REPORT TO

PATHWAYS PROPERTY GROUP

ON

GEOTECHNICAL INVESTIGATION

FOR

PROPOSED MIXED-USE DEVELOPMENT

AT

274-278 LONGUEVILLE ROAD AND 4-18 NORTHWOOD ROAD, LANE COVE, NSW

Date: 30 July 2020
Ref: 33311STrpt

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ATTACHMENTS

1 INTRODUCTION

This report presents the results of a geotechnical investigation for the proposed mixed-use development at 274-278 Longueville Road and 4-18 Northwood Road, Lane Cove, NSW. The location of the site is shown in Figure 1. The investigation was commissioned by Mr Graeme Skerritt of Pathways Property Group by signed Acceptance of Proposal dated 19 June 2020. The investigation was completed on the basis of our fee proposal dated 19 June 2020, Ref: P52059S.

We understand from the supplied architectural drawings prepared by Morrison Design Partnership (Project No. 2924, Drawing Nos. DA101-DA106 and DA208, Revision PA1 dated 27 October 2016) that following demolition of the existing structures on the site it is proposed to construct a four-storey building over two partial and one full basement levels. The proposed basement level is at RL45.05m which will require bulk excavation to depth ranging from about 11.5m to 10.5m along Longueville and Northwood Roads, decreasing to about 6.5m on the north-eastern edge of the basement where ground surface levels fall away.

An existing Telstra transmission tower is located within the proposed building footprint and will need to be relocated prior to development commencing. The new tower location was not known at the time of fieldwork, however we have provided general recommendations regarding footings for the proposed tower within this report.

The purpose of the investigation was to obtain geotechnical information on subsurface conditions as a basis for comments and recommendations on excavation, shoring, earth pressures, groundwater and foundations.

2 INVESTIGATION PROCEDURE

The fieldwork for the investigation was completed on 2, 6 and 8 July 2020 and comprised the drilling of six boreholes (BH1 to BH6) using our track mounted JK205 drill rig. The boreholes were initially drilled using spiral auger techniques through the soils and some of the upper more weathered and lower strength rock. The rock was then core drilled to the borehole termination depth using rotary diamond coring techniques and an NMLC triple tube core barrel with water flush.

The borehole locations as shown on the attached Figure 2 were set out by taped measurements from existing surface features. The approximate surface levels of the boreholes, as shown on the borehole logs, were interpolated from nearby spot heights and contour lines on the survey plan (Ref. 16/236 dated 13 June 2016) prepared by Watson Buchan Pty Ltd. The datum is Australian Height Datum (AHD).

The apparent compaction of the fill and strength of the subsurface soils were assessed from the Standard Penetration Test (SPT) 'N' values, augmented with the results of hand penetrometer tests on cohesive samples obtained from the SPT split tube sampler. Assessment of the rock strength in the augered portion of the boreholes was from observation of the drilling resistance when using a Tungsten Carbide (TC) bit on the augers and inspection of the recovered rock cuttings. It should be noted that rock strengths assessed in this way are approximate, and variations of about one order of strength should not be unexpected.

Where the rock was core drilled, the recovered rock core was placed in steel boxes and returned to our NATA registered laboratory (Soil Test Services) where it was photographed and Point Load Strength Index (Is_{50}) testing was carried out. Using established correlations, the unconfined compressive strength (UCS) of the bedrock was estimated from the Is_{50} results. The Point Load Strength test results are summarised in the attached Soil Test Services (STS) Table A and shown on the borehole logs.

Groundwater observations were made in the boreholes during and shortly after completion of auger drilling. A monitoring well was installed in BH2 upon completion of drilling to allow longer-term monitoring. The details of the well are given in the borehole log. A return visit to site was made on the 22 July 2020 to measure groundwater within the BH2 monitoring well and a selection of wells previously installed by Douglas Partners for environmental purposes.

The fieldwork was completed in the full-time presence of our geotechnical engineers who set out the borehole locations, nominated the sampling and testing, and prepared the borehole logs. The borehole logs are attached with this report, together with a set of explanatory notes which provide further details of the investigation techniques adopted, their limitations and the logging terms and symbols used.

3 RESULTS OF INVESTIGATION

3.1 Site Description

The site is situated within ridge and gully topography and is located on the upper slope of a north-easterly facing hillside that grades down from the crest of a local ridgeline that is roughly followed by Longueville and Northwood Roads. Surface levels across the site typically slope down to the east at about 7°. The site has a western and south-western frontage with Longueville Road which continues as Northwood Road at a point roughly halfway along the site frontage.

The site is occupied by several one and two-storey commercial buildings generally of brick construction with two residential buildings at 274-274A Longueville Road. The buildings across the site typically appeared in good condition upon cursory visual observation though some stepped cracking was observed at the rear of No. 18 Northwood Road. Surface levels across the site generally slope down to the east at about 7° flattening to about 3° within the rear portion of the site. Within the property at 274A, surface levels slope overall to the east at approximately 14°, however the major changes in height are through a couple of steps in the outcropping sandstone that occur between the front and rear of the existing house. Sandstone, which appears to have been cut to allow for the construction of the existing house, was observed between 4m to 5m from the front of the residence with a sub-vertical drop of between 1.8m and 2.3m (from a top of rock level at about RL48.9m) measured across the exposed section. Another step in the sandstone was observed underneath the rear (eastern end) of the house. Between these two steps and above the higher cliff line the exposed bedrock was relatively flat. The sandstone was assessed as being distinctly weathered and mostly of low to medium strength, though the rock encountered under and near the northern edge of the house was typically very low to low.

The property at 4-10 Northwood Road is currently in use as a service station with a relatively level forecourt that appears to have been raised towards the east with fuel tanks appearing to be located on the southern side of the forecourt. At the eastern edge of the forecourt is a two-storey concrete block shop which appears to act as a retaining structure with levels sloping down to the east at about 10° through concrete driveways north and south of the shop to a lower workshop area. At the south-eastern corner of this lower area is a telecommunications monopole tower with an estimated height of 25m. A couple of lightweight equipment shelters are located at the base of the tower.

Surface levels along the north-east boundary (except at No. 274A) are retained by a series of retaining walls of sandstone block construction except at the rear of 4-10 Northwood Road. The height of the sandstone block retaining walls ranged from 1.6m to 4.2m whilst the height of the concrete block wall ranged from 1.4m to 2m. The concrete block wall appeared in good condition where observed downslope. The sandstone block walls varied in condition from poor to good with a portion of the wall at the north-eastern corner of No. 16 Northwood Road having fallen away. Stepped cracking was observed in the higher portions of the walls and vertical cracking with associated outward rotation was observed on the south-eastern corner of the wall at No. 16 Northwood Road. At the toe of the walls surface levels slope down through a heavily vegetated embankment at between 10° and 30° towards Gore Creek.

South of the site is a one- and two-storey brick house (No. 20 Northwood Road) which is set back about 3m from the common boundary. The house appeared in fair condition with stepped cracking observed at a couple of locations on the northern and western external walls. At the northern end is a hardstand driveway and parking which is formed by an approximately 1m high mass concrete retaining wall running perpendicular from the north-western corner of the house. The eastern portion of the house is surrounded by lawn.

Across the northern boundary is a two-storey brick unit building (No. 272 Longueville Road) over an undercroft car parking level which is set back about 2m from the common boundary. Surface levels across the boundary are similar and the building appeared to be in good condition upon cursory visual inspection.

3.2 Subsurface Conditions

The Sydney 1:100,000 Geological Series Sheet 9130 indicates that the site is underlain by a capping layer of Ashfield Shale which follows the ridgeline, roughly concurrent with Longueville and Northwood Roads. Underlying the Ashfield Shale is Hawkesbury Sandstone. The boreholes encountered a generalised profile comprising relatively shallow fill and residual soils overlying sandstone bedrock. A summary of the subsurface conditions is provided below however for a detailed description at each location reference should be made to the attached borehole logs.

Pavements and Fill

Pavements were encountered at surface in each borehole and were of brick (BH1), asphaltic concrete (BH5) or concrete (BH2 to BH4 and BH6) construction. The pavements were typically 60mm to 90mm thick except in the service station at Nos. 4-10 Northwood Road where the concrete was of 120mm and 130mm thickness.

Immediately underlying the pavements was a generally granular fill ranging in depth from 0.16m to 0.4m except in BH4 and BH6 where weathered sandstone and a void were encountered. Clayey fill underlay the granular base fill to depths of 0.5m (BH1 and BH2) and 1.3m (BH3) in the northern boreholes. The clays were assessed as ranging from low to high plasticity and contained inclusions of sandstone and igneous gravel. The deeper fill in BH3 was assessed as well compacted.

Residual Soils

Underlying the fill in all boreholes except BH4 residual soils were encountered to depths ranging from 0.8m to 1.7m. The residual soils within the northern boreholes (BH1 to BH3) typically comprised silty clay assessed as medium plasticity and ranging in strength from stiff to hard. Within BH5 and BH6 clayey sand grading to sand towards the bedrock horizon was encountered and was assessed as loose relative density.

Sandstone Bedrock

Weathered sandstone bedrock was encountered from depths ranging from 0.065m (BH4) to 1.7m (BH3) and reduced levels of 54.9m (BH1and BH2) to 50.1m (BH6). The surface of the bedrock appears to step and slope down towards the south-east within the site. The initial 1m of bedrock in the boreholes typically comprised an extremely weathered to very low strength layer. Below this upper more weathered material and from initial contact in BH5 and BH6, bedrock assessed as at least medium strength was encountered. The rock generally increased in strength with depth to high strength except in BH5 and BH6 where medium strength sandstone was encountered to the borehole termination depths.

Defects within the bedrock typically comprised extremely weathered and clay seams ranging from 1mm to 250mm thick though typically between 10mm and 100mm. The defect spacing generally increased with depth though significant defects were present within a roughly 2.5m and 2.0m layer present in BH5 and BH6 from depths of 4.2m and 5.9m respectively. Bedding partings and joints were also present within the bedrock and were frequently clay lined or filled with sand, clay or extremely weathered material. Roots were encountered within joints near the surface of the bedrock in BH3 and BH4.

Groundwater

No groundwater was encountered during or on completion of auger drilling in any of the boreholes. Groundwater measurements were not recorded on completion of coring due to the introduction of water into the boreholes during coring which results in artificially high measurements. Upon completion of fieldwork the core water was pumped out of the monitoring well in BH2 to a depth of 9.9m.

Groundwater levels were measured within BH2 and previously installed monitoring wells on 22 July 2020 and a summary of the measurements is presented in the table below.

Monitoring Location	Depth to Groundwater (m)	Groundwater Level (mAHD)
BH2	2.80	53.1
DP1	2.71	51.5
DP101	2.89	53.0
DP102	2.56	53.4
DP111	2.24	51.4
DP112	2.30	51.0

The above groundwater levels correlate with the horizon between the extremely weathered and moderately to slightly weathered sandstone bedrock. A distinct hydrocarbon odour was noted upon retrieving the tape measure from DP112 indicating some degree of contamination from the service station up-slope. We consider that the groundwater levels represent perched water within the more permeable extremely weathered profile above the less weathered sandstone.

3.3 Laboratory Test Results

The $Is_{(50)}$ results returned estimated unconfined compressive strength values for the sandstone ranging from 2MPa to 44MPa though typically ranging from 8MPa to 24MPa which correlates with medium to high strength bedrock.

The soil aggression testing is summarised in the table below;

Borehole No.	Sample Depth (m)	Soil Type	pH (pH units)	Chloride Content (mg/kg)	Sulphate Content (mg/kg)	Resistivity (ohm.cm)
BH1	0.5-0.95	Silty CLAY	7.6	160	290	3,600
BH3	1.7-1.95	XW Sandstone	6.3	26	<10	33,000
BH6	0.5-0.95	SAND	6.0	<10	20	48,000

These results correlate with exposure classification of ‘Non-Aggressive’ for both buried concrete and steel structural elements in accordance with Tables 6.4.2(C) and 6.5.2(C) of AS2159-2009 respectively.

4 COMMENTS AND RECOMMENDATIONS

4.1 Excavation

Prior to any excavation commencing we recommend that reference be made to the latest Code of Practice *Excavation Work* prepared by Safe Work Australia.

4.1.1 Dilapidation Surveys

We recommend detailed dilapidation surveys are completed on the neighbouring properties to the north and south-east prior to the start of the works. The preparation of such reports will help to guard against opportunistic claims for damage that was present prior to the start of the work. Council or other authorities may also require dilapidation surveys of their nearby assets and this should be checked prior to demolition.

The dilapidation surveys should comprise a detailed inspection of the adjoining properties, both externally and internally, with all defects rigorously described, i.e. defect location, defect type, crack width, crack length, orientation etc. The owners of the adjoining properties or relevant asset authorities should be asked to confirm that the reports represent a fair record of actual conditions. The dilapidation reports may then be used as a benchmark against which to assess possible future claims for damage arising from the works.

4.1.2 Excavation Methodology and Techniques

Bulk excavation for the proposed basement will require cuts ranging from 11.5m along the north-western boundary grading down to about 6.5m towards the south-eastern edge of the proposed basement. Excavation will encounter surficial soils however will primarily extend through sandstone bedrock. Any topsoil or root-affected soil should be stripped and stockpiled separately for re-use in landscape areas as such soils are not suitable for re-use as engineered fill.

Excavation of the soils and weathered sandstone bedrock up to very low strength should be readily achievable using conventional excavation equipment such as hydraulic excavators with buckets fitted with ‘tiger teeth’. Some assistance from ripping tynes may be required for iron indurated bands within the soils and extremely weathered sandstone.

Sandstone bedrock of low or greater strength will require ‘hard rock’ excavation techniques such as hydraulic rock hammers, rock saws or ripping attachments. Dust resulting from rock excavation should be suppressed by spraying with water. Care will be required during excavation to control the transmission of ground vibrations where rock hammers are employed. We recommend that the boundary faces of the excavation be saw cut to minimise overbreak and instability. The saw cuts should extend below the level at which rock breakers are used to reduce transmitted vibration.

4.1.3 Vibration Monitoring

Due to the presence of the structures close to the boundaries at 272 Longueville Road and 20 Northwood Road we recommend that quantitative vibration monitoring be completed to confirm that peak particle velocities (PPV) fall within acceptable limits. Other movement sensitive infrastructure within the road reserve and site e.g. the relocated Telstra tower may also require vibration monitoring to reduce the risk of damage to infrastructure. The attached Vibration Emission Design Goals provide PPV versus vibration frequency limits to assess acceptable vibrations. We note that vibration limits will reduce the risk of vibration damage to the neighbouring buildings and structures, however vibrations may still be perceptible to occupants of neighbouring buildings. If excessive vibrations are identified by the monitoring then it will be necessary to use lower energy equipment such as smaller rock hammers and/or using rock saws to cut gridlines within the sandstone, maintaining the base of the slots below the level at which the rock hammer is being used. Full time monitoring should be used at this site due to the relatively heavy rock breakers that will be required for economic excavation and to protect all parties from inadvertent exceedances of tolerable vibration limits.

Where rock hammers are used, to reduce vibrations we recommend that the rock hammer be continually orientated towards the face, edges and points of chisels/moils be maintained and hammers to be operated one at a time and in short bursts only to reduce potential amplification of vibrations.

We recommend that only the services of excavation contractors with suitable experience and importantly with a competent supervisor who is aware of vibration damage risks, possible rock face instability issues, etc. be engaged. The contractor should be provided with a copy of this report (and any subsequent reports) and have all appropriate statutory and public liability insurances.

4.1.4 Groundwater

Based on the results of the groundwater monitoring and the site location in the local topography we consider that the groundwater levels measured within wells across the property at No. 4-10 Northwood Road represent perched water within the more permeable extremely weathered profile above the less weathered sandstone. As such groundwater seepage into the excavation should be expected particularly at the soil/rock interface and through any joints and bedding planes within the bedrock exposed in the completed cut faces, particularly after periods of heavy or prolonged rainfall. Seepage, if any, during excavation is expected to be satisfactorily controlled by conventional sump and pump techniques or gravity drainage to the stormwater system. Groundwater levels measured across the site indicate water perched within the extremely weathered sandstone bedrock and we do not anticipate that as a result of excavation and dewatering there will be an adverse impact on the neighbouring properties or on the groundwater table which drains naturally to the Gore Creek valley below the site.

