. Gravel should be clean, hard, durable single sized gravel of 10mm to 20mm in size.

5.7 Slab On Grade Construction

In general terms, construction of floor slabs over the Unit 4c or Unit 4b bedrock would require only a clean-up of debris to expose the rock and placement of a levelling course of sand or gravel of nominal thickness. Sand is not preferred for this purpose due to the risk of 'pumping' at slab joints, particularly if seepage occurs. Roadbase (DGB20) is preferred and should be compacted in place. Single size, clean, hard, durable gravel placed as a drainage blanket is satisfactory, provided only light vehicles can use the pavement.

Externally, slabs and pavements will require specific consideration once further details of the design requirements and ground conditions have been established.

5.8 Earthquake Design Parameters

Based on the advice provided in AS 1170.4-2007 "Structural Design Actions Part 4: Earthquake Actions the site may be assigned a Class B_e (Rock) classification and a Hazard Factor (Z) of 0.08.

With regards to the classification, this assumes that all of the structure is founded on rock, inside and outside the retention system. Obviously the retention system is in contact with soils so liquefaction of the soils will have an effect on the earth pressures behind the walls; however the retention system would be founded in rock and tied into the main structure, which will also be wholly supported on rock.

5.9 Geotechnical Modelling

The proposed construction will affect surrounding structures and other features such as roads and drains to some degree. In order to demonstrate that the construction effects are within a range not expected to result in distress or other detrimental environmental outcomes, the following may be necessary or advisable:

1. Vibration Monitoring: Primarily to check that the effects of large rock breakers lie within acceptable limits.

2. Deflection Monitoring: Primarily to monitor the movement of the shoring systems/surrounding ground to confirm predicted movements are not exceeded to protect vulnerable structures such as ovoid drains. This monitoring can include accurate survey and/or inclinometers.
3. Groundwater Monitoring: Monitoring should be carried out around the external perimeter of the excavation to demonstrate that the water table is not adversely affected. Monitoring wells should be installed for this purpose prior to excavation commencing. The volume of seepage flows into the excavation should also be monitored. Remedial works may be indicated if flows are excessive.

6 GENERAL COMMENTS

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. In the event that any of the construction phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and JK Geotechnics accept no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly tested, inspected and documented.

Occasionally, the subsurface conditions between the completed boreholes may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact this office.

This report provides advice on geotechnical aspects for the proposed civil and structural design. As part of the documentation stage of this project, Contract Documents and Specifications may be prepared based on our report. However, there may be design features we are not aware of or have not commented on for a variety of reasons. The designers should satisfy themselves that all the necessary advice has been obtained. If required, we could be commissioned to review the geotechnical aspects of contract documents to confirm the intent of our recommendations has been correctly implemented.

If there is any change in the proposed development described in this report then all recommendations should be reviewed.

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. Copyright in this report is the property of JK Geotechnics. We have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.

115 Wicks Road
Macquarie Park, NSW 2113
PO Box 976
North Ryde, BC 1670
Telephone: 02 9888 5000
Facsimile: 02 9888 5001

SOIL TEST SERVICES
ABN 43 002 145 173

TABLE A
POINT LOAD STRENGTH INDEX TEST REPORT

Client: JK Geotechnics
Project: Proposed Block 8
Location: O' Connor Street, Chippendale, NSW

Ref No: 22905SD-8
Report: A
Report Date: 3/10/2013
Page 1 of 3

BOREHOLE NUMBER	DEPTH m	$I_{S(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
601	6.22-6.26	0.4	8
	6.73-6.78	0.7	15
	7.03-7.07	0.4	8
	7.77-7.80	1.1	22
	8.23-8.27	1.3	25
	8.72-8.77	1.5	31
	9.18-9.23	1.7	34
	9.72-9.77	1.6	31
	10.19-10.74	1.8	36
	10.76-10.80	2.2	44
	11.02-11.06	1.8	35
	11.73-11.78	1.8	35
	12.21-12.25	1.4	28
	12.73-12.77	1.1	21
	13.21-13.26	1.2	24
	13.73-13.77	1.3	26
	14.16-14.20	1.2	25
	14.68-14.71	1.7	34
602	6.85-6.89	1.8	35
	7.28-7.33	2.5	50
	7.81-7.85	1.7	33
	8.29-8.33	1.8	35
	8.81-8.85	1.6	33
	9.28-9.32	1.6	31
	9.81-9.85	1.4	28
	10.28-10.32	1.7	34

NOTES:SEE PAGE 3 OF 3

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SOIL TEST SERVICES
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TABLE A
POINT LOAD STRENGTH INDEX TEST REPORT

Client: JK Geotechnics
Project: Proposed Block 8
Location: O' Connor Street, Chippendale, NSW

Ref No: 22905SD-8
Report: A
Report Date: 3/10/2013
Page 2 of 3

BOREHOLE NUMBER	DEPTH m	$I_{S(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
602	10.79-10.83	1.5	30
	11.15-11.20	1.4	28
	11.70-11.74	1.4	28
	12.16-12.19	0.2	5
	12.88-12.92	2.2	44
	13.19-13.23	1.7	33
	13.74-13.78	0.4	7
	14.25-14.29	1.7	34
	14.79-14.83	1.4	28
	15.26-15.30	1.6	32
603	6.30-6.35	0.9	18
	6.81-6.84	1.8	35
	7.30-7.34	1.4	27
	7.95-8.00	2.0	40
	8.46-8.50	1.9	38
	8.96-9.00	2.3	45
	9.45-9.50	1.8	36
	9.95-10.00	2.6	51
	10.49-10.53	2.5	50
	10.96-11.00	1.7	34
	11.49-11.54	1.5	30
	12.00-12.04	1.5	29
	12.48-12.53	1.2	24
	13.00-13.04	1.2	24
	13.43-13.47	1.9	38
	14.17-14.22	0.07	1
	14.84-14.88	3.2	64

NOTES:SEE PAGE 3 OF 3

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Page 3 of 3

BOREHOLE NUMBER	DEPTH m	$I_{S(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
604	6.24-6.27	1.7	33
	6.73-6.78	0.9	18
	7.31-7.35	1.8	36
	7.80-7.84	1.6	31
	8.32-8.36	1.9	39
	8.80-8.85	1.7	34
	9.32-9.36	2.6	53
	9.81-9.85	2.6	52
	10.32-10.36	1.7	34
	10.80-10.84	1.5	31
	11.32-11.36	1.7	34
	11.80-11.84	1.3	27
	12.46-12.50	1.5	30
	12.95-13.00	1.6	32
	13.20-13.23	0.4	8
	13.68-13.72	1.6	33
	14.29-14.33	2.4	47
	14.87-14.91	1.9	37

NOTES:

1. In the above table testing was completed in the Axial direction.
2. The above strength tests were completed at the 'as received' moisture content.
3. Test Method: RMS T223.
4. For reporting purposes, the $I_{S(50)}$ has been rounded to the nearest 0.1 MPa
5. The Estimated Unconfined Compressive Strength was calculated from the point load Strength Index by the following approximate relationship and rounded off to the nearest whole number :
   U.C.S. = 20 $I_{S(50)}$

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.envirolabservices.com.au

CERTIFICATE OF ANALYSIS 98509

Client:
JK Geotechnics
PO Box 976
North Ryde BC
NSW 1670

Attention: A Mitchell

Sample log in details:

Your Reference:	**22905SD_8, Chippendale**	
No. of samples:	3 Soils	
Date samples received / completed instructions received	04/10/2013	/ 04/10/2013

Analysis Details:

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	14/10/13	/ 12/10/13
Date of Preliminary Report:	Not issued	

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Accredited for compliance with ISO/IEC 17025. **Tests not covered by NATA are denoted with *.**

Results Approved By:

Jacinta Hurst
Laboratory Manager

ACCREDITED FOR TECHNICAL COMPETENCE

Miscellaneous Inorg - soil				
Our Reference:	UNITS	98509-1	98509-2	98509-3
Your Reference	-------------	BH601	BH602	BH603
Depth	------------	1.5-1.95	4.5-4.9	3.0-3.35
Date Sampled		1/10/2013	1/10/2013	1/10/2013
Type of sample		Soil	Soil	Soil
Date prepared	-	09/10/2013	09/10/2013	09/10/2013
Date analysed	-	09/10/2013	09/10/2013	09/10/2013
pH 1:5 soil:water	pH Units	7.8	5.4	8.5
Chloride, Cl 1:5 soil:water	mg/kg	2	10	16
Sulphate, SO4 1:5 soil:water	mg/kg	39	33	38

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA 22nd ED, 4500-H+.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA 22nd ED, 4110 -B.

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			09/10/2013	[NT]	[NT]	LCS-1	09/10/2013
Date analysed	-			09/10/2013	[NT]	[NT]	LCS-1	09/10/2013
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	LCS-1	99%
Chloride, Cl 1:5 soil:water	mg/kg	2	Inorg-081	<2	[NT]	[NT]	LCS-1	103%
Sulphate, SO4 1:5 soil:water	mg/kg	2	Inorg-081	<2	[NT]	[NT]	LCS-1	116%

Report Comments:

Asbestos ID was analysed by Approved Identifier:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job

INS: Insufficient sample for this test	PQL: Practical Quantitation Limit	NT: Not tested
NA: Test not required	RPD: Relative Percent Difference	NA: Test not required
<: Less than	>: Greater than	LCS: Laboratory Control Sample

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics and 10-140% for SVOC and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No.
601
1/3

Client: FRASERS PROPERTY
Project: PROPOSED DEVELOPMENT AT BLOCK 8
Location: O'CONNOR STREET, CHIPPENDALE, NSW

Job No. 22905SD_8
Method: SPIRAL AUGER JK350
R.L. Surface: ≅ 12.3m
Date: 30-9-13
Datum: AHD
Logged/Checked by: D.W./A.M.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Gravelly sand, fine to medium grained, grey, fine to medium grained igneous gravel.	M			GRAVEL COVER
				■	N = 13 16,9,4				FILL: Silty sand, medium grained, orange brown, with fine to medium grained sandstone gravel, trace of clay fines.				APPEARS POORLY COMPACTED
ON COMPLETION OF CORING				■	N = 29 8,13,16	1			as above, but grey.				APPEARS WELL COMPACTED
						2		SP	SAND: medium grained, grey, trace of silt fines.	M	(L)		AEOLIAN
AFTER 4.5 HRS									as above, but light grey.				
AFTER 20 HRS				■	N = 9 14,7,2	3				W	L		
								SC	CLAYEY SAND: medium grained, orange brown.				
				■	N > 15 7,8,7/50mm REFUSAL	4		CL/SC	SANDY CLAY/CLAYEY SAND: medium plasticity, fine grained, light grey mottled orange brown and red brown, fine grained sand, with fine to medium grained red brown ironstone gravel.	MC>PL / W	VSt/ MD	280	RESIDUAL
						5		-	SANDSTONE: medium grained, red brown, light grey and orange brown, with iron indurated bands and low strength bands.	DW	M		MODERATE 'TC' BIT RESISTANCE WITH LOW BANDS
						6			REFER TO CORED BOREHOLE LOG				
						7							

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Job No. 22905SD_8 BH601 START CORING AT 6.13m
6
7
8
9
10
11
12
13
14
EOH
14.95m

