Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Geotechnical Desktop Study

The Ribbon

31 Wheat Street
Darling Harbour

Prepared for
Grocon Constructions Pty Ltd

Project 73201.00/Rev.1
November 2012

Douglas Partners
Geotechnics / Environment / Groundwater

Document History

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
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Executive Summary

A desktop study has been carried out on behalf of Grocon Constructions Pty Ltd for the proposed commercial and retail re-development of the IMAX Theatre at 31 Wheat Road, Darling Harbour.

The desktop study has identified potential geotechnical issues related to the proposed re-development, provided preliminary design information and outlined further site investigation to confirm the ground conditions at the site. Significant infrastructure constraints exist including the Western Distributor Highway that bounds the site to the north and south, the existing wharf structure, stormwater culverts and a multitude of near surface services. These constraints will need to be taken into account in design and construction planning.

At their nearest point, the existing footings and foundations along the northern side of the Western Distributor are located over 2 m from the proposed structure at ground level and are founded in rock. On the southern side, the footings and foundations are in the order of 1 to 2 m away, also founded in rock.

Based on these distances, and the fact that the proposed piles and the existing Western Distributor piles are founded in rock, it is considered unlikely that adequately designed piled foundations will have an adverse geotechnical impact on the Western Distributor overpass footings.

It is therefore DP's view that it should be possible, with careful design, especially with regard to the layout of foundations, to overcome any geotechnical issues and infrastructure constraints.

Based on the findings of the desktop study, the site is therefore expected to be suitable for the proposed development.

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Report on Geotechnical Desktop Study
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1. Introduction

This report presents the results of a Geotechnical Desktop Study undertaken by Douglas Partners Pty Ltd (DP) for "The Ribbon" at 31 Wheat Road, Darling Harbour. The study was commissioned by Grocon Constructions Pty Ltd.

It is understood that the proposed development of the site will include replacing the existing IMAX Theatre with an office, cinema and retail development.

The objectives of the assessment were to identify potential geotechnical issues related to the proposed development, provide preliminary design and construction comments, and comment on the need for further investigation.

2. Site Description

The site is located at 31 Wheat Road, Darling Harbour, bound by the Western Distributor to the north and south, and is currently occupied by the IMAX Theatre. The Darling Harbour wharf structure is located beneath the northern portion of the site. Stormwater culverts cross the central and western portions of the site in a north-south direction. The existing site ground level is at approximately RL 2.5 m relative to the Australian Height Datum (AHD).

3. Review of Geological Maps

Reference to the Sydney 1:100,000 series geological sheet indicates that the site is located on an area of reclaimed land, which overlies Hawkesbury Sandstone bedrock. Hawkesbury Sandstone typically comprises medium to coarse grained quartz sandstone with minor shale and laminite lenses. Previous investigations on the site confirm the presence of filling overlying Hawkesbury Sandstone.

Review of mapping suggests that no geological structures such as major fault zones or dykes intersect the site.

4. Review of Previous Investigations

4.1 Discovery Village

In 1986 and 1987 DP undertook two geotechnical investigations in the area for the Discovery Village project. The results were included in the reports titled:

- *Report on Geotechnical Investigation, Discovery Village, Darling Harbour,* DP Report 9710, dated July 1986;
- *Report on Geotechnical Investigation, Discovery Village, Darling Harbour,* DP Report 9710-2, dated March 1987.

These investigations, in the area of the current proposed works, included two cored boreholes (DV12 and DV13), three augered boreholes (DV119, DC18 and DC21) and three Cone Penetration Tests which were continued from the base of shallow augered boreholes (DC16, DC17 and DC19). Locations of the boreholes are shown on Drawing 1 and Drawing 2 in Appendix B.

The principal strata sequentially encountered (beneath pavement materials) comprised:

- Filling – Gravelly sand, clayey silty sand and crushed sandstone filling to depths of 1.9 to 4.0 m;
- Alluvium – Very loose to loose silty clayey sand, and some soft dark grey organic marine clay (encountered in DV13, DV119, DC16 and DC17 only), to depths of 4.2 m to 6.7 m;
- Residual – Dense, clayey sand to depths of 4.4 m to 6.9 m;
- Sandstone – Weak to medium strong and slightly fractured, to a maximum tested depth of 9.4 m.

Groundwater was encountered at about 2.4 m depth (RL -0.2 m to -0.1 m) during drilling in boreholes DV12 and DV13.