We recommend that groundwater seepage into the excavation be monitored by site personnel and the results (quantity, location, source, etc.) be reported to the geotechnical and hydraulic engineers so that any unexpected conditions can be promptly addressed. In the long term, drainage should be provided behind all retaining or basement walls and below the lowest floor slabs. Disposal of water off-site may be subject to treatment due to contamination within groundwater down-gradient of the service station forecourt as identified in the previous Douglas Partners groundwater testing report.

4.2 Excavation Support and Retention

Temporary batter slopes through the relatively shallow soils and extremely weathered sandstone should be no steeper than 1 Vertical (V) in 1.5 Horizontal (H). These temporary batters will generally be achievable within the site geometry along the south-eastern edge of the building, providing all surcharge loads are kept a distance of at least 2H (where H is the height of the batter) away from the crest of these batters. Elsewhere engineered in-situ shoring will be required particularly along the frontage with Longueville and Northwood Roads where excavation extends to the boundary. Here it is important that the architect allows sufficient room in the design for temporary support as it will be some time before the bulk excavation is complete and retaining walls can be constructed up to street level. It is likely that the shoring along the road frontages will have to be approved by RMS in which case geotechnical analysis will be required once the preliminary structural design is prepared. The absolute minimum depth of material to be retained appears to generally be between 1.5m to 3m which includes the soil and upper more weathered (Class V) sandstone; the depth of the shoring will also be governed by the level of the future building slabs which will provide propping for long-term support. As a general rule it is better to run shoring piles a little deeper than the minimum indicated by interpretation of the borehole information as underpinning or otherwise reinforcing inadequate shoring is a difficult and time consuming activity.

Retaining walls will be required to support at least the upper parts of excavation batters in the long term and may be preferred for the full depth of excavation to minimise long term maintenance issues. If exposed rock faces are to be left in the basements then rigorous seam treatment would be required and provision made for regular maintenance of perimeter drains which will tend to become filled with sand and silt which gradually erode from the face. There is also the issue of seepage flows likely to emerge sporadically on bedding and joints and which may be charged with ferruginous compounds which precipitate on contact with the air and cause unsightly build-up of sludgy residue.

Our recommendation for this site is to install a soldier pile shoring wall with reinforced shotcrete panels down through the upper zones of lower, Class V to Class III sandstone with the piles founded on the Class II or better sandstone.

Sandstone of Class III or better be cut vertically subject to inspection by an experienced geotechnical engineer. Where the rock is excessively weathered or adverse defects are present (such as inclined joints or bedding partings) stabilisation measures would likely be required which may include rock bolting, shotcreting, dental seam treatment, underpinning etc. We therefore recommend that the rock face be progressively inspected by an experienced geotechnical engineer or engineering geologist at not greater than 1.5m depth intervals and on completion, to identify adverse defects and to propose appropriate stabilisation measures. Defects evident in the rock cores indicate that a suitable budget should be allowed in the contract for these contingencies.

Footings should not be located within a distance from the crest equal to the height of the vertical rock cut, unless approval is provided by the geotechnical engineers.

Walls constructed from the base of the excavation should be waterproofed before backfilling. For the design of retaining walls, landscape walls or wall stabilisation measures the following earth pressure coefficients and subsoil parameters may be adopted:

- For design of any retaining walls that will be propped by the structure supporting a soil profile, we recommend the use of an ‘at-rest’ lateral earth pressure coefficient (K_0) of 0.55 for the retained profile, assuming a horizontal backfill surface.
- Where some minor movements of retaining walls may be tolerated (e.g. landscape walls), they may be designed using a triangular lateral earth pressure distribution and an ‘active’ earth pressure coefficient (K_a) of 0.35 for the soil profile.
- For all walls assume a pressure of 5kPa is applied by vertically cut rock faces of low to medium strength or above including a nominal backfill of about 0.3m thickness between rock and wall.
- A bulk unit weight of $20kN/m^3$ should be adopted for the soil profile.
- Any surcharge affecting the walls (e.g. construction traffic, pavement and ground floor slab loads, compaction stresses during backfilling, etc.) should be allowed in the design using the appropriate above earth pressure coefficients.
- The retaining walls should be designed as permanently drained. Subsurface drains should incorporate a non-woven geotextile filter fabric such as Bidim A34 to control subsoil erosion.
- The passive lateral toe resistance for retaining walls founded in sandstone of medium strength may be taken to be 300kPa assuming horizontal ground in front of the wall and no excavations for footings or service trenches. The upper 0.2m below bulk excavation level should be ignored in the design to cater for excavation tolerances.

- Following retaining wall construction and backfilling, we recommend that a dish drain be provided immediately uphill of the walls (where appropriate) to intercept surface water run-off. The discharge from such drains should be piped to the stormwater system.
- Backfill to retaining walls built in front of temporary soil batters should comprise engineered fill but where this is impractical due to the difficulty of compaction in confined areas we recommend that a single size durable gravel such as 20mm blue metal should be used. Blue metal does not require compaction in layers but should be tamped or vibrated until consolidation no longer occurs. A clay capping layer should be placed over the gravel and separated by a geofabric or surface slabs used to limit penetration of surface water into the backfill. Where backfill of narrow cavities in front of rock faces is required then either 2mm washed filter sand or 10mm blue metal gravel should be used.

4.3 Footings

4.3.1 Proposed Building

Excavation for the basement is expected to expose sandstone bedrock across the building footprint. Pad and strip footings may be designed using an allowable bearing pressure of 1000kPa for sandstone of at least low strength. Higher bearing pressures of 3500kPa should be feasible for most of the site within the bulk excavation. The following table outlines the depth and approximate rock classification for the four cored boreholes.

Borehole	Depth to Top of Bedrock Class* (m) [Approximate Reduced Level at Top of Bedrock Class (mAHD)]			
	V	IV	III	II or better
1	1.1 [54.9]	2.4 [53.6]	-	7.0 [49.0]
2	1.0 [54.9]	-	2.6 [53.3]†	8.0 [47.9]
3	1.7 [52.0]	-	4.6 [49.1]	8.5 [45.2]
4	0.1 [54.0]	1.1 [53.0]	-	6.2 [47.9]
5	0.6 [51.7]	-	0.9 [51.4]††	6.6 [45.7]
6	-	-	1.0 [50.1]‡	>9.6 [<41.5]

Notes on above table:

* Classification based on *Foundations on Shale and Sandstone in the Sydney Region* by Pells et al. (1998)

† Note a band of Class IV sandstone is present at 7.0m to 8.0m depth. 2

†† Note a band of Class V sandstone is present at 4.2m to 6.6m depth. 5

‡ Note a band of Class V sandstone is present at 5.9m to 7.8m depth.6

The following table presents serviceability end bearing pressures and allowable shaft adhesion values for the various rock classes as assessed in the table above. Where foundations are designed to found on Class II or better sandstone additional boreholes should be drilled to confirm the depth and presence of this stratum across the site particularly below the eastern portion of the ground floor footprint; spoon testing of footings may also be required. Where shoring piles are founded on Class II sandstone above BEL an ABP of up to 2,000kPa may be adopted.

Allowable and Ultimate Bearing Pressures

Classification of Sandstone	Allowable End Bearing Pressure (MPa)	Allowable Shaft Adhesion (kPa)*	Ultimate End Bearing Pressure (MPa)
V	0.8	50	3
IV	1.5	150	6
III	3.5	350	20
II or better	6.0	600	50

* Based on 'R2' roughness. When calculating shaft adhesion in tension (i.e. uplift) for the above rock profiles, the allowable shaft adhesion values above are to be halved.

Footings may also be designed using Limit State analysis procedures based on the ultimate end bearing pressures in the table above. Ultimate material values must be used in conjunction with an appropriate geotechnical reduction factor (ϕ_g) which must be calculated in accordance with the methodology outlined in AS2159-2009. The use of ultimate values will result in higher settlements and therefore specific analysis must be carried out to confirm that it is consistent with the required structural performance. Ultimate bearing pressures must only be adopted for footings founded below BEL. We can provide further advice in that regard if requested.

As a minimum requirement, the initial stages of footing excavation should be inspected by a geotechnical engineer to confirm that the recommended foundation has been reached and to check initial assumptions about foundation conditions and possible variations that may occur between borehole locations. The need for further inspections can be assessed following the initial visit. We can assist with the future geotechnical inspections if you wish to commission us at the appropriate time.

All footings should be excavated, cleaned, inspected and poured with minimal delay. If delays in pouring high level footings on weak, weathered rock are anticipated we recommend that the footing base be covered with a protective blinding layer of concrete.

4.3.2 Telstra Tower Footings

Footings for the proposed Telstra tower may comprise piled or pad footings which we recommend be founded within weathered sandstone. Depending on the final location and the depth to bedrock, the allowable end bearing and shaft adhesions in Section 4.3.1 may be adopted for design of footings on bedrock for the tower and equipment shelter. For the tower we anticipate that the vertical loads on the proposed foundation will be relatively light, and that the most critical loading is likely to be lateral and moment loading which will be transferred to the foundation. The following parameters may be adopted for footing design with respect to latera loading on single piled footings. The capacity should be checked for both drained and undrained conditions. The upper soil should be ignored in the lateral load calculation.

Stratum	c' (kPa)	ϕ' (°)	c_u (kPa)	E' (kPa)
XW/HW sandstone	10	30	300	50
Low or higher strength sandstone	100	35	500	200

If large pad footings are excavated to depths greater than 1.5m through soil and extremely weathered sandstone below existing ground surface levels then the sides of the excavation must be temporarily battered or benched or supported by a shoring system to reduce the risk to personnel working in the base of the excavation. Temporary batters or benches should be formed no steeper than 1V:1H. Sub-vertical cuts through low or greater strength rock may be suitable subject to inspection by a geotechnical engineer.

It is important that the design does not transfer lateral loads into the perimeter shoring system unless it has been designed to accommodate them. We recommend that the design be reviewed by JK Geotechnics prior to construction. Alternatively, the tower could be incorporated into the permanent structure rather than being a stand-alone structure.

4.4 Basement Floor Slabs

We expect that weathered sandstone will be uniformly exposed at bulk excavation level for the basement floor slabs. A subbase layer of durable, clean gravel should be placed below the slab to act as a separation layer between the basement and the bedrock and provide drainage.

As noted in Section 4.2, suitable long-term drainage should be allowed for behind all retaining walls, at the base of all sandstone cut faces and below the slab with a longitudinal fall to appropriate discharges. The gravel subbase layer could be incorporated as a drainage layer by using a free-draining granular material free of plastic fines or alternatively, a grid of subsoil drains could be constructed below the slab and subbase layer to capture seepage.

4.5 Further Geotechnical Input

The following is a summary of the further geotechnical input which is required and which has been detailed in the preceding sections of this report:

- Review of shoring design.
- Vibration monitoring/advice if excavation using hydraulic rock hammers is carried out.
- Progressive geotechnical inspections of rock cuts every 1.5m of vertical excavation.
- Inspection of footing excavations.

5 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.

A waste classification is required for any soil and/or bedrock excavated from the site prior to offsite disposal. Subject to the appropriate testing, material can be classified as Virgin Excavated Natural Material (VENM), Excavated Natural Material (ENM), General Solid, Restricted Solid or Hazardous Waste. Analysis can take up to seven to ten working days to complete, therefore, an adequate allowance should be included in the construction program unless testing is completed prior to construction. If contamination is encountered, then substantial further testing (and associated delays) could be expected. We strongly recommend that this requirement is addressed prior to the commencement of excavation on site.

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

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SOIL TEST SERVICES

TABLE A
POINT LOAD STRENGTH INDEX TEST REPORT

Client:	JK Geotechnics	**Ref No:**	33311ST
Project:	Proposed Mixed Use Development	**Report:**	A
Location:	274-274A Longueville Road & 4-18 Northwood Road, Longueville, NSW	**Report Date:**	20/07/2020
		Page 1 of 6	

BOREHOLE NUMBER	DEPTH m	$I_{S\ (50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
1	2.48 - 2.53	1.0	20
	2.90 - 2.93	0.6	12
	2.24 - 2.29	0.7	14
	2.63 - 2.68	0.9	18
	4.26 - 4.31	0.8	16
	4.87 - 4.92	0.5	10
	5.31 - 5.36	0.5	10
	5.87 - 5.92	1.6	32
	6.09 - 6.14	0.5	10
	6.54 - 6.59	0.1	2
	7.06 - 7.11	1.2	24
	7.69 - 7.73	0.5	10
	8.00 - 8.04	0.4	8
	8.22 - 8.27	1.0	20
	8.67 - 8.72	0.8	16
	9.04 - 9.09	0.7	14
	9.46 - 9.50	1.0	20
	9.90 - 9.94	1.1	22
	10.19 - 10.24	0.8	16
	10.82 - 10.87	1.0	20
	11.11 - 11.15	0.7	14
	11.74 - 11.79	1.2	24
	12.24 - 12.29	1.2	24
	12.85 - 12.89	1.3	26
	13.23 - 13.28	1.5	30

NOTES: See Page 6 of 6

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SOIL TEST SERVICES

TABLE A
POINT LOAD STRENGTH INDEX TEST REPORT

Client: JK Geotechnics
Project: Proposed Mixed Use Development
Location: 274-274A Longueville Road &
4-18 Northwood Road, Longueville, NSW

Ref No: 33311ST
Report: A
Report Date: 20/07/2020
Page 2 of 6

BOREHOLE NUMBER	DEPTH m	$I_{S\ (50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
1	13.82 - 13.87	1.4	28
	14.13 - 14.18	1.2	24
2	2.92 - 2.96	1.2	24
	3.10 - 3.13	0.7	14
	3.86 - 3.90	0.2	4
	4.21 - 4.24	1.3	26
	4.82 - 4.85	0.7	14
	5.13 - 5.16	1.5	30
	5.72 - 5.76	0.7	14
	6.14 - 6.18	0.6	12
	6.75 - 6.79	0.8	16
	7.03 - 7.07	0.4	8
	7.66 - 7.69	1.4	28
	8.16 - 8.20	1.2	24
	8.78 - 8.82	1.0	20
	9.20 - 9.24	1.3	26
	9.75 - 9.86	1.3	26
	10.09 - 10.14	0.8	16
	10.80 - 10.84	1.6	32
	11.15 - 15.20	1.6	32
	11.58 - 11.63	1.1	22
	12.11 - 12.16	1.3	26
	12.87 - 12.92	1.5	30
	13.06 - 13.11	1.6	32
	13.90 - 13.95	1.0	20

NOTES: See Page 6 of 6

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SOIL TEST SERVICES

TABLE A
POINT LOAD STRENGTH INDEX TEST REPORT

Client:	JK Geotechnics	**Ref No:**	33311ST
Project:	Proposed Mixed Use Development	**Report:**	A
Location:	274-274A Longueville Road & 4-18 Northwood Road, Longueville, NSW	**Report Date:**	20/07/2020
		Page 3 of 6	

BOREHOLE NUMBER	DEPTH m	$I_{S\ (50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
3	2.92 - 2.97	0.5	10
	3.42 - 3.46	0.2	4
	3.78 - 3.82	0.7	14
	4.66 - 4.71	0.6	12
	5.11 - 5.16	0.6	12
	5.70 - 5.75	0.7	14
	6.26 - 6.30	0.4	8
	6.66 - 6.70	0.3	6
	7.09 - 7.13	0.2	4
	7.74 - 7.74	0.5	10
	8.25 - 8.29	0.4	8
	8.54 - 8.59	0.6	12
	9.19 - 9.22	1.1	22
	9.69 - 9.74	0.6	12
	10.00 - 10.04	0.7	14
	1064 - 10.69	1.0	20
	11.10 - 11.15	1.3	26
	11.77 - 11.81	1.4	28
4	1.70 - 1.75	0.8	16
	2.39 - 2.43	1.5	30
	2.84 - 2.88	0.2	4
	3.25 - 3.30	0.2	4
	3.68 - 3.72	0.09	2
	3.86 - 3.90	0.7	14
	4.10 - 4.14	1.4	28

NOTES: See Page 6 of 6

TABLE A
POINT LOAD STRENGTH INDEX TEST REPORT

Client:	JK Geotechnics	**Ref No:**	33311ST
Project:	Proposed Mixed Use Development	**Report:**	A
Location:	274-274A Longueville Road & 4-18 Northwood Road, Longueville, NSW	**Report Date:**	20/07/2020
		Page 4 of 6	