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

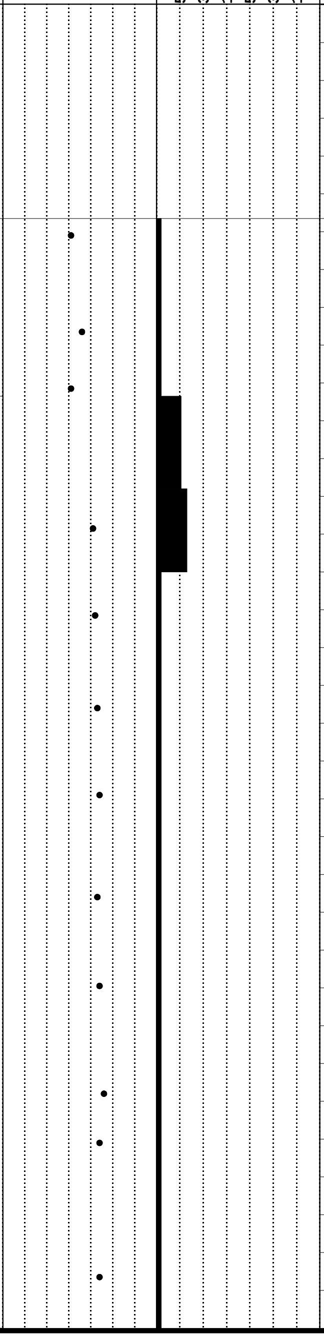
CORED BOREHOLE LOG

Borehole No.
601
2/3

Client: FRASERS PROPERTY
Project: PROPOSED DEVELOPMENT AT BLOCK 8
Location: O'CONNOR STREET, CHIPPENDALE, NSW

Job No. 22905SD_8 **Core Size:** NMLC **R.L. Surface:** ≅ 12.3m
Date: 30-9-13 **Inclination:** VERTICAL **Datum:** AHD
Drill Type: JK350 **Bearing:** - **Logged/Checked by:** D.W./A.M.

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ EL VL L M H VH EH	DEFECT SPACING (mm) 500 300 100 50 30 10	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
		5								
		6		START CORING AT 6.13m						
				SANDSTONE: medium grained, red brown, orange brown and light grey.	DW	M				
				as above, but light grey, with dark grey laminae, cross bedded at 5-15°.	SW					
		7				H			- CS, 0°, 3mm.t	
									- CS, 0°, 3mm.t	
		8							- XWS, 0°, 1mm.t	
					FR					
FULL RET-URN		9								
		10								
		11							- J, 75°, P, R	



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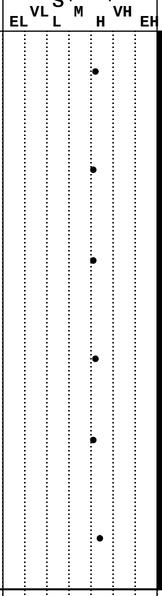
CORED BOREHOLE LOG

Borehole No.
601
3/3

Client: FRASERS PROPERTY
Project: PROPOSED DEVELOPMENT AT BLOCK 8
Location: O'CONNOR STREET, CHIPPENDALE, NSW

Job No. 22905SD_8
Core Size: NMLC
R.L. Surface: ≅ 12.3m
Date: 30-9-13
Inclination: VERTICAL
Datum: AHD
Drill Type: JK350
Bearing: -
Logged/Checked by: D.W./A.M.

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ EL VL L M H VH EH	DEFECT SPACING (mm) 500 300 100 50 30 10	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific / General
FULL RET-URN				SANDSTONE: fine to medium grained, light grey with dark grey laminae, cross bedded at 0-5°.	FR	H			
		13							
		14							- XWS, 0°, 10mm.t
		15							- J, 75°, P, R
				END OF BOREHOLE AT 14.95m					PVC STANDPIPE INSTALLED TO 14.95m DEPTH. SLOTTED FROM 2.95m TO 11.95m DEPTH, SEALED WITH GATIC COVER
		16							
		17							
		18							



BOREHOLE LOG

Borehole No.
602
1/3

Client: FRASERS PROPERTY
Project: PROPOSED DEVELOPMENT AT BLOCK 8
Location: O'CONNOR STREET, CHIPPENDALE, NSW

Job No. 22905SD_8
Date: 30-9-13
Method: SPIRAL AUGER
JK350
Logged/Checked by: D.W./A.M.
R.L. Surface: ≅ 12.3m
Datum: AHD

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Gravelly sand, fine to medium grained, grey, fine to medium grained igneous gravel.	D			GRASS COVER
				■	N = 34 9,13,21				FILL: Silty sand, medium grained, orange brown, with fine to medium grained sandstone gravel.	M			APPEARS WELL COMPACTED
						1			as above, but dark grey, with fine to medium grained igneous and sandstone gravel, gravel sized concrete fragments and tile fragments.				
				■	N = 16 6,8,8	2		SP	SAND: medium grained, grey.	M	MD		AEOLIAN
▼				■	N = 16 5,7,9	3				W			
						4		SM	SILTY SAND: medium gained, green grey, trace of clay fines.				ORGANIC ODOUR
				■	N > 10 14,5, 5/100mm REFUSAL	5		CL-CH	BANDED SILTY CLAY and CLAYEY SAND: medium to high plasticity, grey, medium grained, yellow brown and orange brown, with clay seams and fine to medium grained ironstone gravel.	MC>PL/ W	(F)/ MD		RESIDUAL
						6		-	SANDSTONE: fine to medium grained, red brown, orange brown and light grey.	DW	VL		VERY LOW 'TC' BIT RESISTANCE
										SW	M		MODERATE 'TC' BIT RESISTANCE
						7			REFER TO CORED BOREHOLE				


Job No 22905SD_8 BH602 START CORING AT 6.79m
7
8
9
10
11
12
13
14
15
END OF BH AT 15.54m

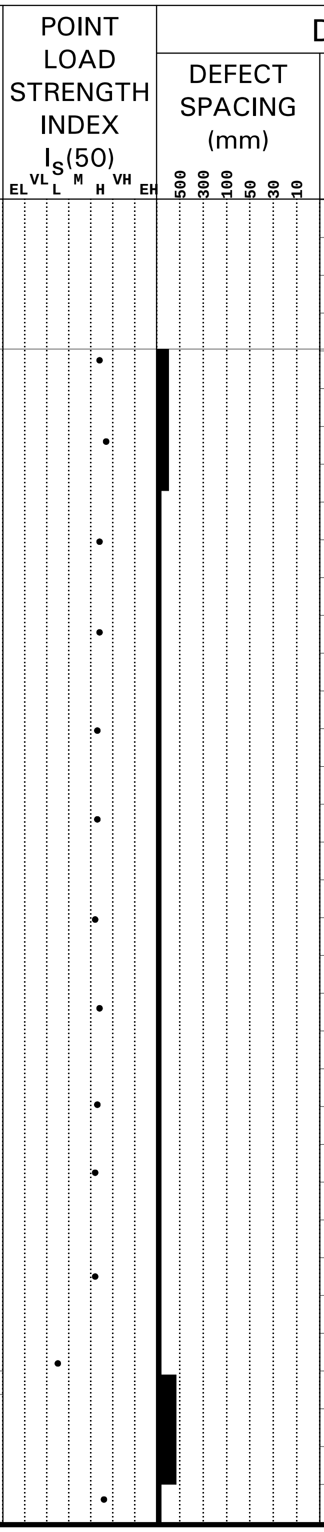
CORED BOREHOLE LOG

Borehole No.
602
2/3

Client: FRASERS PROPERTY
Project: PROPOSED DEVELOPMENT AT BLOCK 8
Location: O'CONNOR STREET, CHIPPENDALE, NSW

Job No. 22905SD_8
Core Size: NMLC
R.L. Surface: ≅ 12.3m
Date: 30-9-13
Inclination: VERTICAL
Datum: AHD
Drill Type: JK350
Bearing: -
Logged/Checked by: D.W./A.M.

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
		6		START CORING AT 6.79m				
FULL RETURN		7		SANDSTONE: medium grained, light grey, with dark grey laminae, cross bedded at 5-15°.	FR	H		
							- XWS, 0°, 5mm.t - LOW STRENGTH BAND. 100mm.t	
		8						
		9					- J, 75°, P, R	
		10						
		11		as above, but fine to medium grained, cross bedded at 0-5°.				
		12						
					SW	L	- XWS, 0°, 3mm.t	
					FR	H		
				as above, but fine grained.			- XWS, 0°, 25mm.t	



JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

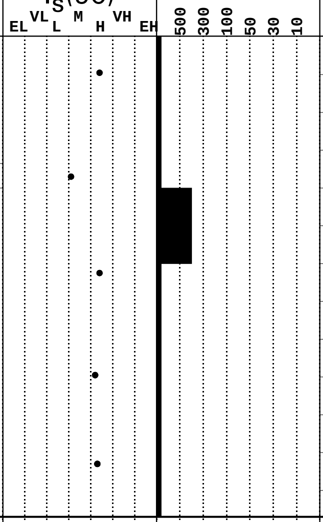
CORED BOREHOLE LOG

Borehole No.
602
3/3

Client: FRASERS PROPERTY
Project: PROPOSED DEVELOPMENT AT BLOCK 8
Location: O'CONNOR STREET, CHIPPENDALE, NSW

Job No. 22905SD_8
Core Size: NMLC
R.L. Surface: ≅ 12.3m
Date: 30-9-13
Inclination: VERTICAL
Datum: AHD
Drill Type: JK350
Bearing: -
Logged/Checked by: D.W./A.M.

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$	DEFECT DETAILS: DEFECT SPACING (mm)	DEFECT DETAILS: DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
				SANDSTONE: fine grained, grey and light grey, with dark grey laminae, cross bedded at 0-5°.	FR	H				
					SW	M				
					FR	H			- XWS, 0°, 1mm.t	
		14								
									- XWS, 0°, 1mm.t	
				as above, but fine to medium grained, grey.						
		15								
				END OF BOREHOLE AT 15.54m						
		16								
		17								
		18								
		19								



JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No.
603
1/3

Client: FRASERS PROPERTY
Project: PROPOSED DEVELOPMENT AT BLOCK 8
Location: O'CONNOR STREET, CHIPPENDALE, NSW

Job No. 22905SD_8
Date: 1-10-13
Method: SPIRAL AUGER
JK350
R.L. Surface: ≅ 12.3m
Datum: AHD
Logged/Checked by: D.W./A.M.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Gravelly sand, fine to medium grained, grey, fine to medium grained igneous gravel.	D			GRAVEL COVER
				■	N = 31 8,10,21				FILL: Silty sand, fine to medium grained, orange brown and light grey, with fine to medium grained sandstone gravel, trace of clay fines.	M			APPEARS WELL COMPACTED
						1							
				■	N > 29 21,22, 7/50mm REFUSAL				FILL: Silty sand, medium grained, grey, with fine to medium grained igneous gravel, brick and plastic fragments.				
ON COMPLETION OF AUGERING ▼						2							
								SM	SILTY SAND: fine to medium grained, yellow brown.	W	MD		
▶				■	N = 21 7,10,11	3			as above, but green grey, trace of clay fines.				ORGANIC ODOUR
						4		CL/SC	SANDY CLAY/CLAYEY SAND: medium plasticity, medium grained, red brown, orange brown and light grey.	MC>PL/ W	VSt /MD		
				■	N = 14 3,6,8							410 100 230	
						5		-	SANDSTONE: medium grained, red brown, orange brown and light grey.	DW	VL		VERY LOW 'TC' BIT RESISTANCE
				■							M		MODERATE RESISTANCE
						6			as above, but light grey.	SW			
									REFER TO CORED BOREHOLE LOG				
						7							