The 1987 borehole logs are included in Appendix C.

It should be noted that rock strength terminology has changed since 1987. Table 1, below, shows an approximate correlation between previous rock strength terminology and the current terminology

Table 1: Sandstone Strength Equivalences

Original Strength Terminology (1987 logs)	Current Strength Terminology
Strong	High
Medium and medium to strong	Medium
Weak	Low
Very weak	Very low

4.2 Theatre Development

In 1992 DP undertook a geotechnical investigation at the site for the IMAX Theatre. The results of the investigation were reported in:

- *Report on Geotechnical Investigation, Theatre Development, Darling Harbour,* DP Project 19013, dated November 1992.

The field investigation comprised five cored boreholes (Bores 1 to 5), two of which were abandoned due to encountering obstructions (Bores 2 and 4). Locations of the boreholes are shown on Drawing 1 and Drawing 2 in Appendix B.

The principal strata sequentially encountered (beneath pavement materials) comprised:

- Filling – Gravelly sand, clayey silty sand and crushed sandstone filling to depths of 4.0 m to 4.6 m;
- Alluvium – Soft to firm, dark grey organic marine clay, encountered to depths of 5.3 m to 6.5 m;
- Residual – Dense, clayey sand in Bore 1 only; overlying
- Sandstone – Medium to high strength, slightly weathered to fresh and slightly fractured to unbroken to a maximum tested depth of 9.55 m.

Selected rock core samples were tested in the laboratory for point load strength index (Is_{50}), at depths as indicated on the borehole logs. The results ranged from 0.5 MPa to 1.3 MPa, correlating to medium and high strength sandstone.

Groundwater was encountered at 2.15 m to 2.40 m depth (RL 0.15 m to 0.41 m) during the drilling.

The 1992 borehole logs are included in Appendix C.

5. Geotechnical Model

The ground profile at the site can be summarised as shown in Table 2 below.

Table 2: Geotechnical Model

Material	RL Range (m, AHD)	Thickness (m)	Description
Filling	+2.5 to -2.0	1.9 to 4.6	Generally poorly compacted, gravelly sand with clay, concrete and crushed sandstone
Alluvium	+0.4 to -4.3	1.0 to 4.2	Generally loose silty clayey sand and some soft -firm marine clay
Residual	-1.9 to -4.5	0.0 to 0.7	Dense clayey sand
Sandstone	-2.1(1) -4.5(2)	-	Medium to high strength sandstone, with some low strength bands

NOTE: (1) Located in the eastern part of the site, Borehole DC19
(2) Located in the western part of the site, Borehole DC16

Table B1 in Appendix B contains a summary of the depths and levels at each borehole of filling, alluvium, residual and sandstone bedrock.

An interpreted contour plot of the top of sound rock (defined as medium strength or better) for the site has been produced using data collated from the previous testing at the site and surrounding sites. Contour surfaces were generated using a triangulation model between data points. The results are presented as Drawing 1 in Appendix B.

It should be noted that contours should be considered approximate only as experience in Hawkesbury Sandstone suggests that the rock surface is likely to be stepped rather than sloping and the locations of the bores are approximate.

Groundwater at the site will be affected by tidal influences, although the extent of tidal influence is uncertain. The mean high water level for Sydney is approximately RL +0.5 m AHD. The previous boreholes intersected groundwater between RL -0.2 m and +0.4 m AHD. It can be expected that groundwater could fluctuate between approximately RL -0.5 and +0.5 m AHD during construction. However, the groundwater level could be expected to rise to RL +1.0 to +1.5 m AHD during heavy rainfall events when coupled with a high tide.

6. Comments

6.1 Proposed Development

The proposed development is understood to include the demolition of current IMAX Theatre building and the construction of an office, cinema and retail development of approximately 18 storeys in height. Significant constraints are imposed on the design and construction of the structure due to the stormwater channels underlying the site, the Darling Harbour wharf structure and the adjacent elevated roadways of the Western Distributor freeway. Due to these constraints, the preliminary design incorporates inclined columns, large diameter piles and tension anchors. The proposed ground and footing plan is shown as Drawing 2 in Appendix B, overlain with a recent aerial photograph and the previous borehole locations.