BOREHOLE NUMBER	DEPTH m	$I_{S\ (50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
4	4.95 - 5.00	0.2	4
	5.25 - 5.30	0.2	4
	5.71 - 5.76	0.09	2
	5.95 - 6.00	0.2	4
	6.03 - 6.07	0.3	6
	6.29 - 6.33	2.2	44
	6.87 - 6.91	1.6	32
	7.28 - 7.32	1.3	26
	7.62 - 7.67	0.9	18
	7.96 - 8.00	1.4	28
	8.20 - 8.25	1.1	22
	8.79 - 8.84	1.1	22
	9.24 - 9.29	0.9	18
	9.77 - 9.82	0.7	14
	10.13 - 10.18	0.9	18
	10.55 - 10.60	1.1	22
	11.07 - 11.12	1.1	22
	11.75 - 11.80	1.1	22
	12.23 - 12.27	1.1	22
	12.72 - 12.76	1.3	26
	13.09 - 13.14	1.4	28
	13.88 - 13.42	1.3	26
5	0.91 - 0.95	0.8	16
	1.13 - 1.17	1.0	20
	1.64 - 1.69	1.3	26

NOTES: See Page 6 of 6

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TABLE A
POINT LOAD STRENGTH INDEX TEST REPORT

Client:	JK Geotechnics	**Ref No:**	33311ST
Project:	Proposed Mixed Use Development	**Report:**	A
Location:	274-274A Longueville Road & 4-18 Northwood Road, Longueville, NSW	**Report Date:**	20/07/2020
		Page 5 of 6	

BOREHOLE NUMBER	DEPTH m	$I_{S\ (50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
5	2.15 - 2.18	1.0	20
	2.80 - 2.84	1.0	20
	3.20 - 3.25	1.0	20
	3.78 - 3.82	0.9	18
	4.00 - 4.05	0.5	10
	4.43 - 4.48	0.3	6
	5.52 - 5.56	0.2	4
	6.09 - 6.13	0.09	2
	6.70 - 6.74	0.2	4
	7.14 - 7.18	0.4	8
	7.70 - 7.75	0.7	14
	8.18 - 8.22	0.9	18
	8.70 - 8.74	0.7	14
	9.21 - 9.25	0.6	12
	9.75 - 9.81	0.8	16
6	1.33 - 1.38	0.7	14
	2.04 - 2.07	0.5	10
	2.66 - 2.71	0.4	8
	3.22 - 3.27	0.7	14
	3.75 - 3.79	0.6	12
	4.23 - 4.27	0.3	6
	4.75 - 4.78	0.8	16
	5.06 - 5.11	0.6	12
	5.73 - 5.77	0.4	8
	6.15 - 6.20	0.5	10

NOTES: See Page 6 of 6

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SOIL TEST SERVICES

TABLE A
POINT LOAD STRENGTH INDEX TEST REPORT

Client:	JK Geotechnics	**Ref No:**	33311ST
Project:	Proposed Mixed Use Development	**Report:**	A
Location:	274-274A Longueville Road & 4-18 Northwood Road, Longueville, NSW	**Report Date:**	20/07/2020
		Page 6 of 6	

BOREHOLE NUMBER	DEPTH m	$I_{S\ (50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
6	6.78 - 6.82	0.7	14
	7.21 - 7.26	0.09	2
	7.82 - 7.87	0.6	12
	8.20 - 8.25	0.3	6
	8.95 - 8.98	0.5	10
	9.27 - 9.32	0.4	8

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 0.1MPa, or to one significant figure if less than 0.1MPa
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 $I_{S\ (50)}$

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12 Ashley St Chatswood NSW 2067
ph 02 9910 6200   fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 246917

Client Details

Client	JK Geotechnics
Attention	Arthur Billingham
Address	PO Box 976, North Ryde BC, NSW, 1670

Sample Details

Your Reference	**33311ST, Lane Cove**
Number of Samples	3 Soil
Date samples received	14/07/2020
Date completed instructions received	14/07/2020

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.

Report Details

Date results requested by	21/07/2020
Date of Issue	20/07/2020

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Results Approved By
Priya Samarawickrama, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

Misc Inorg - Soil				
Our Reference		246917-1	246917-2	246917-3
Your Reference	UNITS	1	3	6
Date Sampled		08/07/2020	06/07/2020	03/07/2020
Type of sample		Soil	Soil	Soil
Date prepared	-	16/07/2020	16/07/2020	16/07/2020
Date analysed	-	16/07/2020	16/07/2020	16/07/2020
pH 1:5 soil:water	pH Units	7.6	6.3	6.0
Chloride, Cl 1:5 soil:water	mg/kg	160	26	<10
Sulphate, SO4 1:5 soil:water	mg/kg	290	<10	20
Resistivity in soil*	ohm m	36	330	480

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA 22nd ED 2510 and Rayment & Lyons. Resistivity is calculated from Conductivity (non NATA). Resistivity (calculated) may not correlate with results otherwise obtained using Resistivity-Current method, depending on the nature of the soil being analysed.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	246917-3
Date prepared	-			16/07/2020	[NT]	[NT]	[NT]	[NT]	16/07/2020	16/07/2020
Date analysed	-			16/07/2020	[NT]	[NT]	[NT]	[NT]	16/07/2020	16/07/2020
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	[NT]	[NT]	102	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	110	99
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	116	122
Resistivity in soil*	ohm m	1	Inorg-002	<1	[NT]	[NT]	[NT]	[NT]	100	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

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.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

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: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics 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.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

JKGeotechnics

BOREHOLE LOG

Borehole No.
1
1 / 3

Client: PATHWAYS PROPERTY GROUP
Project: PROPOSED MIXED USED DEVELOPMENT
Location: 274-274A LONGUEVILLE ROAD & 4-18 NORTHWOOD ROAD, LANE COVE, NSW

Job No.: 33311ST **Method:** SPIRAL AUGER **R.L. Surface:** ~56.0 m
Date: 8/7/20 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** B.A./A.B.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING				■					-	BRICK LAYER: 60mm.t	M			
								▩		FILL: Sand, fine to medium grained, yellow brown, with fine to medium grained ironstone and sandstone gravel.	w~PL			
				■	N = 10 4,4,6			▨	CI	FILL: Sandy clay, low to medium plasticity, grey and dark brown, trace of fine to medium grained sandstone gravel, trace of slag and root fibres.	w~PL	Hd	500 >600 >600	RESIDUAL
						55	1	▨		Silty CLAY: medium plasticity, brown, yellow brown and orange brown, trace of fine grained sand and root fibres.				
				■		54	2	░	-	SANDSTONE: fine to medium grained, light grey and brown.	DW	VL - L		HAWKESBURY SANDTONE LOW 'TC' BIT RESISTANCE
						53 52 51 50	3 4 5 6			REFER TO CORED BOREHOLE LOG				

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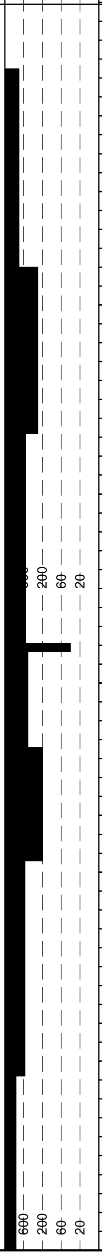
CORED BOREHOLE LOG

Borehole No.
1
2 / 3

Client: PATHWAYS PROPERTY GROUP
Project: PROPOSED MIXED USED DEVELOPMENT
Location: 274-274A LONGUEVILLE ROAD & 4-18 NORTHWOOD ROAD, LANE COVE, NSW

Job No.: 33311ST
Date: 8/7/20
Plant Type: JK205
Core Size: NMLC
Inclination: VERTICAL
Bearing: N/A
R.L. Surface: ~56.0 m
Datum: AHD
Logged/Checked By: B.A./A.B.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	CORE DESCRIPTION Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ VL 0.1, L 0.3, M 1, H 3, VH 10, EH	DEFECT DETAILS DESCRIPTION Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness Specific	General	Formation
				START CORING AT 2.41m						
100% RETURN				SANDSTONE: fine to medium grained, light grey, with dark grey laminae, bedded at 0-15°.	SW	M - H	1.0			Hawkesbury Sandstone
								(2.75m) XWS, 0°, 20 mm.t		
							0.60			
		53	3							
							0.70			
							0.90			
								(3.80m) XWS, 0°, 140 mm.t		
		52	4							
								(4.04m) J, 50°, Ir, R, Cn		
							0.80			
								(4.47m) XWS, 0°, 20 mm.t		
								(4.68m) XWS, 3°, 10 mm.t		
							0.50			
		51	5							
								(5.20m) XWS, 0°, 110 mm.t		
							0.50			
								(5.79m) Be, 3°, Ir, R, Clay Ct		
								(5.83m) Be, 3°, Ir, R, Clay Ct		
							1.6			
		50	6							
							0.50			
								(6.34m) XWS, 0°, 80 mm.t		
								(6.43m) CS, 0°, 110 mm.t		
							0.10			
								(6.75m) XWS, 0°, 15 mm.t		
								(6.94m) J, 40 - 90°, Ir, R, Cn		
		49	7							
							1.2			
								(7.59m) CS, 0°, 25 mm.t		
							0.50			
		48	8				0.40			
								(8.08m) XWS, 0°, 25 mm.t		
				as above, but with red brown and orange brown iron indurated bands.			1.0			
							0.80			



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FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS

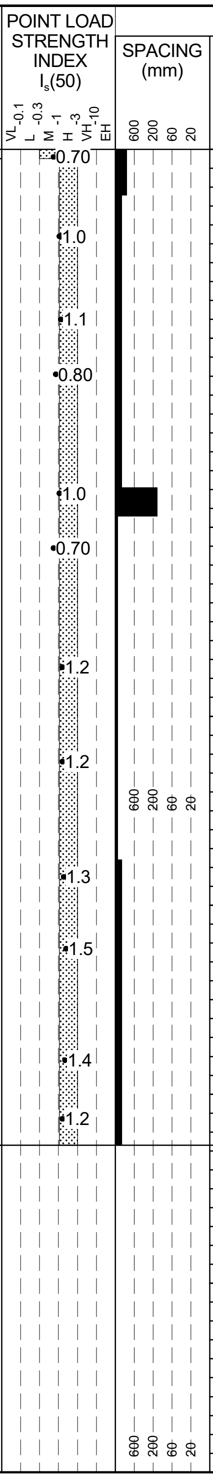
CORED BOREHOLE LOG

Borehole No.
1
3 / 3

Client: PATHWAYS PROPERTY GROUP
Project: PROPOSED MIXED USED DEVELOPMENT
Location: 274-274A LONGUEVILLE ROAD & 4-18 NORTHWOOD ROAD, LANE COVE, NSW

Job No.: 33311ST
Core Size: NMLC
R.L. Surface: ~56.0 m
Date: 8/7/20
Inclination: VERTICAL
Datum: AHD
Plant Type: JK205
Bearing: N/A
Logged/Checked By: B.A./A.B.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Core Description: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	Point Load Strength Index $I_s(50)$	Defect Details – Description (Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness): Specific	General	Formation
100% RETURN				SANDSTONE: fine to medium grained, light grey, with grey and dark grey laminae, and occasional carbonaceous bands, bedded sub-horizontally.	FR	H	0.70	(9.24m) Be, 2°, Ir, R, Clay Cn		Hawkesbury Sandstone
							1.0			
		46	10				1.1			
							0.80			
							1.0	(10.77m) Be, 3°, P, S, Clay Ct		
		45	11				0.70	(10.94m) Be, 2°, P, R, Clay Ct		
							1.2			
		44	12				1.2			
							1.3	(12.76m) Be, 0°, P, R, Clay Ct		
		43	13				1.5			
							1.4			
		42	14				1.2			
				END OF BOREHOLE AT 14.27 m						
		41	15							



FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS

Job No: 33311ST
Borehole No: BH1
Depth: 2.41m - 14.27m

JOB NO. 33311ST BH1 CORING STARTS AT 2.41m

END OF BOREHOLE AT 14.27m

BOREHOLE LOG

Borehole No.
2
1 / 3

Client: PATHWAYS PROPERTY GROUP
Project: PROPOSED MIXED USED DEVELOPMENT
Location: 274-274A LONGUEVILLE ROAD & 4-18 NORTHWOOD ROAD, LANE COVE, NSW

Job No.: 33311ST
Method: SPIRAL AUGER
R.L. Surface: ~55.9 m
Date: 6/7/20
Datum: AHD
Plant Type: JK205
Logged/Checked By: A.B./P.S.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING										CONCRETE: 130mm.t				8mm DIA. REINFORCEMENT 76mm TOP COVER AND 5mm DIA. REINFORCEMENT 85mm TOP COVER
									-	FILL: Sand, fine to coarse grained, yellow brown.	M			
										FILL: Silty clay, high plasticity, grey brown, trace of fine to coarse grained igneous and ironstone gravel.	w>PL			HAND AUGER
						55	1		CI	Silty CLAY: medium plasticity, orange brown mottled light grey, trace of fine grained sand.	w>PL	(St - VSt)		RESIDUAL
ON 22/7/20 ▽ AFTER 1.5 HRS ON COMPLETION OF CORING ▽					N=SPT 3/ 50mm REFUSAL	54	2		-	Extremely Weathered sandstone: SAND, fine to coarse grained, light grey, with 0.1m.t to 0.2m.t medium strength brown and red brown ironstone bands and silty clay seams.	XW	D		HAWKESBURY SANDSTONE VERY LOW 'TC' BIT RESISTANCE WITH MODERATE BANDS
										SANDSTONE: fine to medium grained, yellow brown.	DW	M		MODERATE RESISTANCE
						53	3			REFER TO CORED BOREHOLE LOG				GROUNDWATER MONITORING WELL INSTALLED TO 12.11m. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 6.11m TO 12.11m. CASING 0.11m TO 6.11m. 2mm SAND FILTER PACK 1.5m TO 0m. BENTONITE SEAL 0.11m TO 1.5m. COMPLETED WITH A CONCRETED GATIC COVER.
						52	4							
						51	5							
						50	6							
						49								

JK 9.02.4 LIB.GLB Log JK AUGERHOLE - MASTER 33311ST LANECOVE.GPJ <<DrawingFile>> 24/07/2020 12:31 10.01.00.01 Datgel Lab and In Situ Tool - DGD | Lib: JK 9.02.4 2019-05-31 Prj: JK 9.01.0 2018-03-20

CORED BOREHOLE LOG

Borehole No.
2
2 / 3

Client: PATHWAYS PROPERTY GROUP
Project: PROPOSED MIXED USED DEVELOPMENT
Location: 274-274A LONGUEVILLE ROAD & 4-18 NORTHWOOD ROAD, LANE COVE, NSW

Job No.: 33311ST
Core Size: NMLC
R.L. Surface: ~55.9 m
Date: 6/7/20
Inclination: VERTICAL
Datum: AHD
Plant Type: JK205
Bearing: N/A
Logged/Checked By: A.B./P.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ VL 0.1, L 0.3, M 1, H 3, VH 10, EH	DEFECT DETAILS SPACING (mm) 600 200 60 20	DEFECT DETAILS DESCRIPTION Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness Specific	General	Formation
					START CORING AT 2.87m							
100% RETURN		53	3		SANDSTONE: fine to medium grained, red brown and light grey, bedded sub-horizontally.	MW	M - H	1.2 0.70				Hawkesbury Sandstone
		52	4		SANDSTONE: fine to medium grained, light grey, with grey bands, bedded sub-horizontally.	SW		0.20 1.3		(3.65m) CS, 0°, 40 mm.t (3.96m) XWS, 0°, 4 mm.t (4.68m) Be, 0°, P, S, Fe Sn		
		51	5		as above, but bedded at 5*-15°.			0.70 1.5		(4.97m) J, 90°, P, S, Cn (5.02m) XWS, 0°, 3 mm.t (5.32m) CS, 0°, 4 mm.t (5.41m) J, 60°, P, R, Fe Sn (5.46m) J, 10°, P, R, Fe Sn		
		50 49	6 7		SANDSTONE: fine grained, light grey, with grey and orange brown bands, bedded sub-horizontally.			0.70 0.60 0.80 0.40		(7.13m) XWS, 0°, 1 mm.t		
					Extremely Weathered siltstone: silty CLAY, medium plasticity, dark grey.	XW	Hd					
		48 47	8		SANDSTONE: fine to medium grained, light grey, grey bands, bedded at 0-10°.	SW	H	1.4 1.2 1.0		(7.91m) J, 10°, P, S, Clay Vn (7.93m) J, 40°, P, S, Cn (7.95m) J, 10°, P, S, Clay Vn, Fe, Sn (8.00m) XWS, 0°, 4 mm.t (8.92m) XWS, 0°, 5 mm.t		