Job No 22905SD_8
BH603
START CORING AT 6.09m
6
7
8
9
10
11
12
13
14

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

CORED BOREHOLE LOG

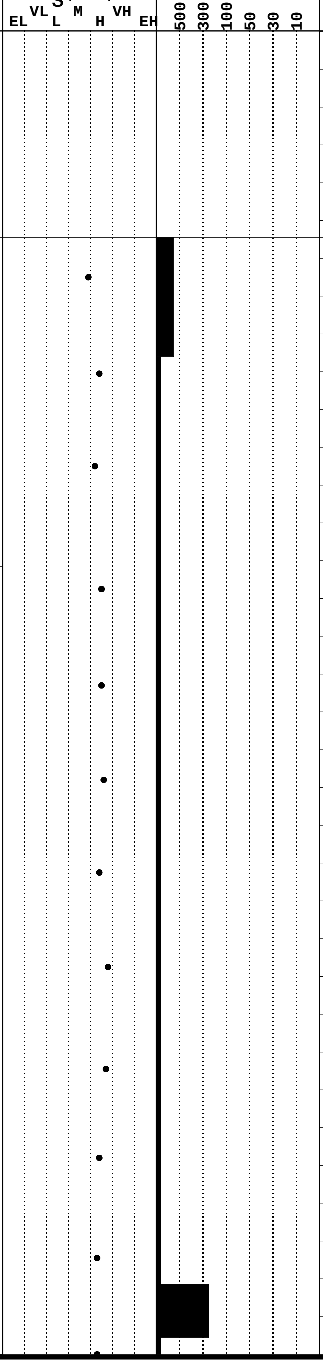
Borehole No.
603
2/3

Client: FRASERS PROPERTY
Project: PROPOSED DEVELOPMENT AT BLOCK 8
Location: O'CONNOR STREET, CHIPPENDALE, NSW

Job No. 22905SD_8 **Core Size:** NMLC **R.L. Surface:** ≅ 12.3m
Date: 1-10-13 **Inclination:** VERTICAL **Datum:** AHD
Drill Type: JK350 **Bearing:** - **Logged/Checked by:** D.W./A.M.

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
		5						
		6		START CORING AT 6.09m				
				SANDSTONE: medium grained, light grey, with dark grey laminae, cross bedded at 0-15°.	SW	M-H		
							- XWS, 0°, 1mm.t	
		7						
							- XWS, 0°, 3mm.t	
		8		as above, but cross bedded at 15°.	FR	H		
		9						
		10						
FULL RET-URN								
		11						
				as above, but fine to medium grained, cross bedded at 0-5°.				
							- J, 70°, P, R	
							- J, 70, P, R	

POINT LOAD STRENGTH INDEX $I_s(50)$ — DEFECT SPACING (mm)



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15
END OF BH603 AT 15.15m

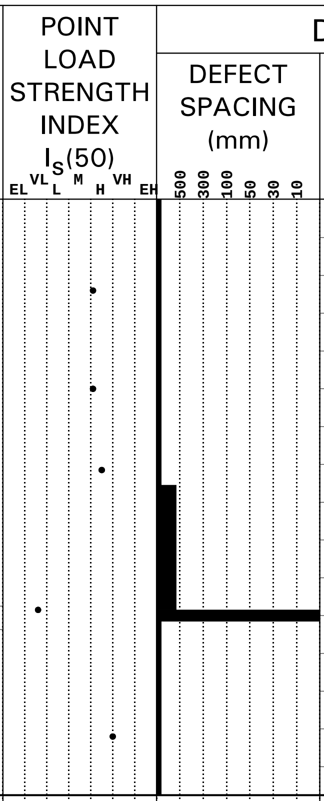
CORED BOREHOLE LOG

Borehole No.
603
3/3

Client: FRASERS PROPERTY
Project: PROPOSED DEVELOPMENT AT BLOCK 8
Location: O'CONNOR STREET, CHIPPENDALE, NSW

Job No. 22905SD_8
Date: 1-10-13
Drill Type: JK350
Core Size: NMLC
Inclination: VERTICAL
Bearing: -
R.L. Surface: ≅ 12.3m
Datum: AHD
Logged/Checked by: D.W./A.M.

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	DEFECT DETAILS – DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
				SANDSTONE: fine to medium grained, light grey, with dark grey laminae, cross bedded at 0-5°.	FR	H		
		13					- XWS, 0°, 15mm.t	
		14			DW	VL	- XWS, 60mm.t - CS, 0°, 2mm.t	
				as above, but fine grained, light grey and grey.	FR	H-VH		
		15					- VL STRENGTH BAND, 25mm.t	
				END OF BOREHOLE AT 15.15m				
		16						
		17						
		18						



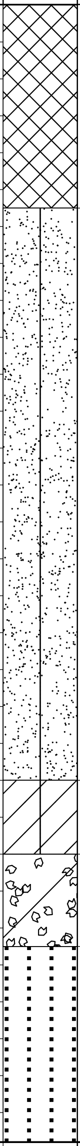
JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No.
604
1/3

Client: FRASERS PROPERTY
Project: PROPOSED DEVELOPMENT AT BLOCK 8
Location: O'CONNOR STREET, CHIPPENDALE, NSW

Job No. 22905SD_8
Date: 1-10-13
Method: SPIRAL AUGER
JK350
R.L. Surface: ≅ 12.4m
Datum: AHD
Logged/Checked by: D.W./A.M.



Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Gravelly sand, fine to medium grained, brown, fine to medium grained igneous gravel.	D			GRAVEL COVER
									FILL: Gravelly silty sand, fine to medium grained, orange brown, fine to medium grained sandstone gravel.	M			
						1			FILL: Gravelly sand, fine to medium grained, grey, fine to medium grained sandstone and igneous gravel, with brick and concrete fragments.				
								SM	SILTY SAND: medium grained, dark grey.	M	MD		AEOLIAN
				■	N = 34 15,17,17								
						2			as above, but brown.				
									as above, but grey.				
▶				■	N = 22 4,10,12	3				W			
						4							
								CL-CH	SILTY CLAY: medium to high plasticity, yellow brown and red brown, with fine to medium grained ironstone gravel.	MC>PL	(F)		
				■	N = 35 10,19,16	5		GC	CLAYEY GRAVEL: fine to medium grained ironstone, red brown.	M	D		
						6		-	SANDSTONE: medium grained, red brown and yellow brown.	DW	M		MODERATE TC' BIT RESISTANCE
						7			REFER TO CORED BOREHOLE LOG				


Job No 22905SD_8
BH604
START CORING AT 6.16m
6
7
8
9
10
11
12
13
14

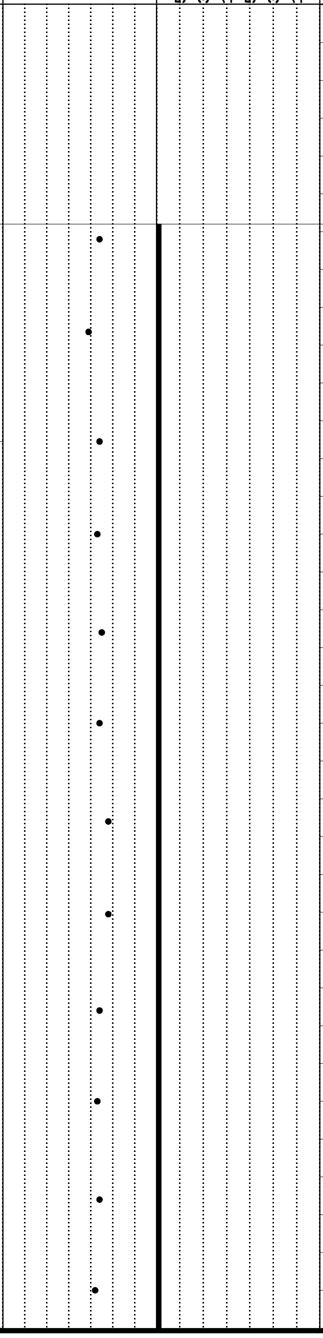
CORED BOREHOLE LOG

Borehole No.
604
2/3

Client: FRASERS PROPERTY
Project: PROPOSED DEVELOPMENT AT BLOCK 8
Location: O'CONNOR STREET, CHIPPENDALE, NSW

Job No. 22905SD_8
Core Size: NMLC
R.L. Surface: ≅ 12.4m
Date: 1-10-13
Inclination: VERTICAL
Datum: AHD
Drill Type: JK350
Bearing: -
Logged/Checked by: D.W./A.M.

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ EL VL L M H VH EH	DEFECT SPACING (mm) 500 300 100 50 30 10	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
		5								
		6		START CORING AT 6.16m						
FULL RET-URN				SANDSTONE: medium grained, red brown, orange brown and yellow brown, with iron indurated bands.	DW	M-H			- Be, 0°, P, R, IS	
					SW					
				SANDSTONE: medium grained, light grey, with dark grey laminae, cross bedded at 5-15°.						
		7			FR	H				
				as above, but cross bedded at 15°.						
		8								
		9								
		10		as above but cross bedded at 0-5°.						
		11								




15
END OF BH604 AT 15.41m

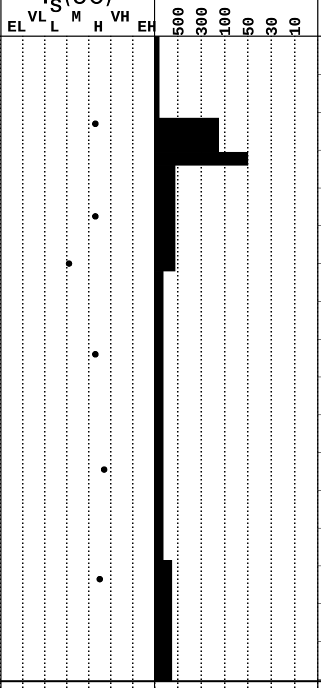
CORED BOREHOLE LOG

Borehole No.
604
3/3

Client: FRASERS PROPERTY
Project: PROPOSED DEVELOPMENT AT BLOCK 8
Location: O'CONNOR STREET, CHIPPENDALE, NSW

Job No. 22905SD_8
Date: 1-10-13
Drill Type: JK350
Core Size: NMLC
Inclination: VERTICAL
Bearing: -
R.L. Surface: ≅ 12.4m
Datum: AHD
Logged/Checked by: D.W./A.M.