6.2 Excavation Conditions

Excavation will probably be required to allow for the construction of the slabs on ground, lift pits, rafts, piles and pile caps. The removal of below-ground obstructions such as piles, pile caps and beams from the existing and previous structures on the site may also require localised excavations. Information from the previous geotechnical investigations indicates that the excavation will probably intersect variable filling, mainly comprising gravelly sand, concrete rubble and crushed sandstone and possibly alluvial soils.

All excavated materials will need to be disposed of in accordance with the provisions of the current legislation and guidelines including the Waste Classification Guidelines (DECC, April 2008; updated 2009). This includes filling and natural materials that may be removed from site. No previous environmental waste classification or contamination assessments have been carried out at the site.

DP experience with recent projects in Darling Harbour indicates that contaminated soil is likely to underlie the site.

6.3 Excavation Support

Vertical excavations in filling and alluvial soils will not be self-supporting. Temporary batters should be feasible, primarily where the water table will not be intersected, and should be cut no steeper than 1.5(H):1(V) for the filling materials and alluvium, up to a maximum excavation of 3 m.

Shoring support will be required in areas where temporary batters cannot be utilised and below the water table. Suitable shoring systems for the site include trench boxes, sheet piling (depending on the extent and nature of obstructions) and contiguous pile walls.

Excavation faces retained either temporarily or permanently will be subjected to earth pressures. Table 3 outlines material and strength parameters that could be used for the design of excavation support structures.

Table 3: Material and Strength Parameters for Excavation Support Structures

Material	Bulk Density (kN/m^3)	Coefficient of Active Earth Pressure (K_a)	Coefficient of Earth Pressure at Rest (K_o)
Filling and Alluvium	20	0.4	0.6
Residual Soil	20	0.3	0.4

A triangular lateral earth pressure distribution may be assumed for cantilevered walls and a rectangular lateral earth pressure distribution for walls propped at the top and bottom. Lateral pressures due to surcharge loads from adjacent structures, roads, sloping ground surfaces and construction machinery should be considered. Below the water table hydrostatic pressure acting on the shoring walls should also be included in the design.

6.4 Foundations

The foundations for the proposed development are proposed to consist of piles, arranged singly and in groups of up to 14 piles. Due to the potential for collapse of the filling and alluvial soils, appropriate piling methods would include bored piles using casing and drilling mud and/or continuous flight auger (CFA) piles. Alternatives such as barrettes could also be considered and a specialist piling contractor should be consulted.

Bored piling, sleaved as required, would be appropriate for the 1800 and 2500 piles. CFA piling at 750 mm diameter would have the benefit of better production rates than bored piling. 750 piling using CFA should take into account penetration into the medium strength sandstone and close monitoring of flight pitch/rotation speed/penetration will be required due to the potential for decompression when encountering bedrock. In addition concrete pump rate and pressure/flight withdrawal rates need to be closely monitored to prevent pile necking in the softer materials. Both methods should take into account the available headroom under the Western Distributor overpass

For the preliminary design of piles, recommended maximum ultimate and allowable (or "serviceability") end bearing pressures, and estimated elastic modulus values for the foundation materials encountered in the field investigations at the site are presented in Table 4. Preliminary lateral modulus of subgrade reaction parameters are also provided in Table 4, where d is the pile diameter in millimetres. It should be noted that the parameters in Table 4 are subject to additional geotechnical investigation.

Table 4: Recommended Parameters for Pile Foundation Design

Material	End Bearing Pressure (kPa)		Ultimate Shaft adhesion(1) (kPa)		Lateral Modulus of Subgrade Reaction k_h (kPa/mm)	Field Elastic Modulus (MPa)
	Allowable	Ultimate	Allowable	Ultimate		
Filling and natural soil	-	-	-	-	(1000 - 6000)/d	1
Medium Strength Sandstone	3500	15000	350	850	(100000 - 250000)/d	500
High Strength Sandstone	8000	80000	900	2200	(100000 - 250000)/d	2000

NOTE (1) For pile foundations in compression only; assumes adequately roughened pile sockets and a minimum pile depth of 4 times the pile diameter; reduce by 50% to obtain values for design against uplift. Adhesion should be applied only below 3 m depth.
If CFA piles are to be used, the shaft adhesion values in table 4 should be reduced by 20%.

7. Further Investigation

Further geotechnical investigation will be required to assess the strength of bedrock to allow for the final design of piles and tension anchors. This should include a minimum of six boreholes cored a minimum of 6 m into bedrock with selected rock samples tested for unconfined compressive strength (UCS).