JK 9.02.4 LIB.GLB Log JK CORED BOREHOLE - MASTER 33311ST LANECOVE.GPJ <<DrawingFile>> 24/07/2020 12:31 10.01.00.01 Datgel Lab and In Situ Tool - DGD | Lib: JK 9.02.4 2019-05-31 Prj: JK 9.01.0 2018-03-20

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS

CORED BOREHOLE LOG

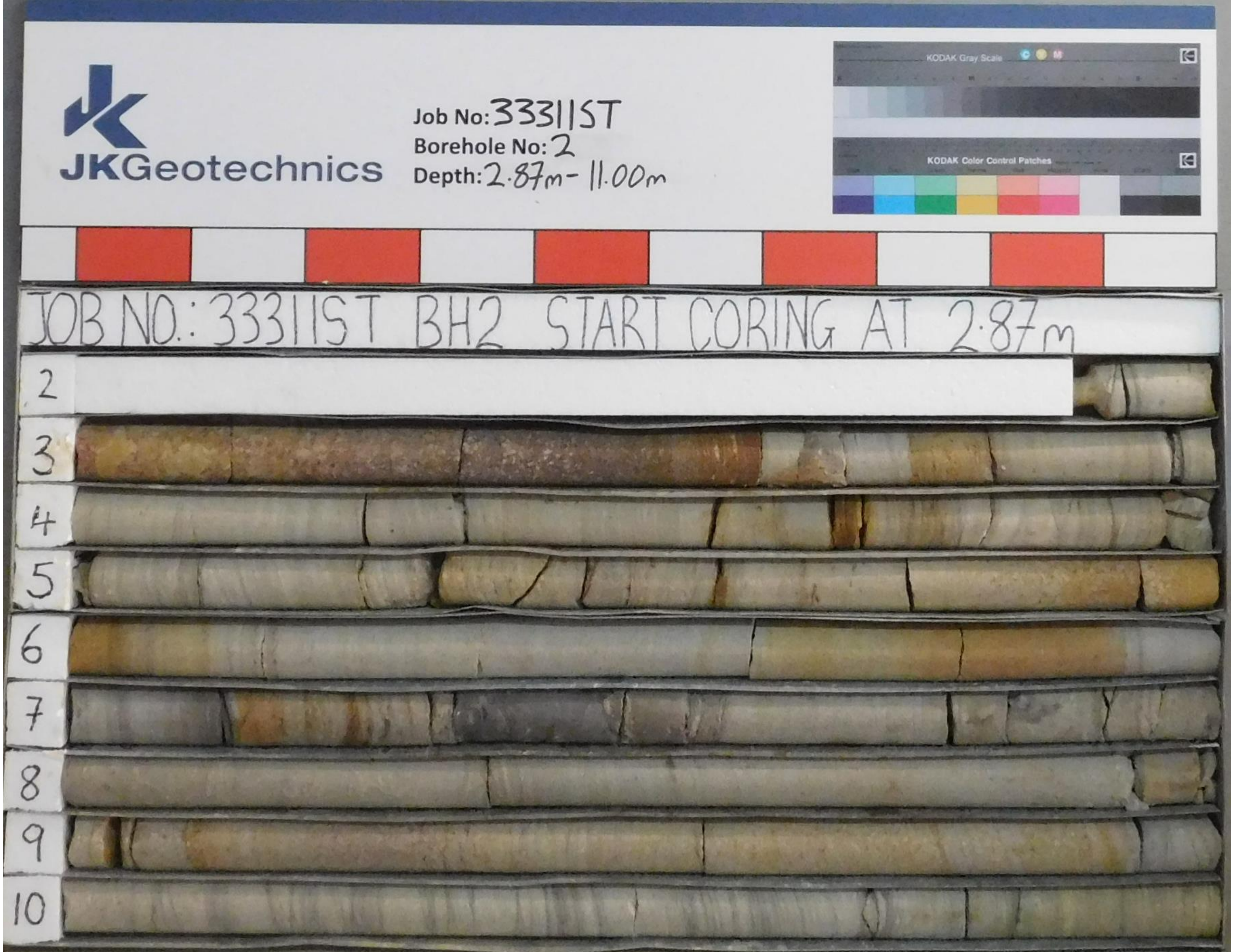
Borehole No.
2
3 / 3

Client: PATHWAYS PROPERTY GROUP
Project: PROPOSED MIXED USED DEVELOPMENT
Location: 274-274A LONGUEVILLE ROAD & 4-18 NORTHWOOD ROAD, LANE COVE, NSW

Job No.: 33311ST
Core Size: NMLC
R.L. Surface: ~55.9 m
Date: 6/7/20
Inclination: VERTICAL
Datum: AHD
Plant Type: JK205
Bearing: N/A
Logged/Checked By: A.B./P.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ VL 0.1 L 0.3 M 1 H 3 VH 10 EH	DEFECT DETAILS SPACING (mm) 600 200 60 20	DEFECT DETAILS DESCRIPTION Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness Specific	General	Formation
AFTER PUMP OUT ON 6/7/20	100% RETURN	46		⠿	SANDSTONE: fine to medium grained, orange brown and light grey, bedded sub-horizontally.	SW	H	1.3 1.3		(9.03m) J, 10°, P, S, Fe Sn		Hawkesbury Sandstone
		45 44 43 42	10 11 12 13 14	⠿	SANDSTONE: fine to medium grained, light grey, with grey bands and dark grey laminae, bedded sub-horizontally.	FR		0.80 1.6 1.6 1.1 1.3 1.5 1.6 1.0	600 200 60 20			
		41 40	15		END OF BOREHOLE AT 14.21 m				600 200 60 20			

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


JKGeotechnics
Job No: 33311ST
Borehole No: 2
Depth: 2.87m - 11.00m
KODAK Gray Scale
KODAK Color Control Patches
JOB NO.: 33311ST BH2 START CORING AT 2.87m
2
3
4
5
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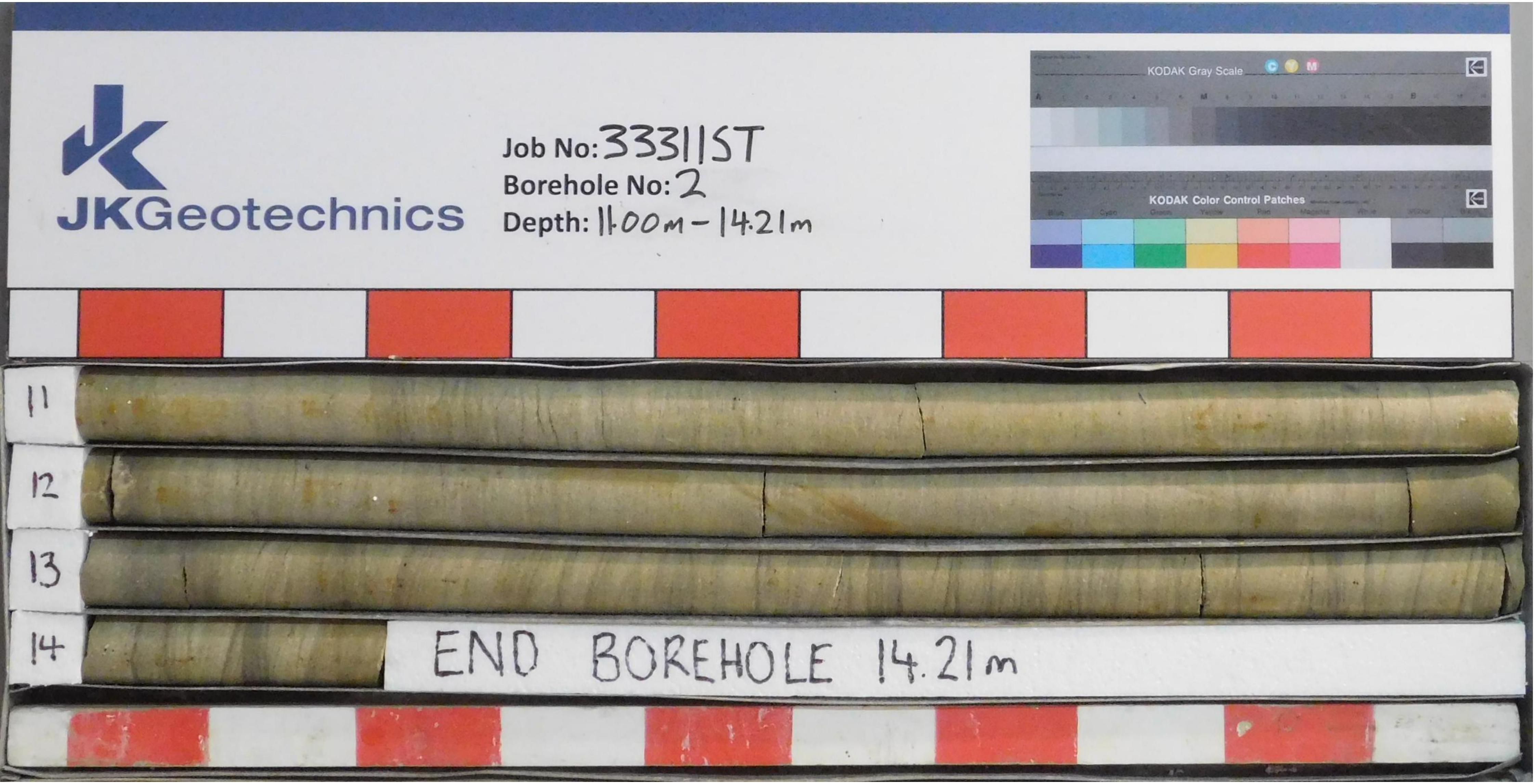


JKGeotechnics

Job No: 33311ST

Borehole No: 2

Depth: 11.00m – 14.21m

END BOREHOLE 14.21m

JKGeotechnics

BOREHOLE LOG

Borehole No.
3
1 / 3

Client: PATHWAYS PROPERTY GROUP
Project: PROPOSED MIXED USED DEVELOPMENT
Location: 274-274A LONGUEVILLE ROAD & 4-18 NORTHWOOD ROAD, LANE COVE, NSW

Job No.: 33311ST
Method: SPIRAL AUGER
R.L. Surface: ~53.7 m
Date: 6/7/20
Datum: AHD
Plant Type: JK205
Logged/Checked By: A.B./P.S.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING									CONCRETE: 120mm.t				7mm DIA. REINFORCEMENT 55mm TOP COVER
								-	FILL: Gravelly sand, fine to coarse grained, dark grey, fine to medium grained igneous gravel.	M			
				■	N = 15 9,9,6	53	1		FILL: Sandy clay, low plasticity, brown and grey, fine to medium grained, with fine to medium grained ironstone and sandstone gravel, trace of slag and ash.	w~PL			APPEARS WELL COMPACTED
				■	N = 21 4,12,9	52		CI	Silty CLAY: medium plasticity, light brown, trace of fine grained sand.	w>PL	St VSt	170 310	RESIDUAL
				■		51	2	-	Extremely Weathered sandstone: SAND, fine to medium grained, light grey, with ironstone bands.	XW	D		HAWKESBURY SANDSTONE STRONG HYDROCARBON ODOUR
									SANDSTONE: fine to medium grained, light grey.	DW	M		MODERATE 'TC' BIT RESISTANCE
						50 49 48 47	3 4 5 6		REFER TO CORED BOREHOLE LOG				

CORED BOREHOLE LOG

Borehole No.
3
2 / 3

Client: PATHWAYS PROPERTY GROUP
Project: PROPOSED MIXED USED DEVELOPMENT
Location: 274-274A LONGUEVILLE ROAD & 4-18 NORTHWOOD ROAD, LANE COVE, NSW

Job No.: 33311ST
Core Size: NMLC
R.L. Surface: ~53.7 m
Date: 6/7/20
Inclination: VERTICAL
Datum: AHD
Plant Type: JK205
Bearing: N/A
Logged/Checked By: A.B./P.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ VL -0.1 L -0.3 M -1 H -3 VH -10 EH	DEFECT DETAILS SPACING (mm) 600 200 60 20	DEFECT DETAILS DESCRIPTION Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness Specific General	Formation
		51			START CORING AT 2.88m						
100% RETURN		50	3		SANDSTONE: fine to medium grained, light grey, bedded sub-horizontally.	SW	M	0.50 0.20		(3.20m) J, 80 - 90°, P, S, Root FILLED (3.57m) J, 10°, P, S, Clay FILLED	Hawkesbury Sandstone
					as above, but with orange brown iron staining.			0.70			
			4		NO CORE 0.22m						
		49			SANDSTONE: fine to medium grained, light grey and orange brown, bedded sub-horizontally.	MW	L - M			(4.25m) J, 90°, P, S, Cn (4.29m) CS, 0°, 10 mm.t (4.33m) XWS, 0°, 30 mm.t (4.43m) XWS, 0°, 20 mm.t (4.49m) CS, 0°, 5 mm.t (4.56m) J, 20°, P, S, Cn (4.58m) J, 30°, P, S, Cn	Hawkesbury Sandstone
		48 47	5 6 7			SW	M	0.60 0.60 0.70 0.40 0.30 0.20	600 200 60 20	(5.90m) J, 20°, P, S, Clay Ct (6.80m) XWS, 0°, 1 mm.t (7.25m) J, 20°, P, S, Cn	
		46 45	8		SANDSTONE: fine to medium grained, light grey, with grey bands, dark grey laminae, bedded sub-horizontally.	FR		0.50 0.40 0.60	600 200 60 20	(8.84m) J, 70°, P, R, Fe Sn	

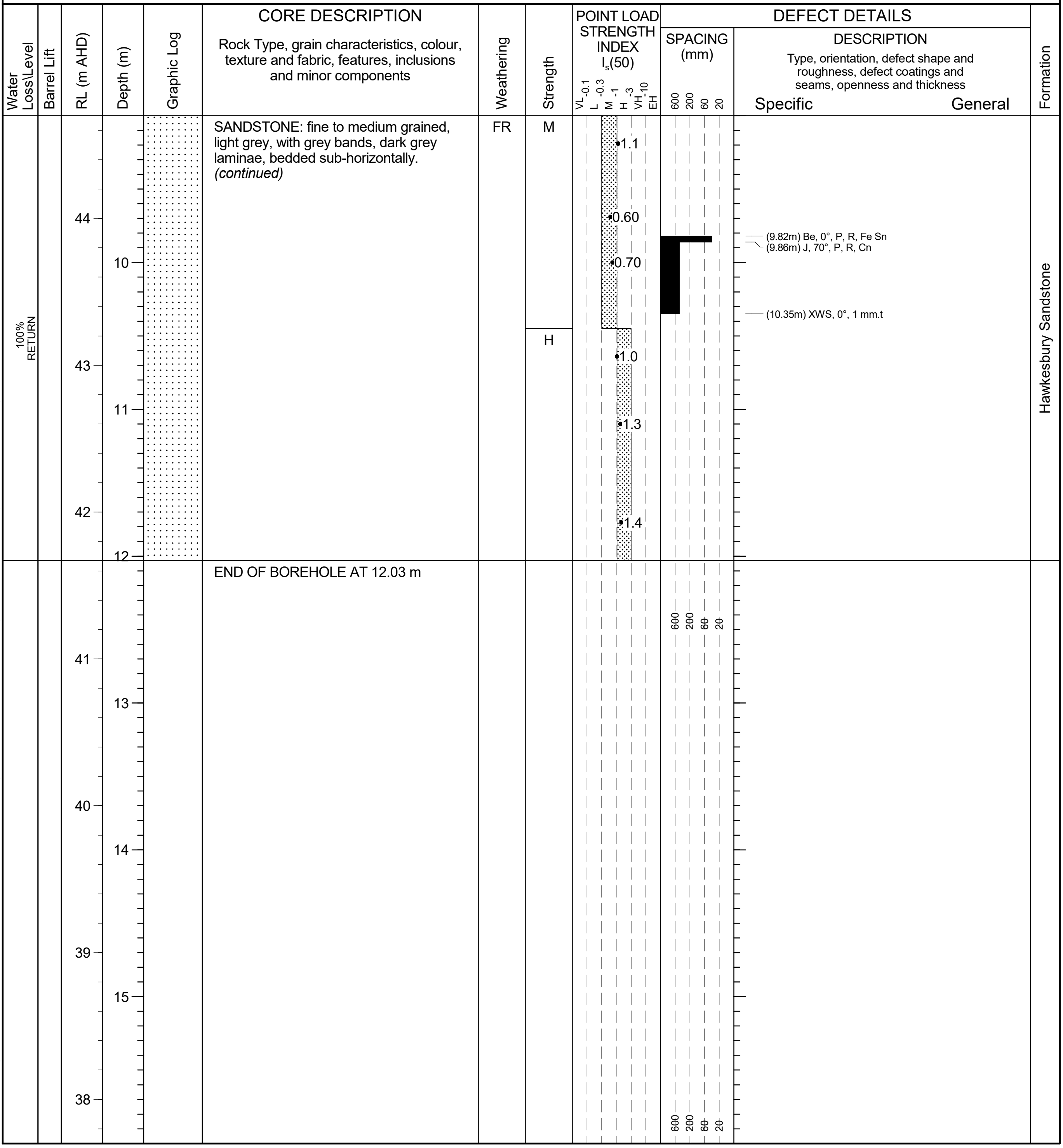
FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS

CORED BOREHOLE LOG

Borehole No.
3
3 / 3

Client: PATHWAYS PROPERTY GROUP
Project: PROPOSED MIXED USED DEVELOPMENT
Location: 274-274A LONGUEVILLE ROAD & 4-18 NORTHWOOD ROAD, LANE COVE, NSW

Job No.: 33311ST
Date: 6/7/20
Plant Type: JK205
Core Size: NMLC
Inclination: VERTICAL
Bearing: N/A
R.L. Surface: ~53.7 m
Datum: AHD
Logged/Checked By: A.B./P.S.