POINT LOAD STRENGTH INDEX $I_s(50)$ / DEFECT DETAILS – DEFECT SPACING (mm)



Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	DEFECT DETAILS – DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
				SANDSTONE: medium grained, grey and light grey, with dark grey laminae, bedded at 0-5°.	FR	H		
					SW		- XWS, 0°, 12mm.t	
							- XWS, 0°, 15mm.t - XWS, 0°, 2mm.t	
		13						
					FR	L-M H	- XWS, 0°, 2mm.t	
FULL RET-URN								
		14					- LOW STRENGTH BAND, 5mm.t	
							- XWS, 0°, 2mm.t	
		15						
				END OF BOREHOLE AT 15.41m			PVC STANDPIPE INSTALLED TO 15.41m DEPTH, SLOTTED FROM 12.41m TO 3.41m, BACKFILLED WITH SAND AND SPOIL, SEALED WITH GATIC COVER AT SURFACE	
		16						
		17						
		18						

BOREHOLE LOG

Borehole No.
JK2
1/1

Client: FRASERS BROADWAY
Project: PROPOSED DETENTION TANK
Location: CORNER O'CONNOR AND CARLTON STREETS, CHIPPENDALE, NSW

Job No. 22905S
Date: 25-5-09
Method: SPIRAL AUGER JK300
R.L. Surface: ≈ 14.0m
Datum: AHD
Logged/Checked by: J.C./

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
				■		0	SP	SAND: fine to medium grained, brown and orange brown, with a trace of silt fines.	M	VL-L		
				■	N = 5 2,2,3					L		
						1	SP	SAND: fine to medium grained, light grey.				
				■	N = 10 4,5,5							
						2				MD		
				■	N = 22 7,10,12	3						
▶								as above, but light grey and yellow brown.	W			
						4	CL	SILTY CLAY: low plasticity, brown mottled orange brown and red brown, with L strength sandstone and ironstone gravel.	MC>PL	F-St	-	
				■	N > 18 2,18/ 150mm REFUSAL			Inferred ironstone band.			120 130 70	
						5		-				
							-	SANDSTONE: fine to coarse grained, red brown.	DW	L-M	-	LOW TO MODERATE 'TC' BIT RESISTANCE
						6		REFER TO CORED BOREHOLE LOG				
						7						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JOB No. 229055 BH2 START CORING AT 5.95m
6
7
8
END OF BH AT 8.47m

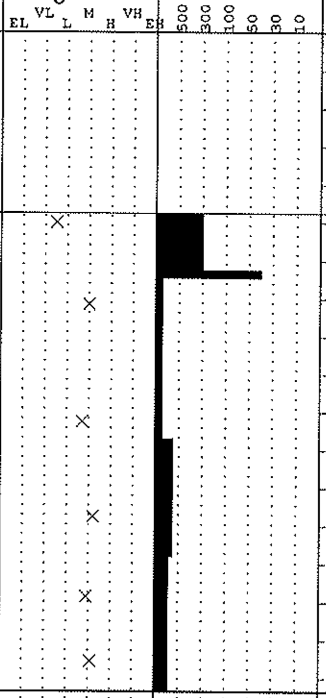
CORED BOREHOLE LOG

Borehole No.
JK2
2/2

Client: FRASERS BROADWAY
Project: PROPOSED DETENTION TANK
Location: CORNER O'CONNOR AND CARLTON STREETS, CHIPPENDALE, NSW

Job No. 22905S
Core Size: NMLC
R.L. Surface: ≈ 14.0m
Date: 25-5-09
Inclination: VERTICAL
Datum: AHD
Drill Type: JK300
Bearing: -
Logged/Checked by: J.C./

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$	DEFECT SPACING (mm)	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
		5		START CORING AT 5.95m						
FULL RET- - URN		6		SANDSTONE: fine to coarse grained, red brown and orange brown.	DW	M-H			- CS, 20mm.t - CS, 10mm.t	
		7		SANDSTONE: fine to medium grained, light grey, with dark grey sandstone laminae, bedded at 0-15°.	SW				- CS, 5mm.t - CS, 30mm.t	
		8								
				END OF BOREHOLE AT 8.47m						
		9								
		10								
		11								



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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No.
JK4
1/2

Client: FRASERS BROADWAY
Project: PROPOSED DETENTION TANK
Location: CORNER O'CONNOR AND CARLTON STREETS, CHIPPENDALE, NSW

Job No. 22905S
Date: 26-5-09
Method: SPIRAL AUGER
JK300
R.L. Surface: ≈ 11.5m
Datum: AHD
Logged/Checked by: J.C./

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Sand, fine to medium grained, light brown, with a trace of fine to medium grained sandstone gravel and root fibres.	M			APPEARS POORLY COMPACTED
					N = 14 4,7,7			SP	SAND: fine to medium grained, light grey and dark grey.	M	MD	-	
▶						1				W			
					N = 24 7,10,14								
						2							
								SM	SILTY SAND: fine to medium grained, red brown.				
								CL	SILTY CLAY: low plasticity, dark grey.	MC>PL	(VS)	-	
					N = 4 0,2,2	3			SILTY CLAY: low plasticity, grey mottled brown.		F	50 70 70	RESIDUAL
								CH	SILTY CLAY: high plasticity, red brown mottled grey and brown.		St- VSt	250 190 140	
						4							
								-	SANDSTONE: fine to medium grained, red brown, orange brown and light grey. REFER TO CORED BOREHOLE LOG	DW	L-M	-	LOW TO MODERATE 'TC' BIT RESISTANCE
						5							
						6							
						7							


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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
JOB No. 22905S BH4 START CORING AT 4.25 m
4
CORE LOSS 0.23m
5
6
7
END OF BOREHOLE AT 7.2m

CORED BOREHOLE LOG

Borehole No.
JK4
2/2

Client: FRASERS BROADWAY
Project: PROPOSED DETENTION TANK
Location: CORNER O'CONNOR AND CARLTON STREETS, CHIPPENDALE, NSW

Job No. 22905S
Date: 26-5-09
Drill Type: JK300
Core Size: NMLC
Inclination: VERTICAL
Bearing: -
R.L. Surface: ≈ 11.5m
Datum: AHD
Logged/Checked by: J.C./

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ EL VL L M H VH EH	DEFECT SPACING (mm) 500 300 100 50 30 10	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
		4		START CORING AT 4.25m						
FULL RET-URN				CORE LOSS 0.23m						
				SANDSTONE: fine to coarse grained, red brown, orange brown and light grey.	DW	M L	× ×			
		5 6 7		SANDSTONE: fine to medium grained, light grey, with dark grey sandstone laminae, bedded at 0-15°.	SW	M-H H	× × × × ×		- CS, 20mm.t - CS, 10mm.t	
		8 9 10		END OF BOREHOLE AT 7.2m						

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No.
205
1/3

Client: FRASERS PROPERTY
Project: PROPOSED DEVELOPMENT AT BLOCK 4S
Location: CNR. ABERCROMBIE STREET & IRVING STREET, CHIPPENDALE, NSW

Job No. 22905S
Date: 31-1-13
Method: SPIRAL AUGER
JK305
R.L. Surface: ≈ 11.2m
Datum: AHD
Logged/Checked by: D.W./A.M

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Gravelly silty sand, fine to medium grained, dark grey, fine to coarse grained igneous and sandstone gravel, with geofabric fragments.	M			APPEARS POORLY COMPACTED
					N = 4 2,3,1				FILL: Silty sand, fine to medium grained, dark grey, with fine to medium grained igneous gravel, trace of clay and ash.				
						1			as above, but brown.				
					N = 8 4,3,5				as above, but orange brown, dark grey and light grey, with fine to medium grained sandstone gravel, trace of brick fragments and ash.				
						2		SM	SILTY SAND: fine to medium grained, dark grey.	M	L		
▶										W			
					N = 6 3,3,3	3							MONITORING WELL INSTALLED TO 4.93m DEPTH, SLOTTED FROM 4.93m TO1.93m. PVC CASING 1.93m TO SURFACE, BACKFILLED WITH SAND FROM 4.93m TO 1.6m, BENTONITE FROM 1.6m TO SURFACE SEALED WITH MONUMENT AND CAP
						4							
					N = 0 0,0,0			CL-CH	SILTY CLAY: medium to high plasticity, grey.	MC>PL	S	40 40 50	
						5		-	SANDSTONE: fine to medium grained, with medium strength bands.	XW-DW	EL-VL		VERY LOW TO LOW 'TC' BIT RESISTANCE BANDED
						6			REFER TO CORED BOREHOLE LOG				
						7							

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CLIENT: FRASERS PROPERTY

PROJECT: PROPOSED DEVELOPMENT AT BLOCK 4S

LOCATION: CORNER OF ABERCROMBIE STREET AND IRVING STREET, CHIPPENDALE, NSW

Job. No 22905SD BH205 START CORING AT 6.16m

END OF BH205 AT 12.19m

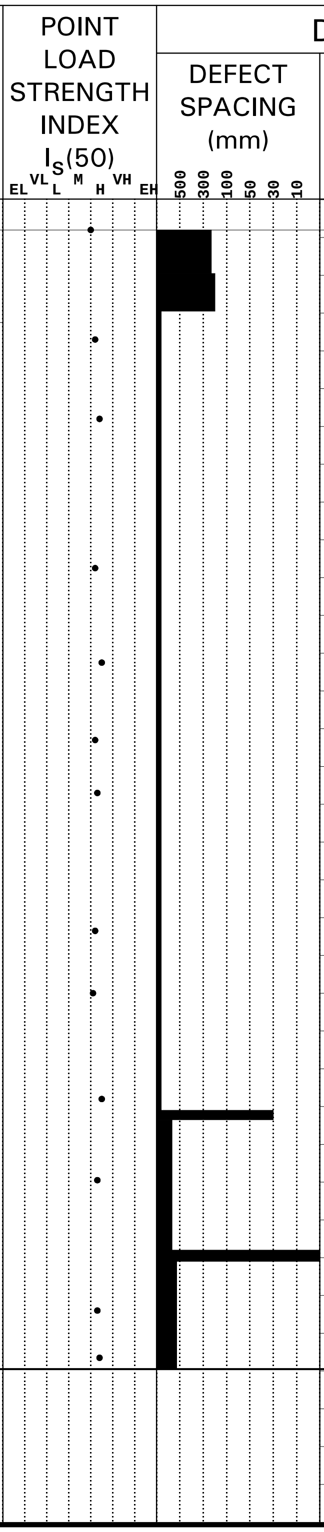
CORED BOREHOLE LOG

Borehole No.
205
2/3

Client: FRASERS PROPERTY
Project: PROPOSED DEVELOPMENT AT BLOCK 4S
Location: CNR. ABERCROMBIE STREET & IRVING STREET, CHIPPENDALE, NSW

Job No. 22905S
Core Size: NMLC
R.L. Surface: ≈ 11.2m
Date: 31-1-13
Inclination: VERTICAL
Datum: AHD
Drill Type: JK305
Bearing: -
Logged/Checked by: D.W./A.M

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
		6		START CORING AT 6.16m				
				SANDSTONE: fine to medium grained, orange brown.	DW	M-H		
				SANDSTONE: fine to medium grained, light grey, with grey laminae, cross bedded at 0-20°.	SW		- Be, 0°, P, R, IS - XWS, 0°, 40mm.t	
					FR	H		
		7						
		8					- 2x J, 70-80°, P, R	
FULL RET-URN		9						
		10						
					SW		- CS, 0°, 20mm.t - CS, 0°, 20mm.t	
		11		as above, but fine grained.				
							- CS, 0°, 60mm.t	
		12						
				END OF BOREHOLE AT 12.19m				



JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No.
207
1/3

Client: FRASERS PROPERTY
Project: PROPOSED DEVELOPMENT AT BLOCK 4S
Location: CNR. ABERCROMBIE STREET & IRVING STREET, CHIPPENDALE, NSW

Job No. 22905S
Date: 30-1-13
Method: SPIRAL AUGER JK305
Logged/Checked by: D.W./A.M
R.L. Surface: ≈ 11.9m
Datum: AHD