A preliminary waste classification investigation should be conducted to provide information on the filling materials likely to be removed as part of the proposed excavations.

8. Limitations

Douglas Partners Pty Ltd (DP) has prepared this report for The Ribbon at 31 Wheat Road, Darling Harbour, in accordance with the proposal dated 26 September 2012. This report is provided for the exclusive use of Grocon Constructions Pty Ltd for the specific project and purpose as described in the

report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party.

The results provided in the report are considered to be indicative of the sub-surface conditions on the site only to the depths investigated at the specific sampling and/or testing locations, and only at the time the work was carried out. DP's advice is based on observations, measurements, tests or derived interpretations. The accuracy of the advice provided by DP in this report is limited by unobserved features and variations in ground conditions across the site in areas between test locations and beyond the site boundaries or by variations with time. The advice may be limited by restrictions in the sampling and testing previously carried out.

This report must be read in conjunction with the attached "About This Report" and any other attached explanatory notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others, which are not otherwise supported by an expressed statement, interpretation, outcome or conclusion stated in this report. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

This report, or sections of this report, should not be used as part of a specification for a project without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

Douglas Partners Pty Ltd

Appendix A

About this Report

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

Borehole and Test Pit Logs

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

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

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

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole 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. They may not be the same at the time of construction as are indicated in the report; and
- 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 first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or 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 a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

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

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

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, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

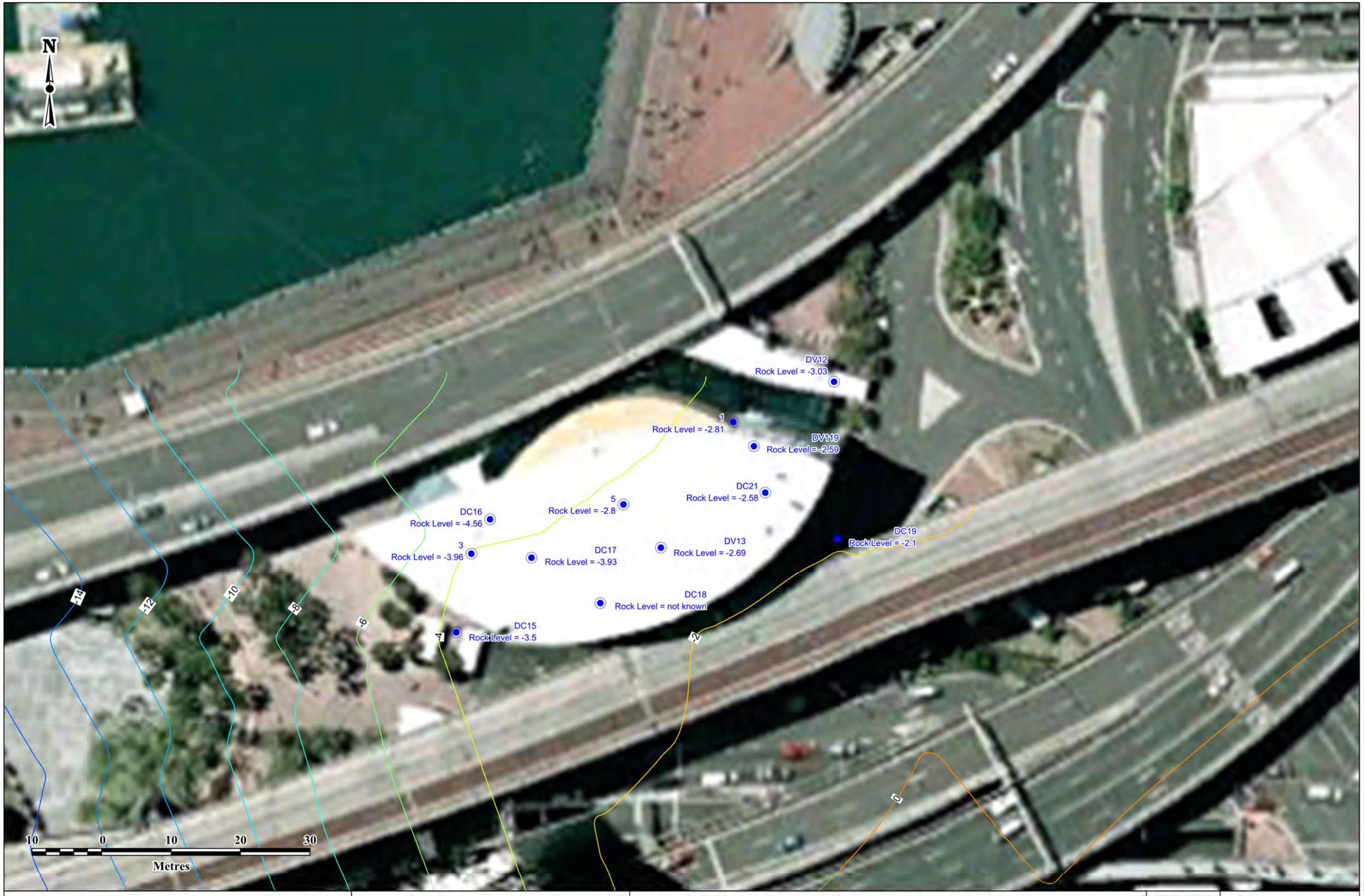
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Appendix B