SANDSTONE: fine to medium grained, light grey, with grey bands, dark grey laminae, bedded sub-horizontally. *(continued)*

(9.82m) Be, 0°, P, R, Fe Sn
(9.86m) J, 70°, P, R, Cn
(10.35m) XWS, 0°, 1 mm.t

END OF BOREHOLE AT 12.03 m

JK 9.02.4 LIB.GLB Log JK CORED BOREHOLE - MASTER 33311ST LANECOVE.GPJ <<DrawingFile>> 24/07/2020 12:31 10.01.00.01 Datgel Lab and In Situ Tool - DGD | Lib: JK 9.02.4 2019-05-31 Prj: JK 9.01.0 2018-03-20

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS

JKGeotechnics

Job No: 3331IST

Borehole No: 3

Depth: 2.88m – 11.00m

JOB No. 3331IST BH3 START CORING AT 2.88m

JKGeotechnics

Job No: 33311ST

Borehole No: 3

Depth: 11.00m - 12.03m

END BOREHOLE 12.03m

BOREHOLE LOG

Borehole No.
4
1 / 3

Client: PATHWAYS PROPERTY GROUP
Project: PROPOSED MIXED USED DEVELOPMENT
Location: 274-274A LONGUEVILLE ROAD & 4-18 NORTHWOOD ROAD, LANE COVE, NSW

Job No.: 33311ST
Method: SPIRAL AUGER
R.L. Surface: ~54.1 m
Date: 8/7/20
Datum: AHD
Plant Type: JK205
Logged/Checked By: B.A./A.B.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING						54				CONCRETE: 65mm.t				NO OBSERVED REINFORCEMENT
									-	Extremely Weathered sandstone: silty clayey SAND, fine to medium grained, yellow brown.	XW	D		HAWKESBURY SANDSTONE
							1			SANDSTONE: fine to medium grained, yellow brown and orange brown, with extremely weathered seams.	DW	VL		LOW 'TC' BIT RESISTANCE
						53				SANDSTONE: fine to medium grained, orange brown and red brown, iron indurated.		M		MODERATE TO HIGH RESISTANCE
						52 51 50 49 48	2 3 4 5 6			REFER TO CORED BOREHOLE LOG				

JKGeotechnics

CORED BOREHOLE LOG

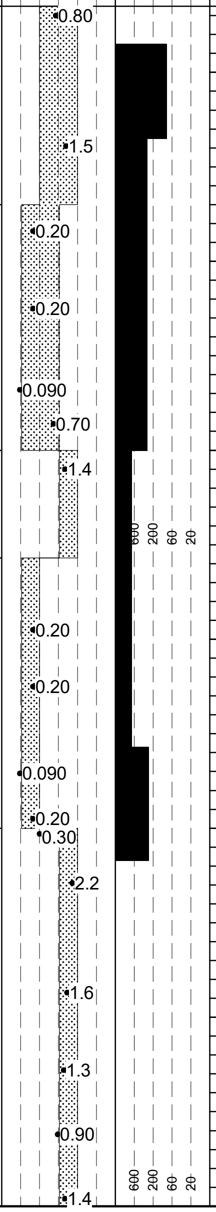
Borehole No.
4
2 / 3

Client: PATHWAYS PROPERTY GROUP
Project: PROPOSED MIXED USED DEVELOPMENT
Location: 274-274A LONGUEVILLE ROAD & 4-18 NORTHWOOD ROAD, LANE COVE, NSW

Job No.: 33311ST
Core Size: NMLC
R.L. Surface: ~54.1 m
Date: 8/7/20
Inclination: VERTICAL
Datum: AHD
Plant Type: JK205
Bearing: N/A
Logged/Checked By: B.A./A.B.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	Formation
		53			START CORING AT 1.65m			
		52	2		SANDSTONE: fine to medium grained, light grey, with orange brown iron indurated bands, bedded sub-horizontally.	MW	M - H	Hawkesbury Sandstone
		51	3				L - M	
		50	4		SANDSTONE: fine to medium grained, red brown and orange brown, iron indurated bedded sub-horizontally.		H	
		49	5		SANDSTONE: fine to medium grained, light grey, with occasional grey bands and carbonaceous laminae, bedded sub-horizontally.		L	
		48	6		SANDSTONE: fine to medium grained, red brown and light grey, bedded at 5-10°.		H	
		47	7					

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



DEFECT DETAILS — DESCRIPTION
Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness

Specific	General
(1.85m) J, 80 - 90°, Ir, R, Clay Ct	
(1.96m) CS, 0°, 60 mm.t	
(2.05m) XWS, 0°, 20 mm.t	
(2.13m) J, 60 - 90°, Ir, R, Roots FILLED	
(2.22m) XWS, 0°, 10 mm.t	
(2.35m) XWS, 0°, 5 mm.t	
(2.70m) XWS, 0°, 5 mm.t	
(3.07m) XWS, 0°, 140 mm.t	
(3.46m) Jh, 55°, P	
(3.79m) XWS, 0°, 5 mm.t	
(4.00m) J, 40°, P, R, Fe Sn	
(4.71m) XWS, 0°, 220 mm.t	
(5.57m) XWS, 0°, 20 mm.t	
(5.88m) XWS, 0°, 70 mm.t	
(6.17m) CS, 3°, 20 mm.t	

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS

CORED BOREHOLE LOG

Borehole No.
4
3 / 3

Client: PATHWAYS PROPERTY GROUP
Project: PROPOSED MIXED USED DEVELOPMENT
Location: 274-274A LONGUEVILLE ROAD & 4-18 NORTHWOOD ROAD, LANE COVE, NSW

Job No.: 33311ST
Date: 8/7/20
Plant Type: JK205
Core Size: NMLC
Inclination: VERTICAL
Bearing: N/A
R.L. Surface: ~54.1 m
Datum: AHD
Logged/Checked By: B.A./A.B.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ VL -0.1, L -0.3, M -1, H -3, VH -10, EH	DEFECT DETAILS SPACING (mm) 600, 200, 60, 20	DEFECT DETAILS DESCRIPTION Specific Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness	General	Formation
		46 45 44 43 42 41	9 10 11 12 13		SANDSTONE: fine to medium grained, light grey, with grey bands, and occasional carbonaceous laminae, bedded sub-horizontally.	FR	H	1.1 1.1 0.90 0.70 0.90 1.1 1.1 1.1 1.1 1.3 1.4		(8.16m) Be, 2°, P, S, Clay Ct (9.67m) Be, 2°, P, S, Clay Ct		Hawkesbury Sandstone
		40	14		END OF BOREHOLE AT 13.51 m							

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FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS

Job No: 33311ST
Borehole No: BH4
Depth: 1.65m - 13.51m

BOREHOLE LOG

Borehole No.
5
1 / 3

Client: PATHWAYS PROPERTY GROUP
Project: PROPOSED MIXED USED DEVELOPMENT
Location: 274-274A LONGUEVILLE ROAD & 4-18 NORTHWOOD ROAD, LANE COVE, NSW

Job No.: 33311ST **Method:** SPIRAL AUGER **R.L. Surface:** ~52.3 m
Date: 2/7/20 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** S.D./A.B.

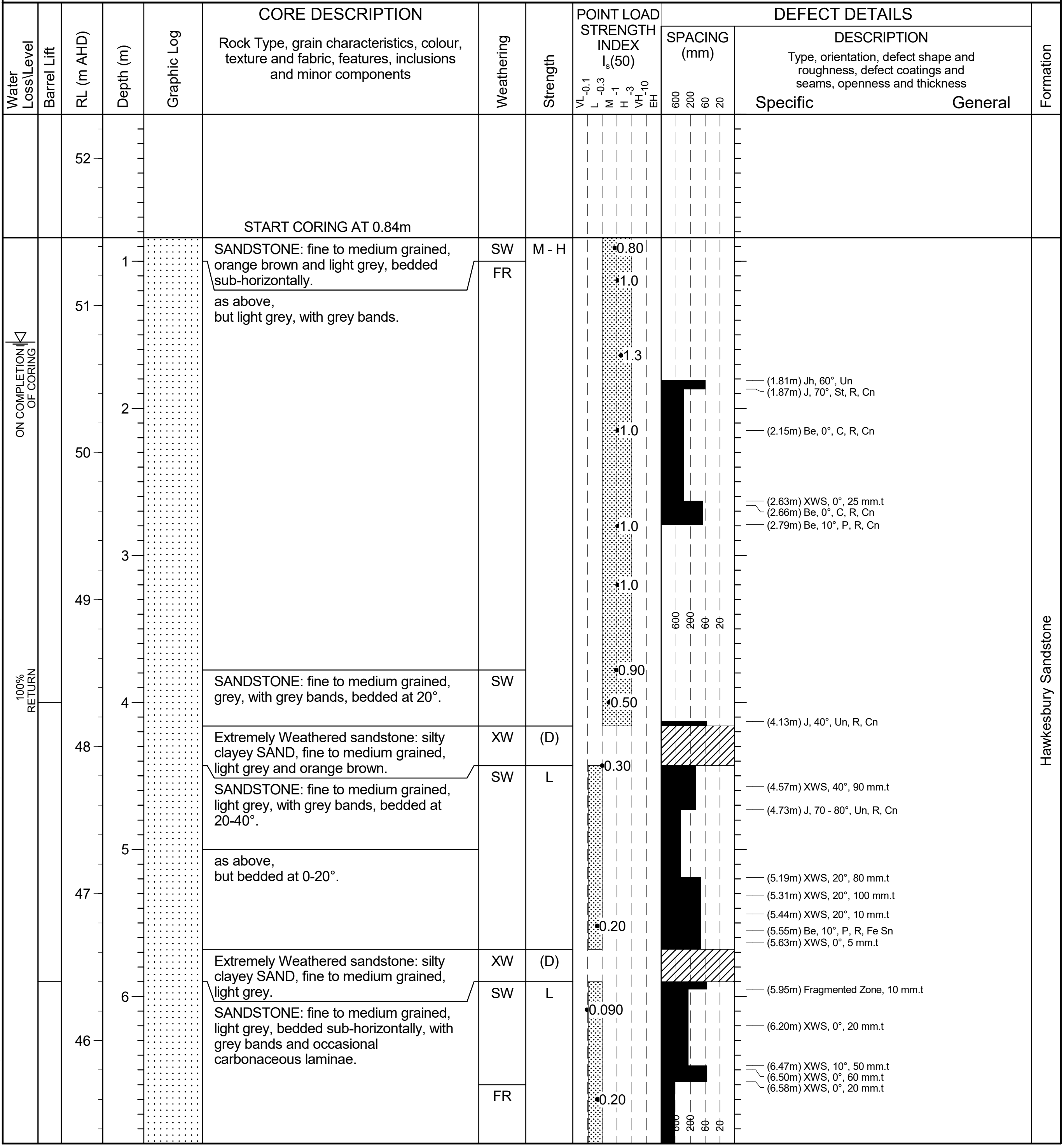
Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING										ASPHALTIC CONCRETE: 90mm.t				
									-	FILL: Silty gravelly sand, fine to medium grained, dark grey, with fine to medium grained igneous gravel.				
						52			SC	Silty clayey SAND: fine to medium grained, grey brown, trace of ash and root fibres.	M	(L)		RESIDUAL
				■	N > 12 2,9,3/ 4mm REFUSAL				-	Extremely Weathered sandstone: SAND: fine to medium grained, light grey and orange brown.	XW	(D)		HAWKESBURY SANDSTONE
							1			SANDSTONE: fine to medium grained, orange brown. REFER TO CORED BOREHOLE LOG	DW	M - H		
						51								
							2							
						50								
							3							
						49								
							4							
						48								
							5							
						47								
							6							
						46								

CORED BOREHOLE LOG

Borehole No.
5
2 / 3

Client: PATHWAYS PROPERTY GROUP
Project: PROPOSED MIXED USED DEVELOPMENT
Location: 274-274A LONGUEVILLE ROAD & 4-18 NORTHWOOD ROAD, LANE COVE, NSW

Job No.: 33311ST
Core Size: NMLC
R.L. Surface: ~52.3 m
Date: 2/7/20
Inclination: VERTICAL
Datum: AHD
Plant Type: JK205
Bearing: N/A
Logged/Checked By: S.D./A.B.