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Gravelly silty sand, fine to medium grained, brown, fine to coarse grained igneous and sandstone gravel, with concrete fragments.	M			APPEARS MODERATELY COMPACTED
				■	N = 23 15,14,9				as above, but grey.				
						1							
									FILL: Silty sand, fine to medium grained, orange brown and grey, trace of fine to medium grained ironstone gravel.				APPEARS POORLY COMPACTED
				■	N = 10 5,4,6								
ON COMPLETION OF AUGERING ▼						2		SM	SILTY SAND: fine to medium grained, grey.	M	(L)		
									as above, but brown.		MD		
					N = 15 8,8,7	3							
▶										W			
						4					VL		
					N = 1 0,0,1								
						5			as above, but with XW sandstone bands.				
								-	SANDSTONE: fine to medium grained, orange brown and grey.	DW	L-M		LOW TO MODERATE 'TC' BIT RESISTANCE
											M		
									REFER TO CORED BOREHOLE LOG				MODERATE TO HIGH RESISTANCE
						6							
						7							

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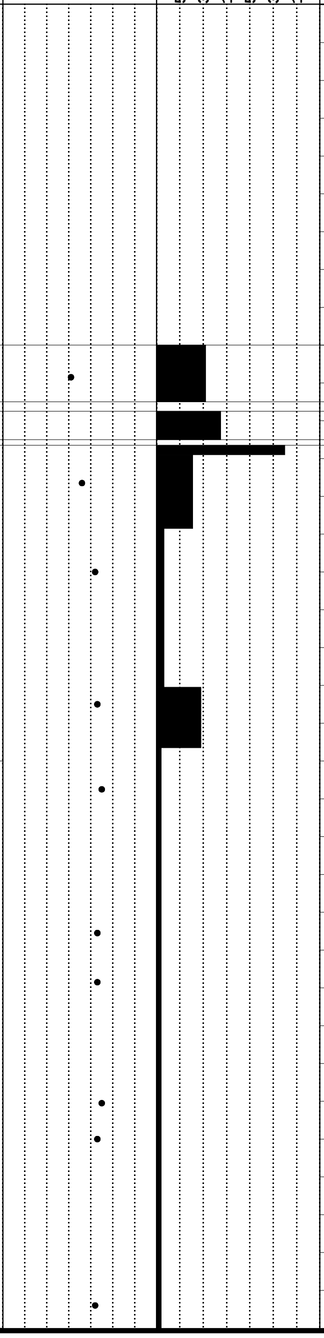
CORED BOREHOLE LOG

Borehole No.
207

Client: FRASERS PROPERTY
Project: PROPOSED DEVELOPMENT AT BLOCK 4S
Location: CNR. ABERCROMBIE STREET & IRVING STREET, CHIPPENDALE, NSW

Job No. 22905S
Core Size: NMLC
R.L. Surface: ≈ 11.9m
Date: 31-1-13
Inclination: VERTICAL
Datum: AHD
Drill Type: JK305
Bearing: -
Logged/Checked by: D.W./A.M



Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$	DEFECT SPACING (mm)	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
		4								
		5								
				START CORING AT 5.80m						
		6		SANDSTONE: fine to medium grained, orange brown, red brown and light grey.	DW	M-H			- CS, 0°, 20mm.t	
				CORE LOSS 0.05m	DW	M-H				
				SANDSTONE: fine to medium grained, red brown and light grey.	DW SW	M-H			- CS, 0°, 20mm.t - Be, 10°, P, R, IS	
				CORE LOSS 0.03m						
									- Be, 0°, P, R	
				SANDSTONE: fine to medium grained, red brown.						
		7		SANDSTONE: fine to medium grained, light grey, with grey laminae, cross bedded at 5-20°.						
									- CS, 5°, 3mm.t	
									- J, 70°, P, R	
		8			FR	H				
FULL RET-URN		9								
		10								

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CORED BOREHOLE LOG

Borehole No.
207
3/3

Client: FRASERS PROPERTY
Project: PROPOSED DEVELOPMENT AT BLOCK 4S
Location: CNR. ABERCROMBIE STREET & IRVING STREET, CHIPPENDALE, NSW

Job No. 22905S
Date: 31-1-13
Drill Type: JK305
Core Size: NMLC
Inclination: VERTICAL
Bearing: -
R.L. Surface: ≈ 11.9m
Datum: AHD
Logged/Checked by: D.W./A.M

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ EL VL L M H VH EH	DEFECT DETAILS: DEFECT SPACING (mm) 500 300 100 50 30 10	DEFECT DETAILS: DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
		12		SANDSTONE: fine to medium grained, light grey, with grey laminae, cross bedded at 5-20°.	SW	M-H	• •		- XWS, 0°, 30mm.t	
		13 14 15 16 17		END OF BOREHOLE AT 12.08m						

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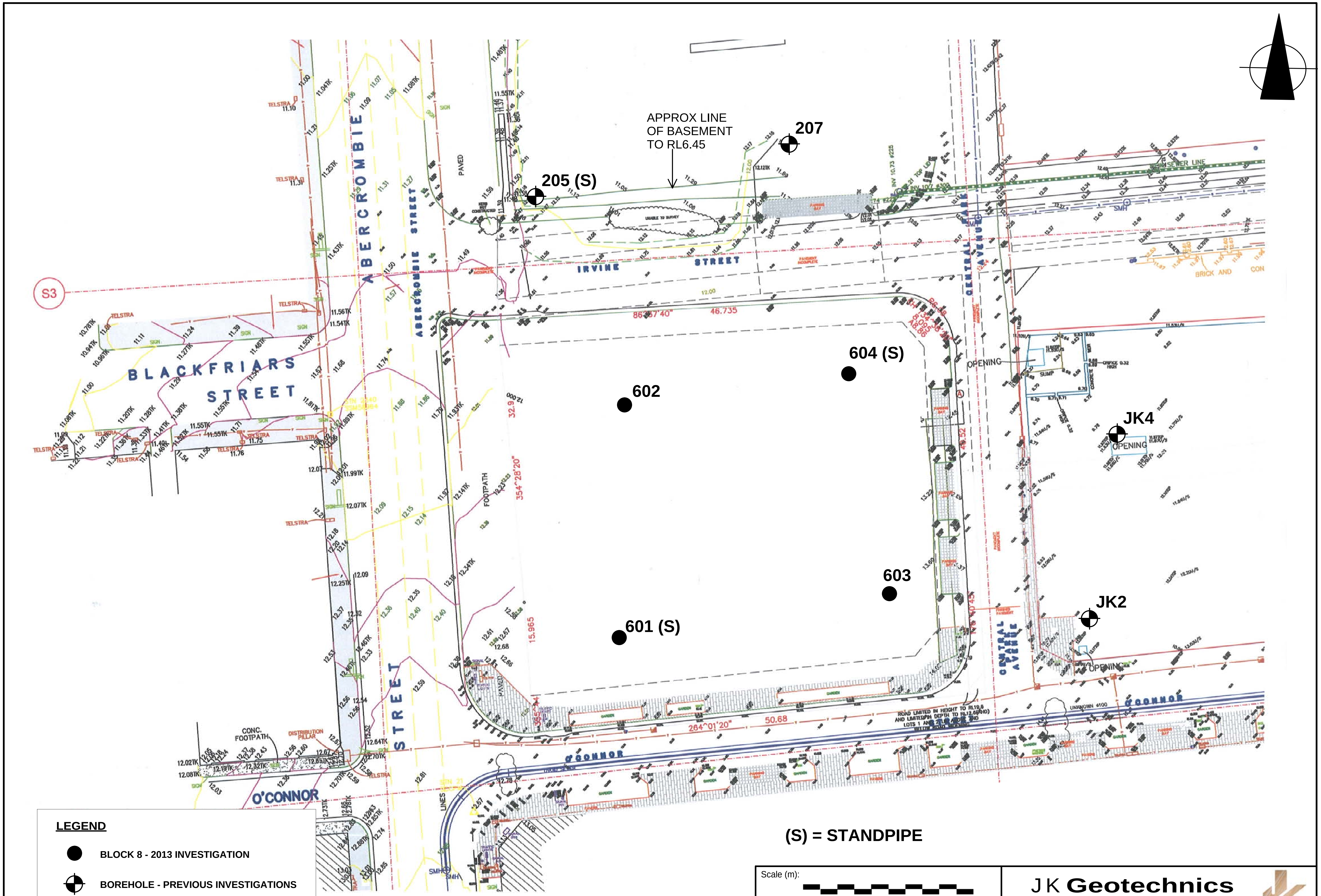

LEGEND

● BLOCK 8 - 2013 INVESTIGATION

⊕ BOREHOLE - PREVIOUS INVESTIGATIONS

Scale (m): 0 20

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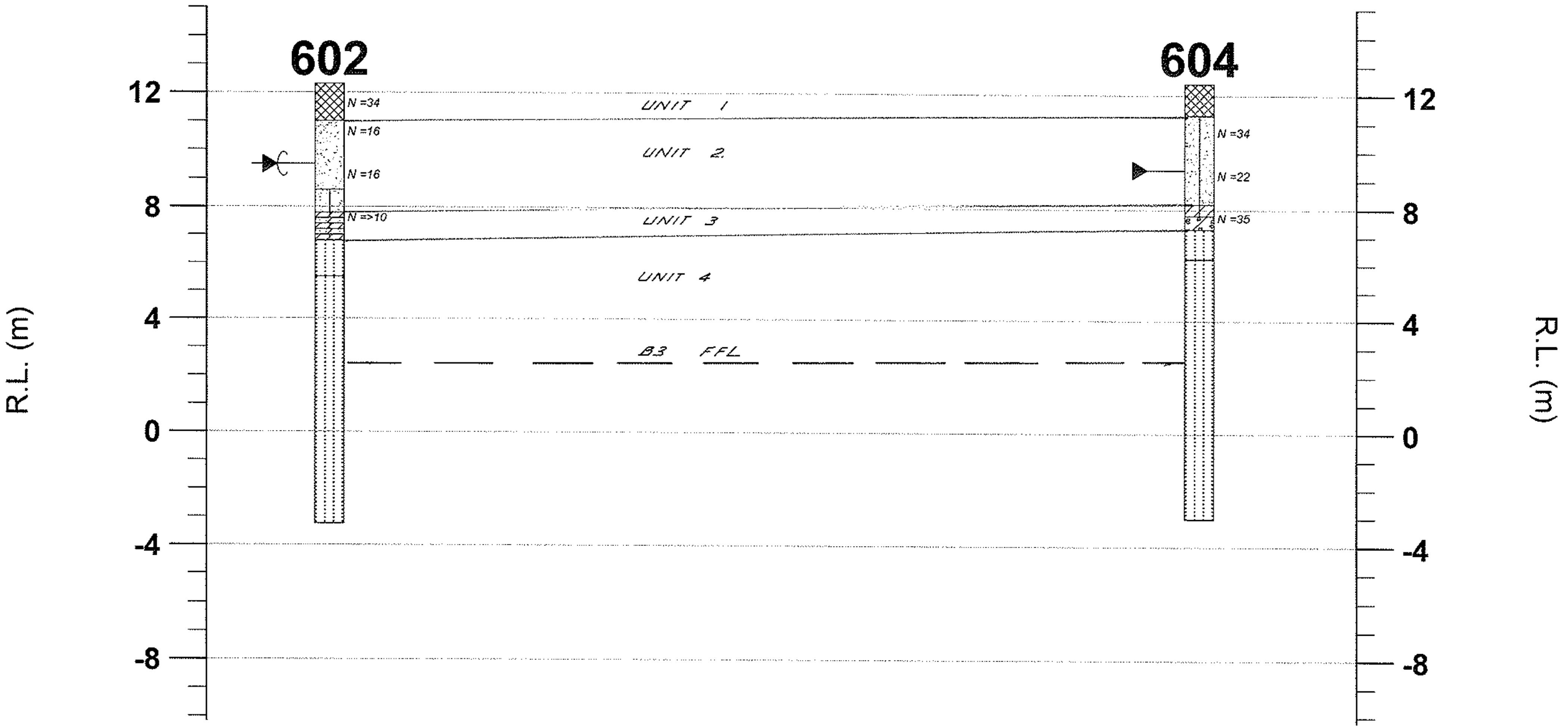
Title:	Report Number:	Figure Number:
BOREHOLE LOCATION PLAN	22905SD_8	1