Drawing 1 – Previous Test Locations and Top of Rock Contours
Drawing 2 – Proposed Ground & Footing Plan
Sketch 1 – Geological Cross Section A-A'
Table B1 – Summary of Previous Test Results



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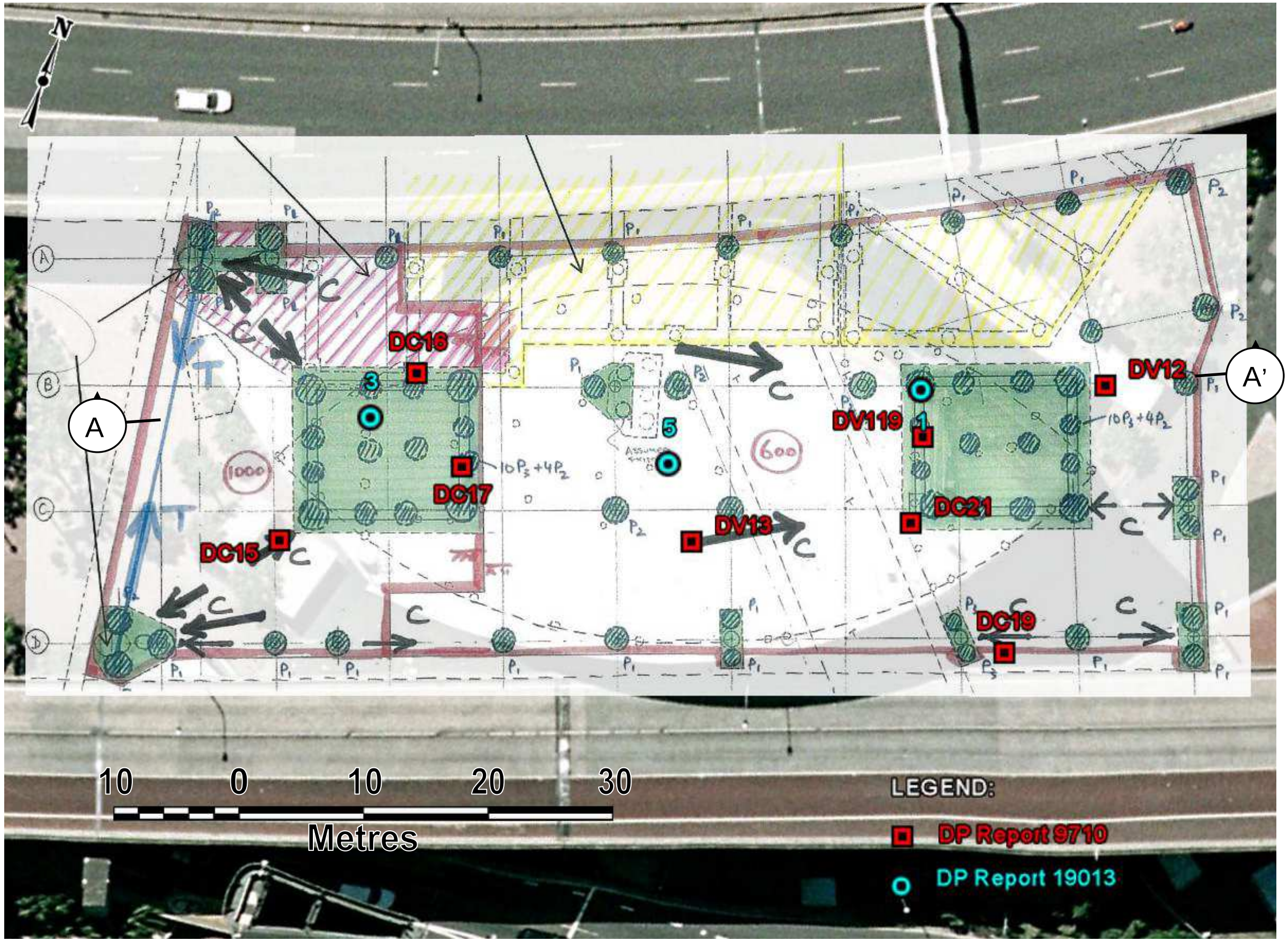
CLIENT: Grocon		
OFFICE: Sydney	DRAWN BY: DF	
SCALE: 1:500 @ A3	DATE: 10.10.2012	