CORE DESCRIPTION Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength
START CORING AT 0.84m		
SANDSTONE: fine to medium grained, orange brown and light grey, bedded sub-horizontally.	SW	M - H
as above, but light grey, with grey bands.	FR	
SANDSTONE: fine to medium grained, grey, with grey bands, bedded at 20°.	SW	
Extremely Weathered sandstone: silty clayey SAND, fine to medium grained, light grey and orange brown.	XW	(D)
SANDSTONE: fine to medium grained, light grey, with grey bands, bedded at 20-40°.	SW	L
as above, but bedded at 0-20°.		
Extremely Weathered sandstone: silty clayey SAND, fine to medium grained, light grey.	XW	(D)
SANDSTONE: fine to medium grained, light grey, bedded sub-horizontally, with grey bands and occasional carbonaceous laminae.	SW	L
	FR	

DEFECT DETAILS

DESCRIPTION
Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness

Specific

(1.81m) Jh, 60°, Un
(1.87m) J, 70°, St, R, Cn
(2.15m) Be, 0°, C, R, Cn
(2.63m) XWS, 0°, 25 mm.t
(2.66m) Be, 0°, C, R, Cn
(2.79m) Be, 10°, P, R, Cn
(4.13m) J, 40°, Un, R, Cn
(4.57m) XWS, 40°, 90 mm.t
(4.73m) J, 70 - 80°, Un, R, Cn
(5.19m) XWS, 20°, 80 mm.t
(5.31m) XWS, 20°, 100 mm.t
(5.44m) XWS, 20°, 10 mm.t
(5.55m) Be, 10°, P, R, Fe Sn
(5.63m) XWS, 0°, 5 mm.t
(5.95m) Fragmented Zone, 10 mm.t
(6.20m) XWS, 0°, 20 mm.t
(6.47m) XWS, 10°, 50 mm.t
(6.50m) XWS, 0°, 60 mm.t
(6.58m) XWS, 0°, 20 mm.t

General

Formation: Hawkesbury Sandstone

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS

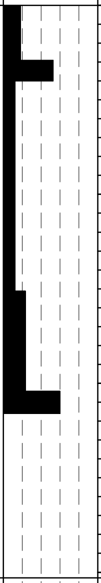
CORED BOREHOLE LOG

Borehole No.
5
3 / 3

Client: PATHWAYS PROPERTY GROUP
Project: PROPOSED MIXED USED DEVELOPMENT
Location: 274-274A LONGUEVILLE ROAD & 4-18 NORTHWOOD ROAD, LANE COVE, NSW

Job No.: 33311ST
Core Size: NMLC
R.L. Surface: ~52.3 m
Date: 2/7/20
Inclination: VERTICAL
Datum: AHD
Plant Type: JK205
Bearing: N/A
Logged/Checked By: S.D./A.B.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ VL -0.1 L -0.3 M -1 H -3 VH -10 EH	DEFECT DETAILS SPACING (mm) 600 200 60 20	DEFECT DETAILS DESCRIPTION Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness Specific General	Formation
100% RETURN		45 44 43	8 9 10	▒	SANDSTONE: fine to medium grained, light grey, bedded sub-horizontally, with grey bands and occasional carbonaceous laminae. *(continued)*	FR	M	0.40 0.70 0.90 0.70 0.60 0.80		(7.29m) XWS, 0°, 25 mm.t (7.40m) XWS, 0°, 10 mm.t (8.51m) Be, 0°, P, R, Clay Vn (9.04m) Be, 0°, P, R, Cb Vn (9.13m) XWS, 0°, 20 mm.t (9.16m) XWS, 0°, 5 mm.t	Hawkesbury Sandstone
		42 41 40 39	11 12 13		END OF BOREHOLE AT 10.03 m				600 200 60 20		



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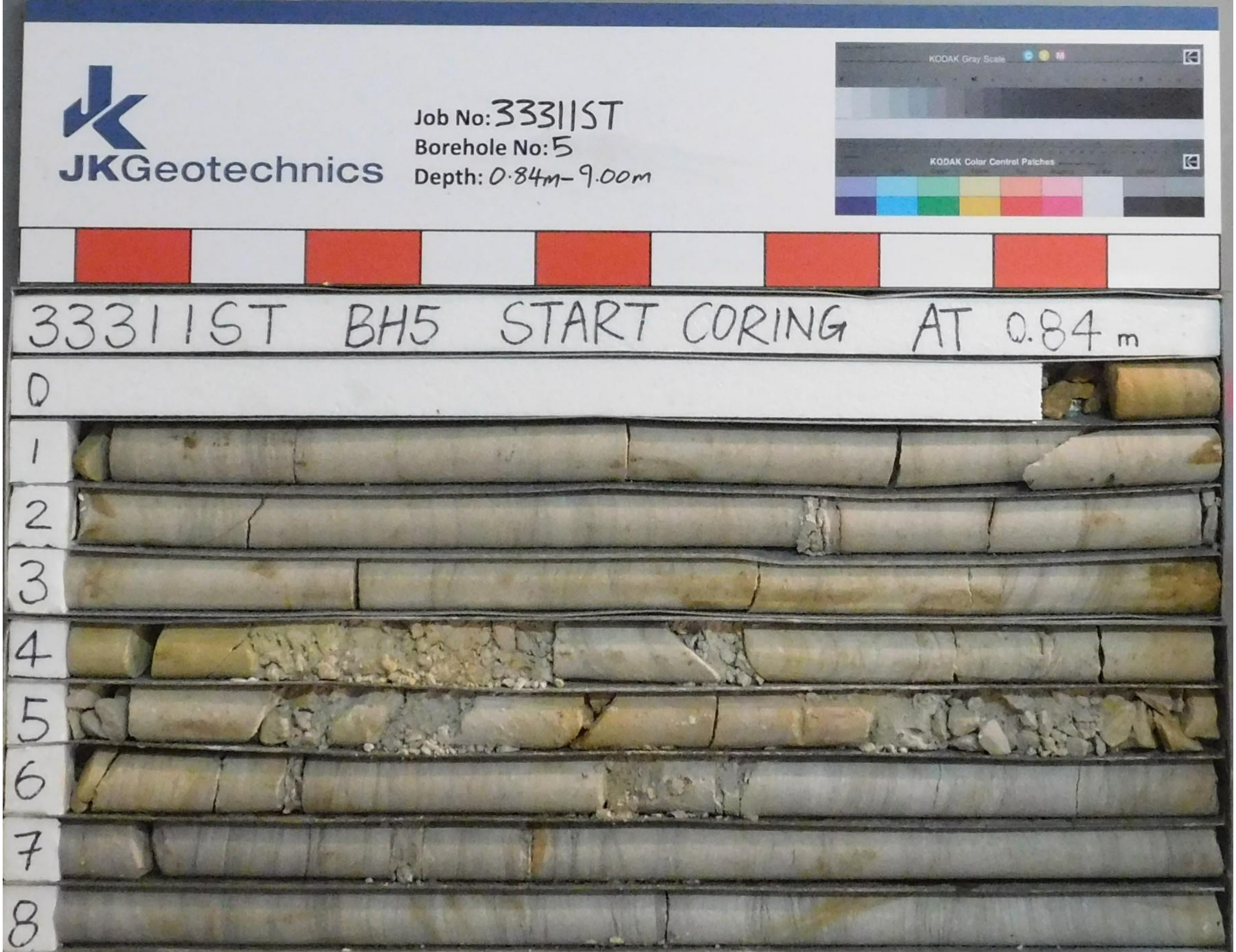
FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS



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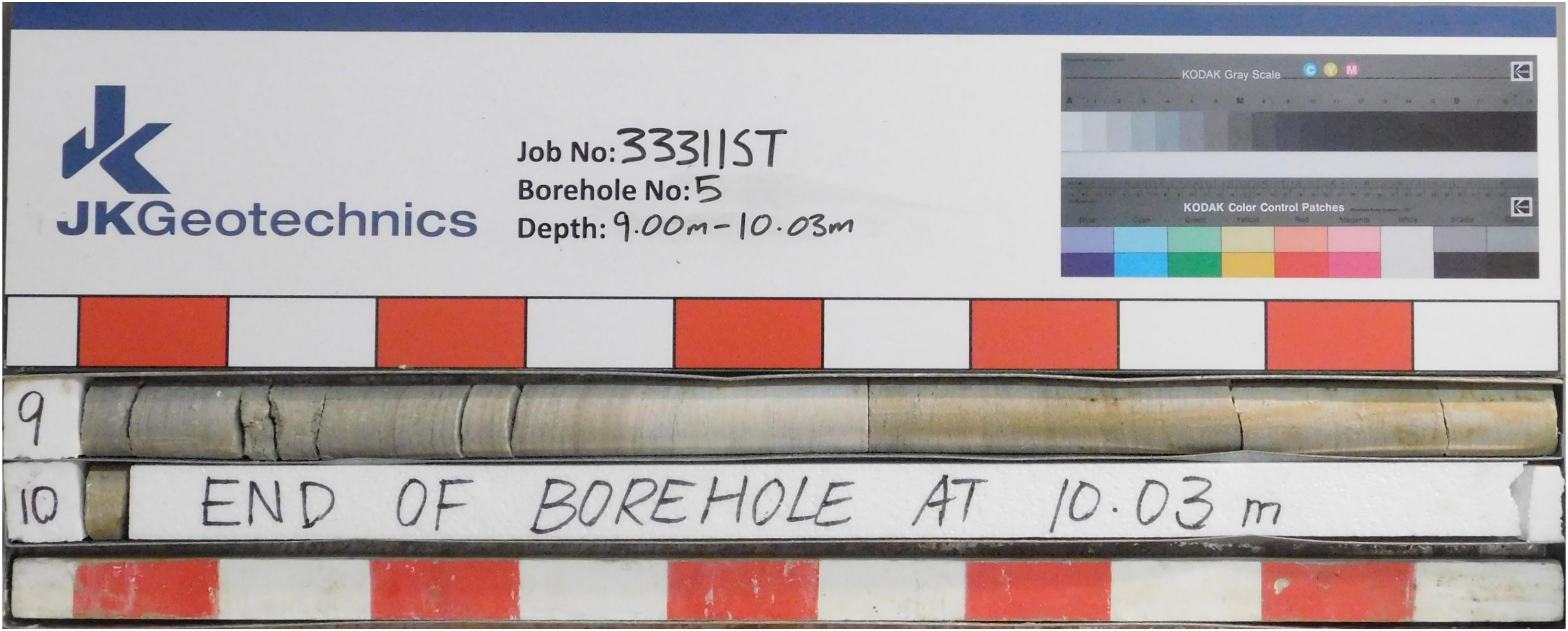
Job No: 33311ST
Borehole No: 5
Depth: 0.84m–9.00m

33311ST BH5 START CORING AT 0.84 m



Job No: 33311ST
Borehole No: 5
Depth: 9.00m-10.03m

BOREHOLE LOG

Borehole No.
6
1 / 3

Client: PATHWAYS PROPERTY GROUP
Project: PROPOSED MIXED USED DEVELOPMENT
Location: 274-274A LONGUEVILLE ROAD & 4-18 NORTHWOOD ROAD, LANE COVE, NSW

Job No.: 33311ST
Method: SPIRAL AUGER
R.L. Surface: ~51.1 m
Date: 2/7/20
Datum: AHD
Plant Type: JK205
Logged/Checked By: S.D./A.B.

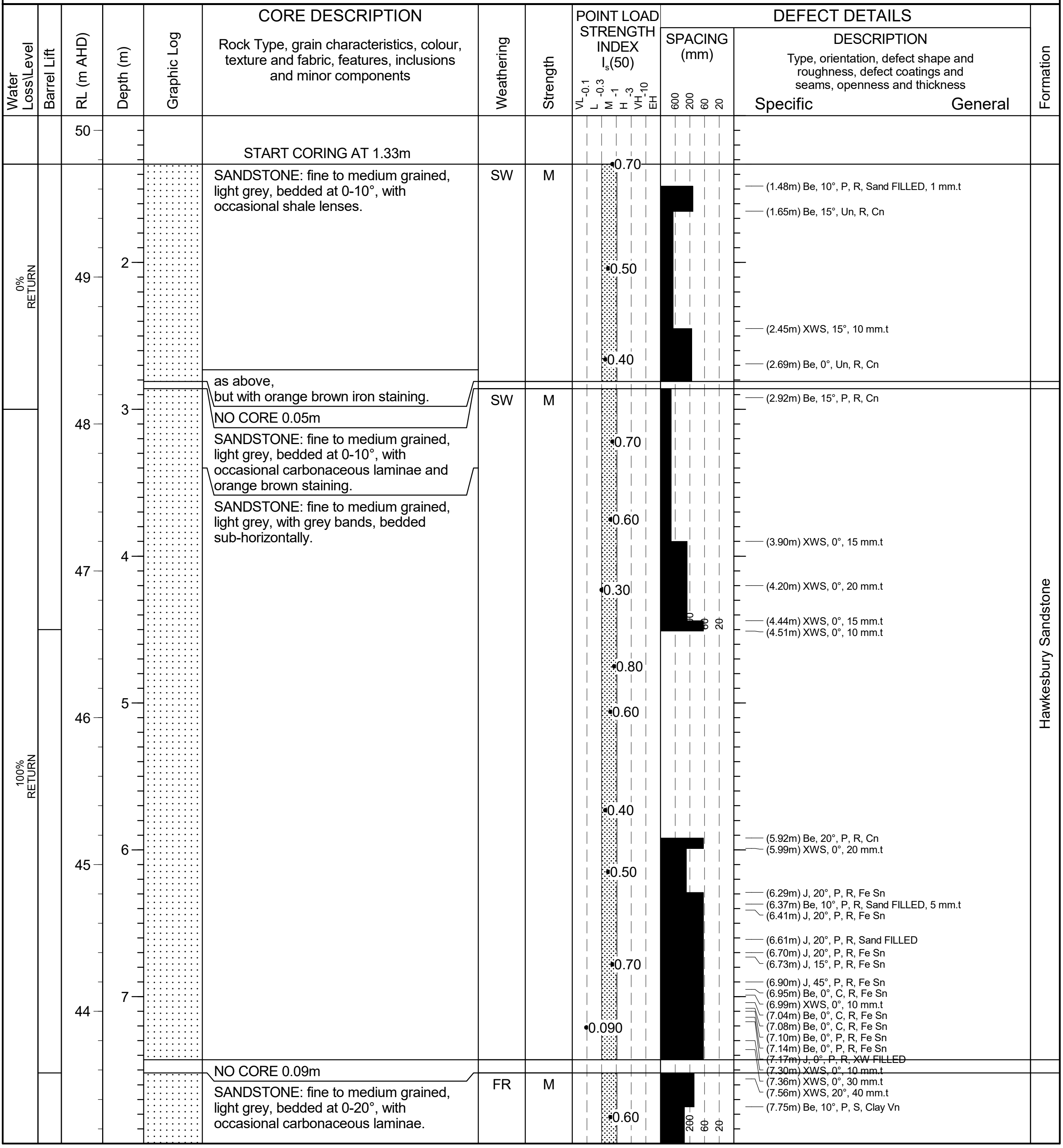
Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING										CONCRETE: 60mm.t				
						51				VOID: 50mm.t				
				■					SM	Silty clayey SAND: fine to medium grained, grey brown, trace of fine to medium grained ironstone gravel, ash and root fibres.	W	L		RESIDUAL NO SAMPLE RETURN FROM AUGER
ON COMPLETION OF CORING ▽				■	N = 7 1,2,5				SP	SAND: fine to medium grained, light grey, brown and orange brown, with fine to medium grained sandstone gravel.	M			
						50	1		-	SANDSTONE: fine to medium grained, light grey and orange brown, with extremely weathered bands.	DW	M		HAWKESBURY SANDSTONE VERY LOW 'TC' BIT RESISTANCE MODERATE RESISTANCE
										REFER TO CORED BOREHOLE LOG				
						49	2							
						48	3							
						47	4							
						46	5							
						45	6							

CORED BOREHOLE LOG

Borehole No.
6
2 / 3

Client: PATHWAYS PROPERTY GROUP
Project: PROPOSED MIXED USED DEVELOPMENT
Location: 274-274A LONGUEVILLE ROAD & 4-18 NORTHWOOD ROAD, LANE COVE, NSW

Job No.: 33311ST	**Core Size:** NMLC	**R.L. Surface:** ~51.1 m
Date: 2/7/20	**Inclination:** VERTICAL	**Datum:** AHD
Plant Type: JK205	**Bearing:** N/A	**Logged/Checked By:** S.D./A.B.



START CORING AT 1.33m

SANDSTONE: fine to medium grained, light grey, bedded at 0-10°, with occasional shale lenses. — SW — M

as above,
but with orange brown iron staining. — SW — M

NO CORE 0.05m

SANDSTONE: fine to medium grained, light grey, bedded at 0-10°, with occasional carbonaceous laminae and orange brown staining.

SANDSTONE: fine to medium grained, light grey, with grey bands, bedded sub-horizontally.