GRAPHICAL BOREHOLE SUMMARY



▩ Fill
▨ Sand
▥ Silty Sand
▨ Silty Clay
▨ Clayey Sand
▥ Sandstone/ Greywacke
▨ Clayey Gravel
—<— Borehole Collapse Depth
▶— Groundwater seepage level
N SPT "N" VALUE
Nc SOLID CONE BLOW COUNTS PER 150mm

NOTE: REFER TO BOREHOLE LOGS

Scale: 1 : 200 (vert) ; NTS (horiz)

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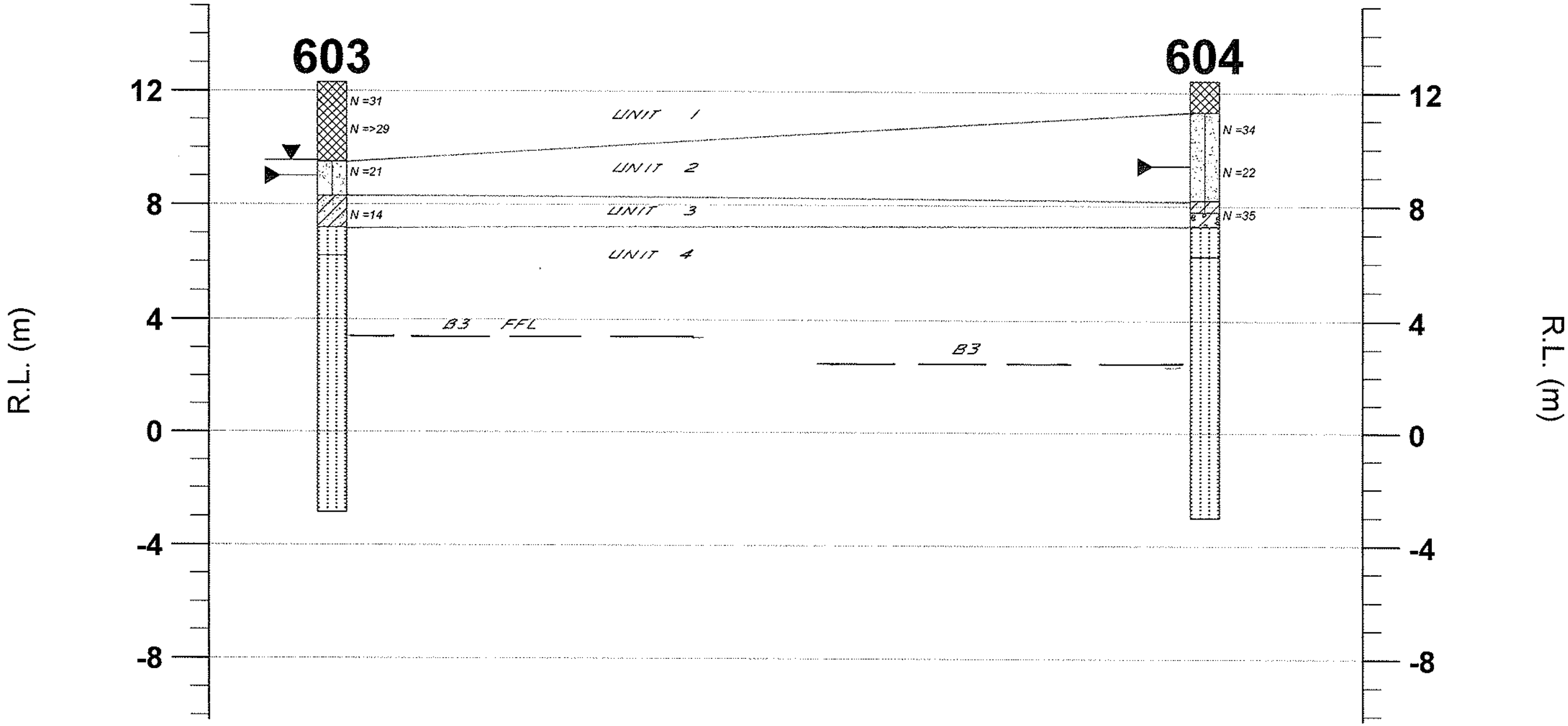
Job No.: 22905SD 8

Figure No.: 2a

GRAPHICAL BOREHOLE SUMMARY



▩ Fill
▥ Silty Sand
▨ Sandy Clay/ Clayey Sand
▥ Sandstone/ Greywacke
▨ Silty Clay
▩ Clayey Gravel
▼ Observed water level
▶ Groundwater seepage level
N SPT "N" VALUE
Nc SOLID CONE BLOW COUNTS PER 150mm

NOTE: REFER TO BOREHOLE LOGS

Scale: 1 : 200 (vert) ; NTS (horiz)

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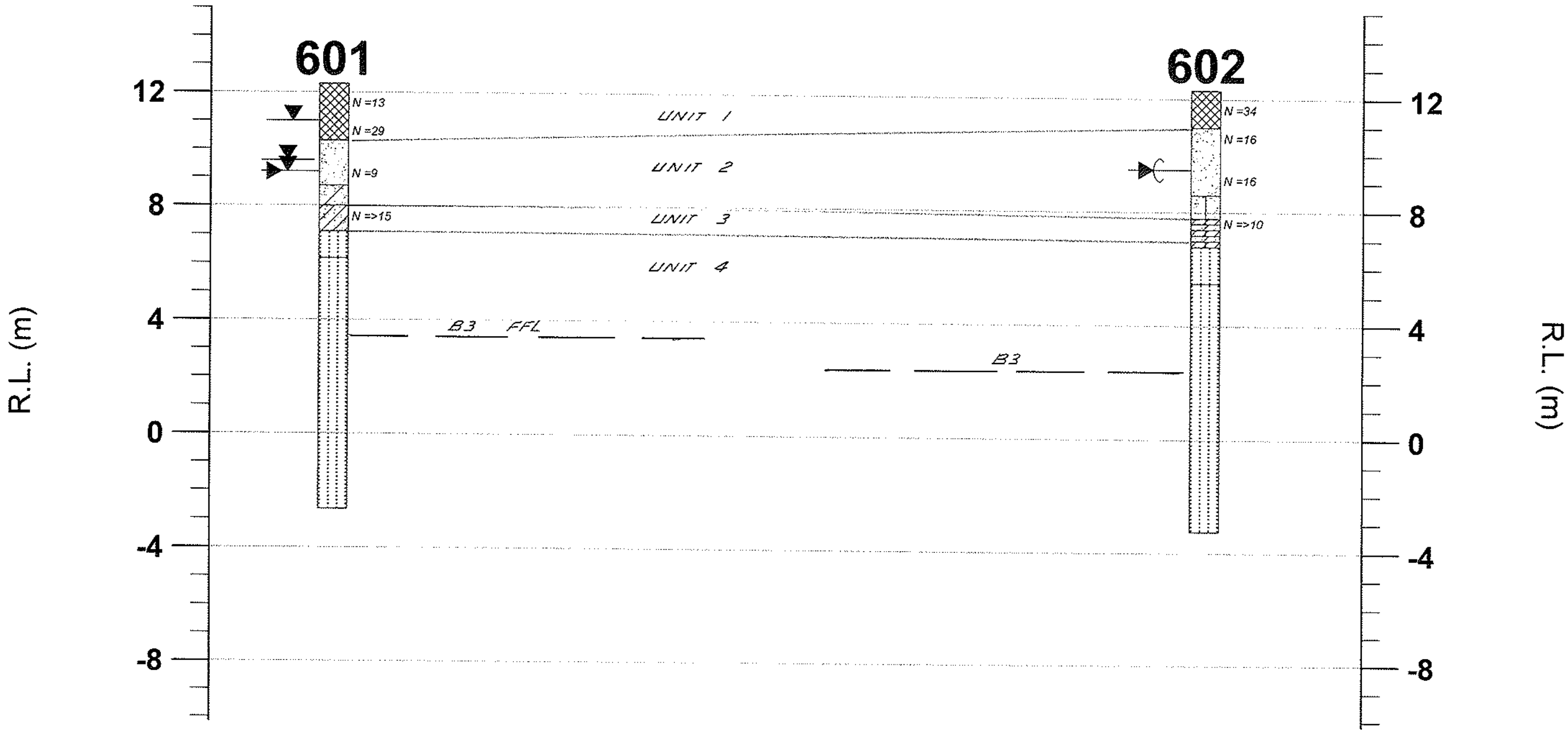
Job No.: 22905SD 8

Figure No.: 2b

GRAPHICAL BOREHOLE SUMMARY



- ▩ Fill
- ░ Sand
- ▨ Clayey Sand
- ▨ Sandy Clay/ Clayey Sand
- ▥ Sandstone/ Greywacke
- ▥ Silty Sand
- ▨ Silty Clay
- ▼ Observed water level
- ► Groundwater seepage level
- —c— Borehole Collapse Depth
- N SPT "N" VALUE
- Nc SOLID CONE BLOW COUNTS PER 150mm

NOTE: REFER TO BOREHOLE LOGS

Scale: 1 : 200 (vert) ; NTS (horiz)

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Job No.: 22905SD 8

Figure No.: 2c

VIBRATION EMISSION DESIGN GOALS

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 recognised to be conservative.

The DIN 4150 values (maximum levels measured in any direction at the foundation, OR, maximum levels measured in (x) or (y) horizontal directions, in the plane of the uppermost floor), are summarised in Table 1 below.

It should be noted that peak vibration velocities higher than the minimum figures in Table 1 for low frequencies may be quite 'safe', depending on the frequency content of the vibration and the actual condition 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 effects such as superficial 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 1: DIN 4150 – Structural Damage – Safe Limits for Building Vibration

Group	Type of Structure	Peak Vibration Velocity in mm/s			
		At Foundation Level at a Frequency of:			Plane of Floor of Uppermost Storey
		Less than 10Hz	10Hz to 50Hz	50Hz to 100Hz	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 (eg. buildings that are under a preservation order).	3	3 to 8	8 to 10	8

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

-

REPORT EXPLANATION NOTES

INTRODUCTION

These notes have been provided to amplify the geotechnical report in regard to classification methods, field procedures and certain matters relating to the Comments and Recommendations section. Not all notes are necessarily relevant to all reports.