TITLE: The Ribbon Proposed Development, Darling Harbour
Desk Study Information
Approximate Level to Top of Rock, m AHD

MAG N ISG MGA

No: 73201.00	
DRAWING No:	1
REVISION:	1



Douglas Partners Geotechnics / Environment / Groundwater	CLIENT:	Grocon Constructions Pty Ltd		TITLE:	**Proposed Ground & Footing Plan** **The Ribbon** **31 Wheat Road, Darling Harbour**	PROJECT No:	73201
	OFFICE:	Sydney	DRAWN BY: LJH			DRAWING No:	2
	SCALE:	N/A	DATE: 16/10/12			REVISION:	A

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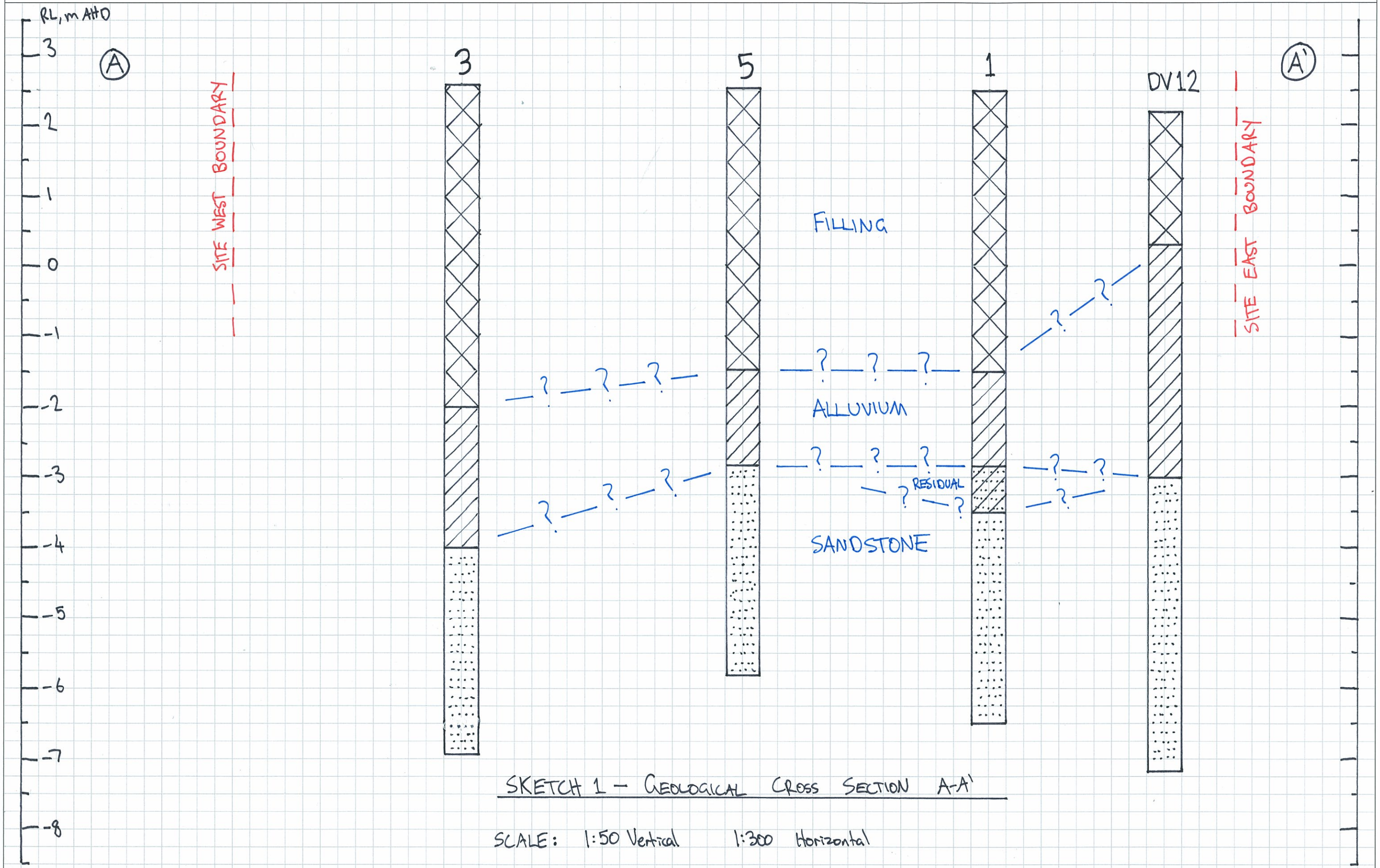
PROJECT The Ribbon, Darling Harbour – Grocon Const. P/L Project No: 73201.00 Page No: Sketch 1 Calcs By: LJH Checked by: FM Date: 17/10/12