NO CORE 0.09m

SANDSTONE: fine to medium grained, light grey, bedded at 0-20°, with occasional carbonaceous laminae. — FR — M

(1.48m) Be, 10°, P, R, Sand FILLED, 1 mm.t
(1.65m) Be, 15°, Un, R, Cn
(2.45m) XWS, 15°, 10 mm.t
(2.69m) Be, 0°, Un, R, Cn
(2.92m) Be, 15°, P, R, Cn
(3.90m) XWS, 0°, 15 mm.t
(4.20m) XWS, 0°, 20 mm.t
(4.44m) XWS, 0°, 15 mm.t
(4.51m) XWS, 0°, 10 mm.t
(5.92m) Be, 20°, P, R, Cn
(5.99m) XWS, 0°, 20 mm.t
(6.29m) J, 20°, P, R, Fe Sn
(6.37m) Be, 10°, P, R, Sand FILLED, 5 mm.t
(6.41m) J, 20°, P, R, Fe Sn
(6.61m) J, 20°, P, R, Sand FILLED
(6.70m) J, 20°, P, R, Fe Sn
(6.73m) J, 15°, P, R, Fe Sn
(6.90m) J, 45°, P, R, Fe Sn
(6.95m) Be, 0°, C, R, Fe Sn
(6.99m) XWS, 0°, 10 mm.t
(7.04m) Be, 0°, C, R, Fe Sn
(7.08m) Be, 0°, C, R, Fe Sn
(7.10m) Be, 0°, P, R, Fe Sn
(7.14m) Be, 0°, P, R, Fe Sn
(7.17m) J, 0°, P, R, XW FILLED
(7.30m) XWS, 0°, 10 mm.t
(7.36m) XWS, 0°, 30 mm.t
(7.56m) XWS, 20°, 40 mm.t
(7.75m) Be, 10°, P, S, Clay Vn

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS

CORED BOREHOLE LOG

Borehole No.
6
3 / 3

Client: PATHWAYS PROPERTY GROUP
Project: PROPOSED MIXED USED DEVELOPMENT
Location: 274-274A LONGUEVILLE ROAD & 4-18 NORTHWOOD ROAD, LANE COVE, NSW

Job No.: 33311ST
Core Size: NMLC
R.L. Surface: ~51.1 m
Date: 2/7/20
Inclination: VERTICAL
Datum: AHD
Plant Type: JK205
Bearing: N/A
Logged/Checked By: S.D./A.B.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ VL 0.1, L 0.3, M 1, H 3, VH 10, EH	DEFECT DETAILS: SPACING (mm) 600, 200, 60, 20	DEFECT DETAILS: DESCRIPTION Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness Specific	General	Formation
100% RETURN		43 42	9	⁙	SANDSTONE: fine to medium grained, light grey, bedded at 0-20°, with occasional carbonaceous laminae. *(continued)*	FR	M	•0.30 •0.50 •0.40		(8.10m) XWS, 0°, 10 mm.t (8.71m) XWS, 5°, 3 mm.t (8.73m) XWS, 0°, 3 mm.t (8.81m) XWS, 0°, 20 mm.t		Hawkesbury Sandstone
		41 40 39 38 37	10 11 12 13 14		END OF BOREHOLE AT 9.56 m							

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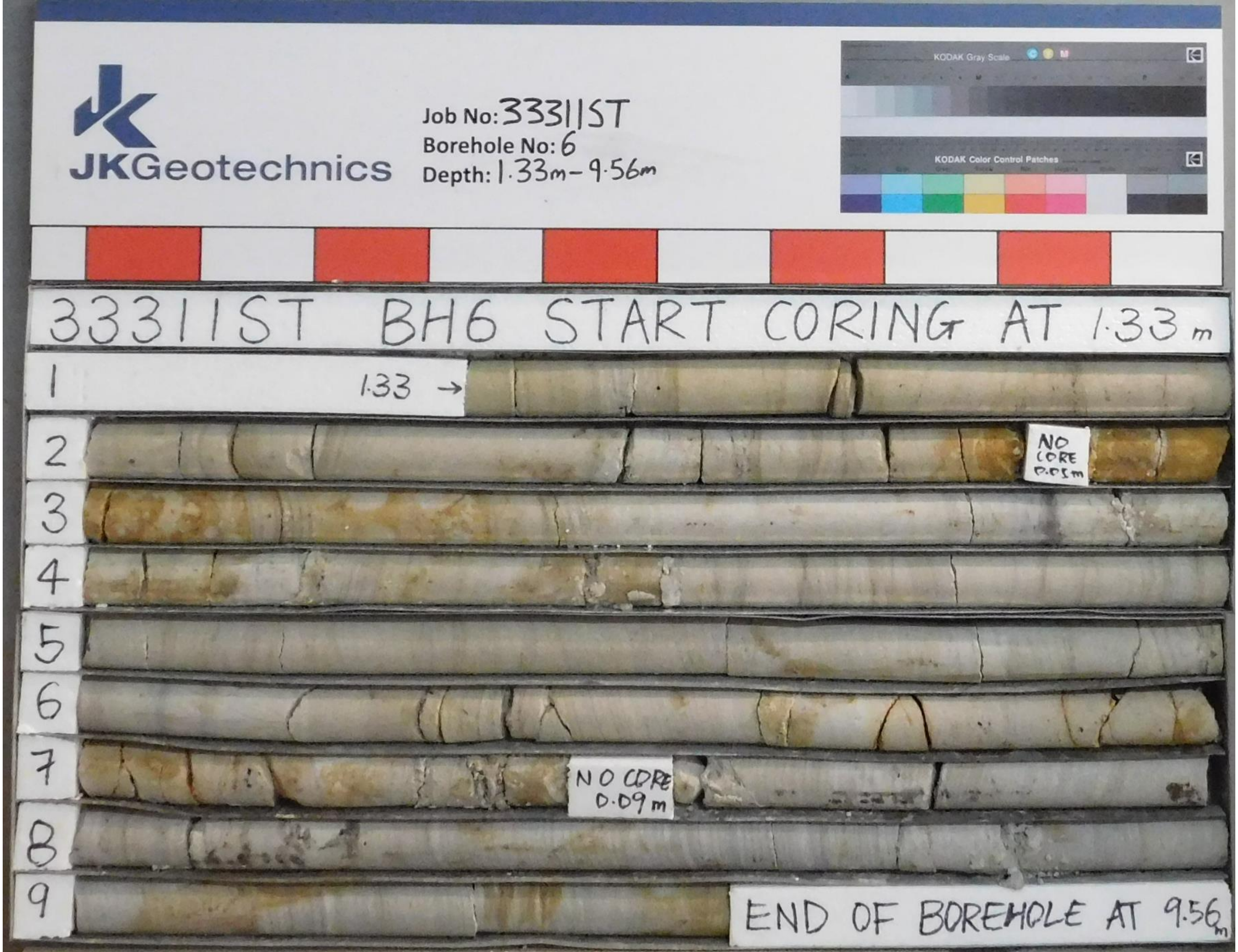
FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS



Job No: 3331IST
Borehole No: 6
Depth: 1.33m – 9.56m

AERIAL IMAGE SOURCE: MAPS.AU.NEARMAP.COM

This plan should be read in conjunction with the JK Geotechnics report.

Title:

SITE LOCATION PLAN

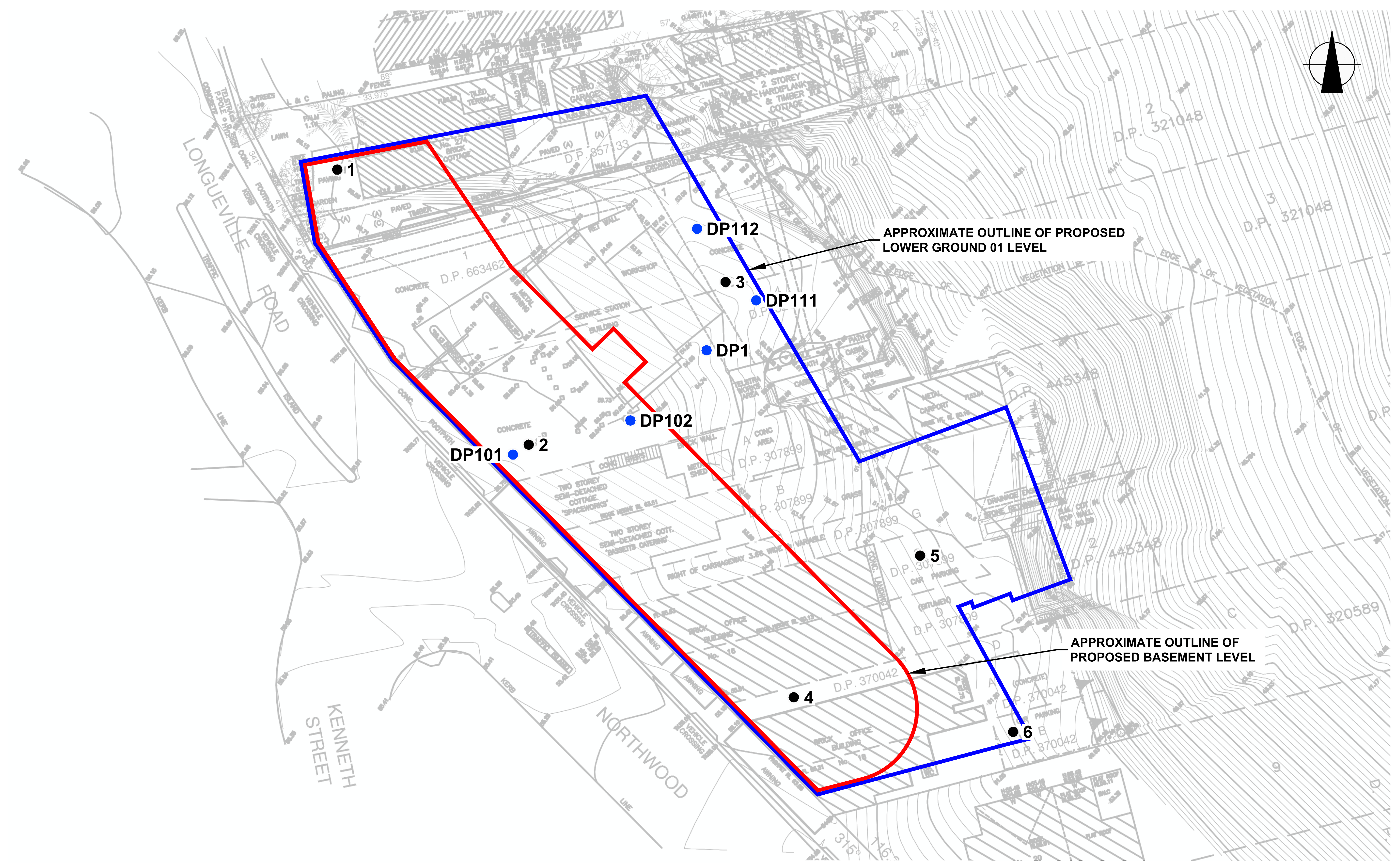
Location:
274-278 LONGUEVILLE ROAD AND
4-18 NORTHWOOD ROAD, LANE COVE, NSW

Report No: 33311ST

Figure No: 1

JKGeotechnics

PLOT DATE: 15/07/2020 2:54:26 PM DWG FILE: Z:\6 GEOTECHNICAL\6F GEOTECHNICAL JOBS\33000'S\33311ST LANE COVE\CAD\33311ST.DWG



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LEGEND

● BOREHOLE

🔵 MONITORING WELL

NOTES:

1. MONITORING WELLS DP1, DP101, DP102, DP111 AND DP112 WERE INSTALLED DURING PREVIOUS DOUGLAS PARTNERS ENVIRONMENTAL INVESTIGATIONS.

0 4 8 12 16 20

SCALE 1:400 @A3 METRES

This plan should be read in conjunction with the JK Geotechnics report.

Title:

BOREHOLE LOCATION PLAN

Location: 274-278 LONGUEVILLE ROAD AND 4-18 NORTHWOOD ROAD, LANE COVE, NSW

Report No: 33311ST

Figure No: 2

JKGeotechnics

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 structure.

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 1726:2017 *'Geotechnical Site Investigations'*. 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 soil classification table qualified by the grading of other particles present (eg. sandy clay) as set out below:

Soil Classification	Particle Size
Clay	< 0.002mm
Silt	0.002 to 0.075mm
Sand	0.075 to 2.36mm
Gravel	2.36 to 63mm
Cobbles	63 to 200mm
Boulders	> 200mm

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 (VL)	< 4
Loose (L)	4 to 10
Medium dense (MD)	10 to 30
Dense (D)	30 to 50
Very Dense (VD)	> 50

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

Classification	Unconfined Compressive Strength (kPa)	Indicative Undrained Shear Strength (kPa)
Very Soft (VS)	≤ 25	≤ 12
Soft (S)	> 25 and ≤ 50	> 12 and ≤ 25
Firm (F)	> 50 and ≤ 100	> 25 and ≤ 50
Stiff (St)	> 100 and ≤ 200	> 50 and ≤ 100
Very Stiff (VSt)	> 200 and ≤ 400	> 100 and ≤ 200
Hard (Hd)	> 400	> 200
Friable (Fr)	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 fissile mudstone, with a weakness parallel to bedding. Rocks with alternating inter-laminations of different grain size (eg. siltstone/claystone and siltstone/fine grained sandstone) is referred to as 'laminite'.

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 shrink-swell behaviour, 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 methods except test pits, hand auger drilling and portable Dynamic Cone Penetrometers require the use of a mechanical rig which is commonly mounted on a truck chassis or track base.

Test Pits: These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils and 'weaker' bedrock 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 a large 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. Refusal of the hand auger can occur on a variety of materials such as obstructions within any fill, tree roots, hard clay, gravel or ironstone, cobbles and boulders, 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 limited 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 cuttings. 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 assessed 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. 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, NMLC or HQ triple tube core barrels, which give a core of about 50mm and 61mm diameter, respectively, 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 NO CORE. The location of NO CORE recovery is determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the bottom 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 1289.6.3.1–2004 (R2016) *'Methods of Testing Soils for Engineering Purposes, Soil Strength and Consolidation Tests – Determination of the Penetration Resistance of a Soil – Standard Penetration Test (SPT)'*.

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 63.5kg 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.

A modification to the SPT 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.

Cone Penetrometer Testing (CPT) and Interpretation: The cone penetrometer is sometimes referred to as a Dutch Cone. The test is described in Australian Standard 1289.6.5.1–1999 (R2013) *'Methods of Testing Soils for Engineering Purposes, Soil Strength and Consolidation Tests – Determination of the Static Cone Penetration Resistance of a Soil – Field Test using a Mechanical and Electrical Cone or Friction-Cone Penetrometer'*.

In the tests, a 35mm or 44mm 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 a hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the frictional resistance on a separate 134mm or 165mm 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. The CPT does not provide soil sample recovery.

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. There are two scales presented for the cone resistance. The lower scale has a range of 0 to 5MPa and the main scale has a range of 0 to 50MPa. For cone resistance values less than 5MPa, the plot will appear on both scales.
- 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 CPT and SPT values can be developed for both sands and clays but may be site specific.

Interpretation of CPT 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.

There are limitations when using the CPT in that it may not penetrate obstructions within any fill, thick layers of hard clay and very dense sand, gravel and weathered bedrock. Normally a 'dummy' cone is pushed through fill to protect the equipment. No information is recorded by the 'dummy' probe.

Flat Dilatometer Test: The flat dilatometer (DMT), also known as the Marchetti Dilometer comprises a stainless steel blade having a flat, circular steel membrane mounted flush on one side.

The blade is connected to a control unit at ground surface by a pneumatic-electrical tube running through the insertion rods. A gas tank, connected to the control unit by a pneumatic cable, supplies the gas pressure required to expand the membrane. The control unit is equipped with a pressure regulator, pressure gauges, an audio-visual signal and vent valves.

The blade is advanced into the ground using our CPT rig or one of our drilling rigs, and can be driven into the ground using an SPT hammer. As soon as the blade is in place, the membrane is inflated, and the pressure required to lift the membrane (approximately 0.1mm) is recorded. The pressure then required to lift the centre of the membrane by an additional 1mm is recorded. The membrane is then deflated before pushing to the next depth increment, usually 200mm down. The pressure readings are corrected for membrane stiffness.

The DMT is used to measure material index (I_D), horizontal stress index (K_D), and dilatometer modulus (E_D). Using established correlations, the DMT results can also be used to assess the 'at rest' earth pressure coefficient (K_o), over-consolidation ratio (OCR), undrained shear strength (C_u), friction angle (ϕ), coefficient of consolidation (C_h), coefficient of permeability (K_h), unit weight (γ), and vertical drained constrained modulus (M).

The seismic dilatometer (SDMT) is the combination of the DMT with an add-on seismic module for the measurement of shear wave velocity (V_s). Using established correlations, the SDMT results can also be used to assess the small strain modulus (G_o).

Portable Dynamic Cone Penetrometers: Portable Dynamic Cone Penetrometer (DCP) tests are carried out by driving a 16mm diameter rod with a 20mm diameter cone end with a 9kg hammer dropping 510mm. The test is described in Australian Standard 1289.6.3.2–1997 (R2013) *'Methods of Testing Soils for Engineering Purposes, Soil Strength and Consolidation Tests – Determination of the Penetration Resistance of a Soil – 9kg Dynamic Cone Penetrometer Test'*.

The results are used to assess the relative compaction of fill, the relative density of granular soils, and the strength of cohesive soils. Using established correlations, the DCP test results can also be used to assess California Bearing Ratio (CBR).