The ground is a product of continuing natural and man-made processes and therefore exhibits a variety of characteristics and properties which vary from place to place and can change with time. Geotechnical engineering involves gathering and assimilating limited facts about these characteristics and properties in order to understand or predict the behaviour of the ground on a particular site under certain conditions. This report may contain such facts obtained by inspection, excavation, probing, sampling, testing or other means of investigation. If so, they are directly relevant only to the ground at the place where and time when the investigation was carried out.

DESCRIPTION AND CLASSIFICATION METHODS

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, the SAA Site Investigation Code. In general, descriptions cover the following properties – soil or rock type, colour, structure, strength or density, and inclusions. Identification and classification of soil and rock involves judgement and the Company infers accuracy only to the extent that is common in current geotechnical practice.

Soil types are described according to the predominating particle size and behaviour as set out in the attached Unified Soil Classification Table qualified by the grading of other particles present (e.g. sandy clay) as set out below:

Soil Classification	Particle Size
Clay	less than 0.002mm
Silt	0.002 to 0.075mm
Sand	0.075 to 2mm
Gravel	2 to 60mm

Non-cohesive soils are classified on the basis of relative density, generally from the results of Standard Penetration Test (SPT) as below:

Relative Density	SPT ‘N’ Value (blows/300mm)
Very loose	less than 4
Loose	4 – 10
Medium dense	10 – 30
Dense	30 – 50
Very Dense	greater than 50

Cohesive soils are classified on the basis of strength (consistency) either by use of hand penetrometer, laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Unconfined Compressive Strength kPa
Very Soft	less than 25
Soft	25 – 50
Firm	50 – 100
Stiff	100 – 200
Very Stiff	200 – 400
Hard	Greater than 400
Friable	Strength not attainable – soil crumbles

Rock types are classified by their geological names, together with descriptive terms regarding weathering, strength, defects, etc. Where relevant, further information regarding rock classification is given in the text of the report. In the Sydney Basin, ‘Shale’ is used to describe thinly bedded to laminated siltstone.

SAMPLING

Sampling is carried out during drilling or from other excavations to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, moisture content, minor constituents and, depending upon the degree of disturbance, some information on strength and structure. Bulk samples are similar but of greater volume required for some test procedures.

Undisturbed samples are taken by pushing a thin-walled sample tube, usually 50mm diameter (known as a U50), into the soil and withdrawing it with a sample of the soil contained in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling used are given on the attached logs.

INVESTIGATION METHODS

The following is a brief summary of investigation methods currently adopted by the Company and some comments on their use and application. All except test pits, hand auger drilling and portable dynamic cone penetrometers require the use of a mechanical drilling rig which is commonly mounted on a truck chassis.

Test Pits: These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. Limitations of test pits are the problems associated with disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact the backfill during construction or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

Hand Auger Drilling: A borehole of 50mm to 100mm diameter is advanced by manually operated equipment. Premature refusal of the hand augers can occur on a variety of materials such as hard clay, gravel or ironstone, and does not necessarily indicate rock level.

Continuous Spiral Flight Augers: The borehole is advanced using 75mm to 115mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling and insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface by the flights or may be collected after withdrawal of the auger flights, but they can be very disturbed and layers may become mixed. Information from the auger sampling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability due to mixing or softening of samples by groundwater, or uncertainties as to the original depth of the samples. Augering below the groundwater table is of even lesser reliability than augering above the water table.

Rock Augering: Use can be made of a Tungsten Carbide (TC) bit for auger drilling into rock to indicate rock quality and continuity by variation in drilling resistance and from examination of recovered rock fragments. This method of investigation is quick and relatively inexpensive but provides only an indication of the likely rock strength and predicted values may be in error by a strength order. Where rock strengths may have a significant impact on construction feasibility or costs, then further investigation by means of cored boreholes may be warranted.

Wash Boring: The borehole is usually advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from “feel” and rate of penetration.

Mud Stabilised Drilling: Either Wash Boring or Continuous Core Drilling can use drilling mud as a circulating fluid to stabilise the borehole. The term ‘mud’ encompasses a range of products ranging from bentonite to polymers such as Revert or Biogel. The mud tends to mask the cuttings and reliable identification is only possible from intermittent intact sampling (eg from SPT and U50 samples) or from rock coring, etc.

Continuous Core Drilling: A continuous core sample is obtained using a diamond tipped core barrel. Provided full core recovery is achieved (which is not always possible in very low strength rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation. In rocks, an NMLC triple tube core barrel, which gives a core of about 50mm diameter, is usually used with water flush. The length of core recovered is compared to the length drilled and any length not recovered is shown as CORE LOSS. The location of losses are determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the top end of the drill run.

Standard Penetration Tests: Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils as a means of indicating density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, “Methods of Testing Soils for Engineering Purposes” – Test F3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube with a tapered shoe, under the impact of a 63kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150mm increments and the ‘N’ value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

- In the case where full penetration is obtained with successive blow counts for each 150mm of, say, 4, 6 and 7 blows, as

  N = 13
  4, 6, 7

- In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm, as

  N>30
  15, 30/40mm

The results of the test can be related empirically to the engineering properties of the soil.

Occasionally, the drop hammer is used to drive 50mm diameter thin walled sample tubes (U50) in clays. In such circumstances, the test results are shown on the borehole logs in brackets.

A modification to the SPT test is where the same driving system is used with a solid 60° tipped steel cone of the same diameter as the SPT hollow sampler. The solid cone can be continuously driven for some distance in soft clays or loose sands, or may be used where damage would otherwise occur to the SPT. The results of this Solid Cone Penetration Test (SCPT) are shown as "N_c” on the borehole logs, together with the number of blows per 150mm penetration.

Static Cone Penetrometer Testing and Interpretation: Cone penetrometer testing (sometimes referred to as a Dutch Cone) described in this report has been carried out using an Electronic Friction Cone Penetrometer (EFCP). The test is described in Australian Standard 1289, Test F5.1.

In the tests, a 35mm diameter rod with a conical tip is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the frictional resistance on a separate 134mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are electrically connected by wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) the information is output as incremental digital records every 10mm. The results given in this report have been plotted from the digital data.

The information provided on the charts comprise:

- Cone resistance – the actual end bearing force divided by the cross sectional area of the cone – expressed in MPa.
- Sleeve friction – the frictional force on the sleeve divided by the surface area – expressed in kPa.
- Friction ratio – the ratio of sleeve friction to cone resistance, expressed as a percentage.

  The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and occasionally very soft clays, rising to 4% to 10% in stiff clays and peats. Soil descriptions based on cone resistance and friction ratios are only inferred and must not be considered as exact.

Correlations between EFCP and SPT values can be developed for both sands and clays but may be site specific.

Interpretation of EFCP values can be made to empirically derive modulus or compressibility values to allow calculation of foundation settlements.

Stratification can be inferred from the cone and friction traces and from experience and information from nearby boreholes etc. Where shown, this information is presented for general guidance, but must be regarded as interpretive. The test method provides a continuous profile of engineering properties but, where precise information on soil classification is required, direct drilling and sampling may be preferable.

Portable Dynamic Cone Penetrometers: Portable Dynamic Cone Penetrometer (DCP) tests are carried out by driving a rod into the ground with a sliding hammer and counting the blows for successive 100mm increments of penetration.

Two relatively similar tests are used:

- Cone penetrometer (commonly known as the Scala Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS1289, Test F3.2). The test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various Road Authorities.
- Perth sand penetrometer – a 16mm diameter flat ended rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test F3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.

LOGS

The borehole or test pit logs presented herein are an engineering and/or geological interpretation of the sub-surface conditions, and their reliability will depend to some extent on the frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will enable the most reliable assessment, but is not always practicable or possible to justify on economic grounds. In any case, the boreholes or test pits represent only a very small sample of the total subsurface conditions.

The attached explanatory notes define the terms and symbols used in preparation of the logs.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore take into account the spacing of boreholes or test pits, the method of drilling or excavation, the frequency of sampling and testing and the possibility of other than “straight line” variations between the boreholes or test pits. Subsurface conditions between boreholes or test pits may vary significantly from conditions encountered at the borehole or test pit locations.

GROUNDWATER

Where groundwater levels are measured in boreholes, there are several potential problems:

- Although groundwater may be present, in low permeability soils it may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes and may not be the same at the time of construction.
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must be washed out of the hole or ‘reverted’ chemically if water observations are to be made.

More reliable measurements can be made by installing standpipes which are read after stabilising at intervals ranging from several days to perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from perched water tables or surface water.

FILL

The presence of fill materials can often be determined only by the inclusion of foreign objects (eg bricks, steel etc) or by distinctly unusual colour, texture or fabric. Identification of the extent of fill materials will also depend on investigation methods and frequency. Where natural soils similar to those at the site are used for fill, it may be difficult with limited testing and sampling to reliably determine the extent of the fill.

The presence of fill materials is usually regarded with caution as the possible variation in density, strength and material type is much greater than with natural soil deposits. Consequently, there is an increased risk of adverse engineering characteristics or behaviour. If the volume and quality of fill is of importance to a project, then frequent test pit excavations are preferable to boreholes.

LABORATORY TESTING

Laboratory testing is normally carried out in accordance with Australian Standard 1289 *'Methods of Testing Soil for Engineering Purposes'*. Details of the test procedure used are given on the individual report forms.

ENGINEERING REPORTS

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. a three storey building) the information and interpretation may not be relevant if the design proposal is changed (eg to a twenty storey building). If this happens, the company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions – the potential for this will be partially dependent on borehole spacing and sampling frequency as well as investigation technique.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of persons or contractors responding to commercial pressures.

If these occur, the company will be pleased to assist with investigation or advice to resolve any problems occurring.

SITE ANOMALIES

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed that at some later stage, well after the event.

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

Attention is drawn to the document *'Guidelines for the Provision of Geotechnical Information in Tender Documents'* , published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Copyright in all documents (such as drawings, borehole or test pit logs, reports and specifications) provided by the Company shall remain the property of Jeffery and Katauskas Pty Ltd. Subject to the payment of all fees due, the Client alone shall have a licence to use the documents provided for the sole purpose of completing the project to which they relate. License to use the documents may be revoked without notice if the Client is in breach of any objection to make a payment to us.

REVIEW OF DESIGN

Where major civil or structural developments are proposed or where only a limited investigation has been completed or where the geotechnical conditions/ constraints are quite complex, it is prudent to have a joint design review which involves a senior geotechnical engineer.

SITE INSPECTION

The company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related.

Requirements could range from:

i) a site visit to confirm that conditions exposed are no worse than those interpreted, to
ii) a visit to assist the contractor or other site personnel in identifying various soil/rock types such as appropriate footing or pier founding depths, or
iii) full time engineering presence on site.