SKETCH 1 – GEOLOGICAL CROSS SECTION A-A'

SCALE: 1:50 Vertical 1:300 Horizontal

Table B1: Summary of Previous Test Results

	Report 9710								Report 19013		
Test	**DV12**	**DV13**	**DV119**	**DC16**	**DC17**	**DC18**	**DC19**	**DC21**	**1**	**3**	**5**
Surface RL	2.22	2.31	2.41	2.34	2.27	2.38	2.30	2.45	2.49	2.59	2.55
Depth to Water Table	2.40	2.40							2.15	2.18	2.40
Depth to Base of Filling	1.90	3.60	4.00	2.50	2.50	2.30	2.50	2.00	4.00	4.60	4.00
Depth to Base of Alluvium	5.25	4.60	4.95	6.70	6.00		4.20	5.00	5.30	6.55	5.35
Depth to Base of Residual		5.00		6.90	6.20		4.40		6.00		
Depth to Top of Rock	5.25	5.00	4.95	6.90	6.20		4.40	5.00	6.00	6.55	5.35
Bottom of Test	9.40	8.25	5.00	6.90	6.20		4.40	5.03	9.00	9.55	8.35
RL Water Table	-0.18	-0.09							0.34	0.41	0.15
RL Base of Filling	0.32	-1.29	-1.59	-0.16	-0.23	0.08	-0.20	0.45	-1.51	-2.01	-1.45
RL Base of Alluvium	-3.03	-2.29	-2.54	-4.36	-3.73		-1.90	-2.55	-2.81	-3.96	-2.80
RL Base of Residual		-2.69		-4.56	-3.93		-2.10		-3.51		
RL Top of Rock	-3.03	-2.69	-2.54	-4.56	-3.93		-2.10	-2.55	-3.51	-3.96	-2.80
RL Bottom of Test	-7.18	-5.94	-2.59	-4.56	-3.93		-2.10	-2.58	-6.51	-6.96	-5.80

Appendix C

Borehole Logs from previous Geotechnical Investigations by Douglas Partners Pty Ltd

Soil Descriptions

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Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

Sampling

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

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm 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 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

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

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Rock Strength

Rock strength is defined by the Point Load Strength Index ($Is_{(50)}$) and refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects. The test procedure is described by Australian Standard 4133.4.1 - 1993. The terms used to describe rock strength are as follows:

Term	Abbreviation	Point Load Index $Is_{(50)}$ MPa	Approx Unconfined Compressive Strength MPa*
Extremely low	EL	<0.03	<0.6
Very low	VL	0.03 - 0.1	0.6 - 2
Low	L	0.1 - 0.3	2 - 6
Medium	M	0.3 - 1.0	6 - 20
High	H	1 - 3	20 - 60
Very high	VH	3 - 10	60 - 200
Extremely high	EH	>10	>200