Refusal of the DCP can occur on a variety of materials such as obstructions within any fill, tree roots, hard clay, gravel or ironstone, cobbles and boulders, and does not necessarily indicate rock level.

Vane Shear Test: The vane shear test is used to measure the undrained shear strength (C_u) of typically very soft to firm fine grained cohesive soils. The vane shear is normally performed in the bottom of a borehole, but can be completed from surface level, the bottom and sides of test pits, and on recovered undisturbed tube samples (when using a hand vane).

The vane comprises four rectangular blades arranged in the form of a cross on the end of a thin rod, which is coupled to the bottom of a drill rod string when used in a borehole. The size of the vane is dependent on the strength of the fine grained cohesive soils; that is, larger vanes are normally used for very low strength soils. For borehole testing, the size of the vane can be limited by the size of the casing that is used.

For testing inside a borehole, a device is used at the top of the casing, which suspends the vane and rods so that they do not sink under self-weight into the 'soft' soils beyond the depth at which the test is to be carried out. A calibrated torque head is used to rotate the rods and vane and to measure the resistance of the vane to rotation.

With the vane in position, torque is applied to cause rotation of the vane at a constant rate. A rate of 6° per minute is the common rotation rate. Rotation is continued until the soil is sheared and the maximum torque has been recorded. This value is then used to calculate the undrained shear strength. The vane is then rotated rapidly a number of times and the operation repeated until a constant torque reading is obtained. This torque value is used to calculate the remoulded shear strength. Where appropriate, friction on the vane rods is measured and taken into account in the shear strength calculation.

LOGS

The borehole or test pit logs presented herein are an engineering and/or geological interpretation of the subsurface 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 terms and symbols used in preparation of the logs are defined in the following pages.

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 reliable water observations are to be made.

More reliable measurements can be made by installing standpipes which are read after the groundwater level has stabilised 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 assess 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 Soils for Engineering Purposes'* or appropriate NSW Government Roads & Maritime Services (RMS) test methods. 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.

Reasonable 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.
- Details of the development that the Company could not reasonably be expected to anticipate.

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 rather than at some later stage, well after the event.

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

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. Licence to use the documents may be revoked without notice if the Client is in breach of any obligation to make a payment to us.

REVIEW OF DESIGN

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

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 and appropriate footing or pile founding depths, or

iii) full time engineering presence on site.

SYMBOL LEGENDS

SOIL

- ▦ FILL
- ≋ TOPSOIL
- ▨ CLAY (CL, CI, CH)
- ▥ SILT (ML, MH)
- ░ SAND (SP, SW)
- ⁘ GRAVEL (GP, GW)
- ▨ SANDY CLAY (CL, CI, CH)
- ▨ SILTY CLAY (CL, CI, CH)
- ▨ CLAYEY SAND (SC)
- ░ SILTY SAND (SM)
- ▨ GRAVELLY CLAY (CL, CI, CH)
- ▨ CLAYEY GRAVEL (GC)
- ▥ SANDY SILT (ML, MH)
- ψ PEAT AND HIGHLY ORGANIC SOILS (Pt)

ROCK

- ⁘ CONGLOMERATE
- ░ SANDSTONE
- ▤ SHALE/MUDSTONE
- ▥ SILTSTONE
- ☰ CLAYSTONE
- ■ COAL
- ▥ LAMINITE
- ⊞ LIMESTONE
- ≋ PHYLLITE, SCHIST
- ▤ TUFF
- ⁘ GRANITE, GABBRO
- ✛ DOLERITE, DIORITE
- ∨ BASALT, ANDESITE
- ∿ QUARTZITE

OTHER MATERIALS

- ⊞ BRICKS OR PAVERS
- △ CONCRETE
- ■ ASPHALTIC CONCRETE

CLASSIFICATION OF COARSE AND FINE GRAINED SOILS

Major Divisions		Group Symbol	Typical Names	Field Classification of Sand and Gravel	Laboratory Classification	
Coarse grained soil (more than 65% of soil excluding oversize fraction is greater than 0.075mm)	GRAVEL (more than half of coarse fraction is larger than 2.36mm	GW	Gravel and gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	$C_u > 4$ $1 < C_c < 3$
		GP	Gravel and gravel-sand mixtures, little or no fines, uniform gravels	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	Fails to comply with above
		GM	Gravel-silt mixtures and gravel-sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	≥ 12% fines, fines are silty	Fines behave as silt
		GC	Gravel-clay mixtures and gravel-sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength	≥ 12% fines, fines are clayey	Fines behave as clay
	SAND (more than half of coarse fraction is smaller than 2.36mm)	SW	Sand and gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	$C_u > 6$ $1 < C_c < 3$
		SP	Sand and gravel-sand mixtures, little or no fines	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	Fails to comply with above
		SM	Sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	≥ 12% fines, fines are silty	N/A
		SC	Sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength	≥ 12% fines, fines are clayey	

Major Divisions		Group Symbol	Typical Names	Field Classification of Silt and Clay			Laboratory Classification
				Dry Strength	Dilatancy	Toughness	% < 0.075mm
ine grained soils (more than 35% of soil excluding oversize fraction is less than 0.075mm)	SILT and CLAY (low to medium plasticity)	ML	Inorganic silt and very fine sand, rock flour, silty or clayey fine sand or silt with low plasticity	None to low	Slow to rapid	Low	Below A line
		CL, CI	Inorganic clay of low to medium plasticity, gravelly clay, sandy clay	Medium to high	None to slow	Medium	Above A line
		OL	Organic silt	Low to medium	Slow	Low	Below A line
	SILT and CLAY (high plasticity)	MH	Inorganic silt	Low to medium	None to slow	Low to medium	Below A line
		CH	Inorganic clay of high plasticity	High to very high	None	High	Above A line
		OH	Organic clay of medium to high plasticity, organic silt	Medium to high	None to very slow	Low to medium	Below A line
	Highly organic soil	Pt	Peat, highly organic soil	–	–	–	–

Laboratory Classification Criteria

A well graded coarse grained soil is one for which the coefficient of uniformity $Cu > 4$ and the coefficient of curvature $1 < C_c < 3$. Otherwise, the soil is poorly graded. These coefficients are given by:

$$C_U = \frac{D_{60}}{D_{10}} \quad \text{and} \quad C_C = \frac{(D_{30})^2}{D_{10}\,D_{60}}$$

Where D_{10}, D_{30} and D_{60} are those grain sizes for which 10%, 30% and 60% of the soil grains, respectively, are smaller.

NOTES:

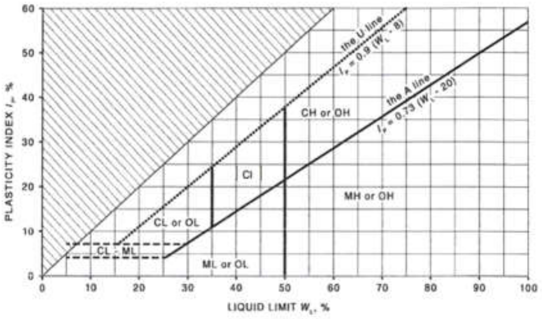
1 For a coarse grained soil with a fines content between 5% and 12%, the soil is given a dual classification comprising the two group symbols separated by a dash; for example, for a poorly graded gravel with between 5% and 12% silt fines, the classification is GP-GM.

2 Where the grading is determined from laboratory tests, it is defined by coefficients of curvature (C_c) and uniformity (C_u) derived from the particle size distribution curve.

3 Clay soils with liquid limits > 35% and ≤ 50% may be classified as being of medium plasticity.

4 The U line on the Modified Casagrande Chart is an approximate upper bound for most natural soils.

Modified Casagrande Chart for Classifying Silts and Clays according to their Behaviour



LOG SYMBOLS

<table>
<tr><th>Log Column</th><th>Symbol</th><th>Definition</th></tr>
<tr><td>Groundwater Record</td><td>—▼—</td><td>Standing water level. Time delay following completion of drilling/excavation may be shown.</td></tr>
<tr><td></td><td>—C—</td><td>Extent of borehole/test pit collapse shortly after drilling/excavation.</td></tr>
<tr><td></td><td>▶—</td><td>Groundwater seepage into borehole or test pit noted during drilling or excavation.</td></tr>
<tr><td>Samples</td><td>ES</td><td>Sample taken over depth indicated, for environmental analysis.</td></tr>
<tr><td></td><td>U50</td><td>Undisturbed 50mm diameter tube sample taken over depth indicated.</td></tr>
<tr><td></td><td>DB</td><td>Bulk disturbed sample taken over depth indicated.</td></tr>
<tr><td></td><td>DS</td><td>Small disturbed bag sample taken over depth indicated.</td></tr>
<tr><td></td><td>ASB</td><td>Soil sample taken over depth indicated, for asbestos analysis.</td></tr>
<tr><td></td><td>ASS</td><td>Soil sample taken over depth indicated, for acid sulfate soil analysis.</td></tr>
<tr><td></td><td>SAL</td><td>Soil sample taken over depth indicated, for salinity analysis.</td></tr>
<tr><td>Field Tests</td><td>N = 17
4, 7, 10</td><td>Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. ‘Refusal’ refers to apparent hammer refusal within the corresponding 150mm depth increment.</td></tr>
<tr><td></td><td>N_c = 5
7
3R</td><td>Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60° solid cone driven by SPT hammer. ‘R’ refers to apparent hammer refusal within the corresponding 150mm depth increment.</td></tr>
<tr><td></td><td>VNS = 25</td><td>Vane shear reading in kPa of undrained shear strength.</td></tr>
<tr><td></td><td>PID = 100</td><td>Photoionisation detector reading in ppm (soil sample headspace test).</td></tr>
<tr><td>Moisture Condition
(Fine Grained Soils)</td><td>$w > PL$</td><td>Moisture content estimated to be greater than plastic limit.</td></tr>
<tr><td></td><td>$w \approx PL$</td><td>Moisture content estimated to be approximately equal to plastic limit.</td></tr>
<tr><td></td><td>$w < PL$</td><td>Moisture content estimated to be less than plastic limit.</td></tr>
<tr><td></td><td>$w \approx LL$</td><td>Moisture content estimated to be near liquid limit.</td></tr>
<tr><td></td><td>$w > LL$</td><td>Moisture content estimated to be wet of liquid limit.</td></tr>
<tr><td>(Coarse Grained Soils)</td><td>D</td><td>DRY – runs freely through fingers.</td></tr>
<tr><td></td><td>M</td><td>MOIST – does not run freely but no free water visible on soil surface.</td></tr>
<tr><td></td><td>W</td><td>WET – free water visible on soil surface.</td></tr>
<tr><td>Strength (Consistency)
Cohesive Soils</td><td>VS</td><td>VERY SOFT – unconfined compressive strength ≤ 25kPa.</td></tr>
<tr><td></td><td>S</td><td>SOFT – unconfined compressive strength > 25kPa and ≤ 50kPa.</td></tr>
<tr><td></td><td>F</td><td>FIRM – unconfined compressive strength > 50kPa and ≤ 100kPa.</td></tr>
<tr><td></td><td>St</td><td>STIFF – unconfined compressive strength > 100kPa and ≤ 200kPa.</td></tr>
<tr><td></td><td>VSt</td><td>VERY STIFF – unconfined compressive strength > 200kPa and ≤ 400kPa.</td></tr>
<tr><td></td><td>Hd</td><td>HARD – unconfined compressive strength > 400kPa.</td></tr>
<tr><td></td><td>Fr</td><td>FRIABLE – strength not attainable, soil crumbles.</td></tr>
<tr><td></td><td>( )</td><td>Bracketed symbol indicates estimated consistency based on tactile examination or other assessment.</td></tr>
<tr><td>Density Index/
Relative Density
(Cohesionless Soils)</td><td>
VL
L
MD
D
VD
( )</td><td><table>
<tr><th></th><th>Density Index (I_D) Range (%)</th><th>SPT ‘N’ Value Range (Blows/300mm)</th></tr>
<tr><td>VERY LOOSE</td><td>≤ 15</td><td>0 – 4</td></tr>
<tr><td>LOOSE</td><td>> 15 and ≤ 35</td><td>4 – 10</td></tr>
<tr><td>MEDIUM DENSE</td><td>> 35 and ≤ 65</td><td>10 – 30</td></tr>
<tr><td>DENSE</td><td>> 65 and ≤ 85</td><td>30 – 50</td></tr>
<tr><td>VERY DENSE</td><td>> 85</td><td>> 50</td></tr>
</table>Bracketed symbol indicates estimated density based on ease of drilling or other assessment.</td></tr>
<tr><td>Hand Penetrometer Readings</td><td>300
250</td><td>Measures reading in kPa of unconfined compressive strength. Numbers indicate individual test results on representative undisturbed material unless noted otherwise.</td></tr>
</table>

Log Column	Symbol	Definition
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Twin pronged tungsten carbide bit.
	T_{60}	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.
	Soil Origin	The geological origin of the soil can generally be described as: RESIDUAL – soil formed directly from insitu weathering of the underlying rock. No visible structure or fabric of the parent rock. EXTREMELY WEATHERED – soil formed directly from insitu weathering of the underlying rock. Material is of soil strength but retains the structure and/or fabric of the parent rock. ALLUVIAL – soil deposited by creeks and rivers. ESTUARINE – soil deposited in coastal estuaries, including sediments caused by inflowing creeks and rivers, and tidal currents. MARINE – soil deposited in a marine environment. AEOLIAN – soil carried and deposited by wind. COLLUVIAL – soil and rock debris transported downslope by gravity, with or without the assistance of flowing water. Colluvium is usually a thick deposit formed from a landslide. The description 'slopewash' is used for thinner surficial deposits. LITTORAL – beach deposited soil.

Classification of Material Weathering

Term		Abbreviation		Definition
Residual Soil		RS		Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported.
Extremely Weathered		XW		Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible.
Highly Weathered	Distinctly Weathered (Note 1)	HW	DW	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Moderately Weathered		MW		The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable, but shows little or no change of strength from fresh rock.
Slightly Weathered		SW		Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.
Fresh		FR		Rock shows no sign of decomposition of individual minerals or colour changes.

NOTE 1: The term 'Distinctly Weathered' is used where it is not practicable to distinguish between 'Highly Weathered' and 'Moderately Weathered' rock. 'Distinctly Weathered' is defined as follows: *'Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores'*. There is some change in rock strength.

Rock Material Strength Classification

			Guide to Strength	
Term	**Abbreviation**	**Uniaxial Compressive Strength (MPa)**	**Point Load Strength Index $I_{s(50)}$ (MPa)**	**Field Assessment**
Very Low Strength	VL	0.6 to 2	0.03 to 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 30mm thick can be broken by finger pressure.
Low Strength	L	2 to 6	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show in the specimen with firm blows of the pick point; has dull sound under hammer. A piece of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium Strength	M	6 to 20	0.3 to 1	Scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High Strength	H	20 to 60	1 to 3	A piece of core 150mm long by 50mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High Strength	VH	60 to 200	3 to 10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
Extremely High Strength	EH	> 200	> 10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

Abbreviations Used in Defect Description

Cored Borehole Log Column		Symbol Abbreviation	Description
Point Load Strength Index		• 0.6	Axial point load strength index test result (MPa)
		x 0.6	Diametral point load strength index test result (MPa)
Defect Details	– Type	Be	Parting – bedding or cleavage
		CS	Clay seam
		Cr	Crushed/sheared seam or zone
		J	Joint
		Jh	Healed joint
		Ji	Incipient joint
		XWS	Extremely weathered seam
	– Orientation	Degrees	Defect orientation is measured relative to normal to the core axis (ie. relative to the horizontal for a vertical borehole)
	– Shape	P	Planar
		C	Curved
		Un	Undulating
		St	Stepped
		Ir	Irregular
	– Roughness	Vr	Very rough
		R	Rough
		S	Smooth
		Po	Polished
		Sl	Slickensided
	– Infill Material	Ca	Calcite
		Cb	Carbonaceous
		Clay	Clay
		Fe	Iron
		Qz	Quartz
		Py	Pyrite
	– Coatings	Cn	Clean
		Sn	Stained – no visible coating, surface is discoloured
		Vn	Veneer – visible, too thin to measure, may be patchy
		Ct	Coating ≤ 1mm thick
		Filled	Coating > 1mm thick
	– Thickness	mm.t	Defect thickness measured in millimetres