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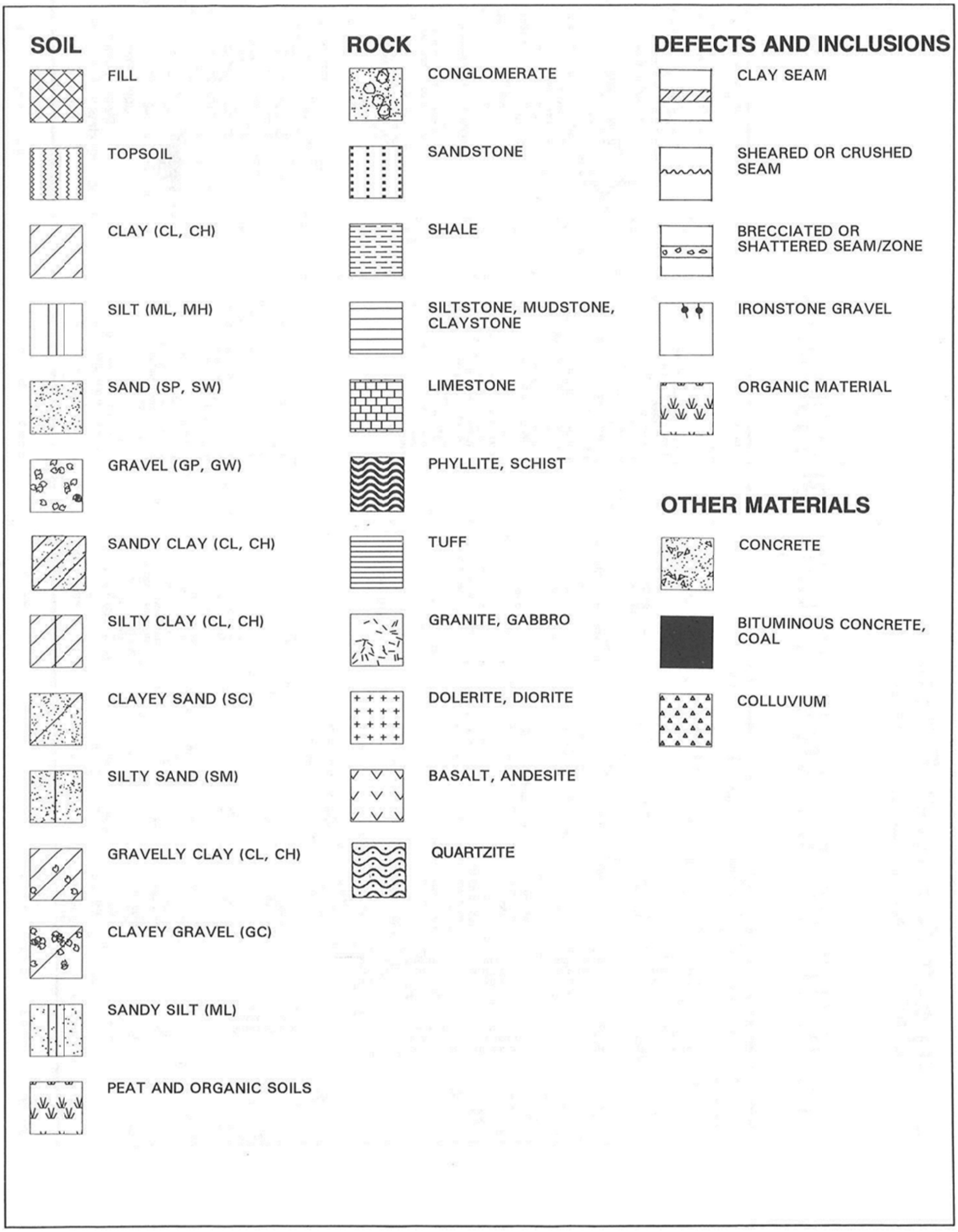
GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS



SOIL

- FILL
- TOPSOIL
- CLAY (CL, CH)
- SILT (ML, MH)
- SAND (SP, SW)
- GRAVEL (GP, GW)
- SANDY CLAY (CL, CH)
- SILTY CLAY (CL, CH)
- CLAYEY SAND (SC)
- SILTY SAND (SM)
- GRAVELLY CLAY (CL, CH)
- CLAYEY GRAVEL (GC)
- SANDY SILT (ML)
- PEAT AND ORGANIC SOILS

ROCK

- CONGLOMERATE
- SANDSTONE
- SHALE
- SILTSTONE, MUDSTONE, CLAYSTONE
- LIMESTONE
- PHYLLITE, SCHIST
- TUFF
- GRANITE, GABBRO
- DOLERITE, DIORITE
- BASALT, ANDESITE
- QUARTZITE

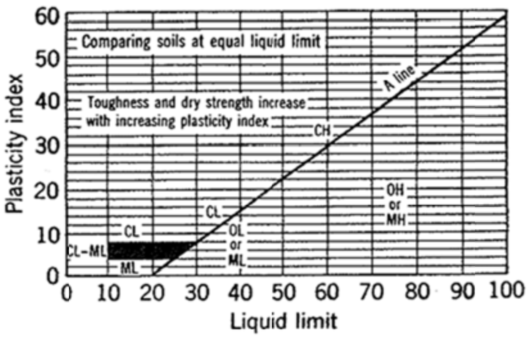
DEFECTS AND INCLUSIONS

- CLAY SEAM
- SHEARED OR CRUSHED SEAM
- BRECCIATED OR SHATTERED SEAM/ZONE
- IRONSTONE GRAVEL
- ORGANIC MATERIAL

OTHER MATERIALS

- CONCRETE
- BITUMINOUS CONCRETE, COAL
- COLLUVIUM

Field Identification Procedures (Excluding particles larger than 75 µm and basing fractions on estimated weights)				Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria			
Coarse-grained soils More than half of material is *larger* than 75 µm sieve size[b] (The 75 µm sieve size is about the smallest particle visible to naked eye)	Gravels More than half of coarse fraction is larger than 4 mm sieve size	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles 12 mm maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)	Use grain size curve in identifying the fractions as given under field identification	Determine percentages of gravel and sand from grain size curve Depending on percentage of fines (fraction smaller than 75 µm sieve size) coarse grained soils are classified as follows: Less than 5% *GW, GP, SW, SP* More than 12% *GM, GC, SM, SC* 5% to 12% *Borderline* cases requiring use of dual symbols	$C_{\mathrm{U}} = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_{\mathrm{C}} = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines				Not meeting all gradation requirements for *GW*	
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures				Atterberg limits below "A" line, or *PI* less than 4	Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures				Atterberg limits above "A" line, with *PI* greater than 7	
	Sands More than half of coarse fraction is smaller than 4 mm sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines				$C_{\mathrm{U}} = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_{\mathrm{C}} = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines				Not meeting all gradation requirements for *SW*	
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures				Atterberg limits below "A" line or *PI* less than 5	Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures				Atterberg limits below "A" line with *PI* greater than 7	

		Identification Procedures on Fraction Smaller than 380 µm Sieve Size						
		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)				
Fine-grained soils More than half of material is *smaller* than 75 µm sieve size (The 75 µm sieve size is about the smallest particle visible to naked eye)	Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)	 Plasticity chart for laboratory classification of fine grained soils
		Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays		
		Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity		
	Silts and clays liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts		
		High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays		
		Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity		
Highly Organic Soils		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils		

Note: 1 Soils possessing characteristics of two groups are designated by combinations of group symbols (eg. GW-GC, well graded gravel-sand mixture with clay fines).

2 Soils with liquid limits of the order of 35 to 50 may be visually classified as being of medium plasticity.

LOG SYMBOLS

LOG COLUMN	SYMBOL	DEFINITION
Groundwater Record	▼	Standing water level. Time delay following completion of drilling may be shown.
	—C—	Extent of borehole collapse shortly after drilling.
	▶—	Groundwater seepage into borehole or excavation noted during drilling or excavation.
Samples	ES	Soil sample taken over depth indicated, for environmental analysis.
	U50	Undisturbed 50mm diameter tube sample taken over depth indicated.
	DB	Bulk disturbed sample taken over depth indicated.
	DS	Small disturbed bag sample taken over depth indicated.
	ASB	Soil sample taken over depth indicated, for asbestos screening.
	ASS	Soil sample taken over depth indicated, for acid sulfate soil analysis.
	SAL	Soil sample taken over depth indicated, for salinity analysis.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. 'R' as noted below.
	N_c = 5 7 3R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60 degree solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25	Vane shear reading in kPa of Undrained Shear Strength.
	PID = 100	Photoionisation detector reading in ppm (Soil sample headspace test).
Moisture Condition (Cohesive Soils)	MC>PL	Moisture content estimated to be greater than plastic limit.
	MC≈PL	Moisture content estimated to be approximately equal to plastic limit.
	MC<PL	Moisture content estimated to be less than plastic limit.
(Cohesionless Soils)	D	DRY – Runs freely through fingers.
	M	MOIST – Does not run freely but no free water visible on soil surface.
	W	WET – Free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS	VERY SOFT – Unconfined compressive strength less than 25kPa
	S	SOFT – Unconfined compressive strength 25-50kPa
	F	FIRM – Unconfined compressive strength 50-100kPa
	St	STIFF – Unconfined compressive strength 100-200kPa
	VSt	VERY STIFF – Unconfined compressive strength 200-400kPa
	H	HARD – Unconfined compressive strength greater than 400kPa
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other tests.
Density Index/ Relative Density (Cohesionless Soils)		**Density Index (I_D) Range (%)** **SPT 'N' Value Range (Blows/300mm)**
	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
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other tests.
Hand Penetrometer Readings	300 250	Numbers indicate individual test results in kPa on representative undisturbed material unless noted otherwise.
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Tungsten carbide wing bit.
	T_{60}	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.

LOG SYMBOLS continued

ROCK MATERIAL WEATHERING CLASSIFICATION

TERM	SYMBOL	DEFINITION
Residual Soil	RS	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.
Extremely weathered rock	XW	Rock is weathered to such an extent that it has “soil” properties, ie it either disintegrates or can be remoulded, in water.
Distinctly weathered rock	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by ironstaining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Slightly weathered rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh rock	FR	Rock shows no sign of decomposition or staining.

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by the International Journal of Rock Mechanics, Mining, Science and Geomechanics. Abstract Volume 22, No 2, 1985.

TERM	SYMBOL	Is (50) MPa	FIELD GUIDE
Extremely Low:	EL		Easily remoulded by hand to a material with soil properties.
----------------------	-------------	0.03	
Very Low:	VL		May be crumbled in the hand. Sandstone is “sugary” and friable.
----------------------	-------------	0.1	
Low:	L		A piece of core 150mm long x 50mm dia. may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.
----------------------	-------------	0.3	
Medium Strength:	M		A piece of core 150mm long x 50mm dia. can be broken by hand with difficulty. Readily scored with knife.
----------------------	-------------	1	
High:	H		A piece of core 150mm long x 50mm dia. core cannot be broken by hand, can be slightly scratched or scored with knife; rock rings under hammer.
----------------------	--------------	3	
Very High:	VH		A piece of core 150mm long x 50mm dia. may be broken with hand-held pick after more than one blow. Cannot be scratched with pen knife; rock rings under hammer.
----------------------	--------------	10	
Extremely High:	EH		A piece of core 150mm long x 50mm dia. is very difficult to break with hand-held hammer. Rings when struck with a hammer.

ABBREVIATIONS USED IN DEFECT DESCRIPTION

ABBREVIATION	DESCRIPTION	NOTES
Be	Bedding Plane Parting	Defect orientations measured relative to the normal to the long core axis (ie relative to horizontal for vertical holes)
CS	Clay Seam	
J	Joint	
P	Planar	
Un	Undulating	
S	Smooth	
R	Rough	
IS	Ironstained	
XWS	Extremely Weathered Seam	
Cr	Crushed Seam	
60t	Thickness of defect in millimetres	