* Assumes a ratio of 20:1 for UCS to $Is_{(50)}$

Degree of Weathering

The degree of weathering of rock is classified as follows:

Term	Abbreviation	Description
Extremely weathered	EW	Rock substance has soil properties, i.e. it can be remoulded and classified as a soil but the texture of the original rock is still evident.
Highly weathered	HW	Limonite staining or bleaching affects whole of rock substance and other signs of decomposition are evident. Porosity and strength may be altered as a result of iron leaching or deposition. Colour and strength of original fresh rock is not recognisable
Moderately weathered	MW	Staining and discolouration of rock substance has taken place
Slightly weathered	SW	Rock substance is slightly discoloured but shows little or no change of strength from fresh rock
Fresh stained	Fs	Rock substance unaffected by weathering but staining visible along defects
Fresh	Fr	No signs of decomposition or staining

Degree of Fracturing

The following classification applies to the spacing of natural fractures in diamond drill cores. It includes bedding plane partings, joints and other defects, but excludes drilling breaks.

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	Core lengths of 20-40 mm with some fragments
Fractured	Core lengths of 40-200 mm with some shorter and longer sections
Slightly Fractured	Core lengths of 200-1000 mm with some shorter and loner sections
Unbroken	Core lengths mostly > 1000 mm

Rock Descriptions

Rock Quality Designation

The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

$$\text{RQD \%} = \frac{\text{cumulative length of 'sound' core sections} \geq \text{100 mm long}}{\text{total drilled length of section being assessed}}$$

where 'sound' rock is assessed to be rock of low strength or better. The RQD applies only to natural fractures. If the core is broken by drilling or handling (i.e. drilling breaks) then the broken pieces are fitted back together and are not included in the calculation of RQD.

Stratification Spacing

For sedimentary rocks the following terms may be used to describe the spacing of bedding partings:

Term	Separation of Stratification Planes
Thinly laminated	< 6 mm
Laminated	6 mm to 20 mm
Very thinly bedded	20 mm to 60 mm
Thinly bedded	60 mm to 0.2 m
Medium bedded	0.2 m to 0.6 m
Thickly bedded	0.6 m to 2 m
Very thickly bedded	> 2 m

Symbols & Abbreviations

Douglas Partners

Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core Drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

Graphic Symbols for Soil and Rock

General


Asphalt


Road base


Concrete


Filling

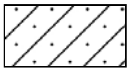
Soils


Topsoil

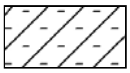

Peat


Clay

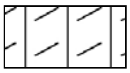

Silty clay

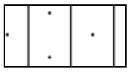

Sandy clay

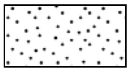

Gravelly clay

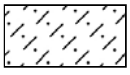

Shaly clay

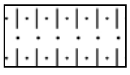

Silt


Clayey silt


Sandy silt

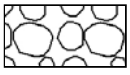

Sand

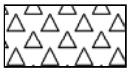

Clayey sand


Silty sand


Gravel


Sandy gravel


Cobbles, boulders

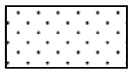

Talus

Sedimentary Rocks

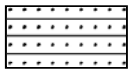

Boulder conglomerate

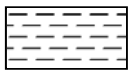

Conglomerate


Conglomeratic sandstone

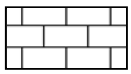

Sandstone


Siltstone


Laminite

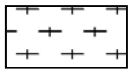

Mudstone, claystone, shale

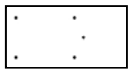

Coal


Limestone

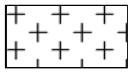
Metamorphic Rocks

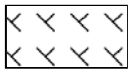

Slate, phyllite, schist

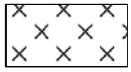

Gneiss

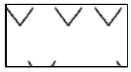

Quartzite

Igneous Rocks


Granite


Dolerite, basalt, andesite


Dacite, epidote


Tuff, breccia


Porphyry

TEST BORE REPORT

CLIENT WARGON CHAPMAN & PARTNERS PTY. LTD.

SITE DISCOVERY VILLAGE

LOCATION DARLING HARBOUR DEVELOPMENT

BORE No. DV 12

DATE 18/7/86

CONTRACT No. SSI/9710

SURFACE LEVEL 2.22 M

DATUM AHD

DEPTH R.L.	Description of Strata	SAMPLING & IN SITU TESTING
0.35	FILLING - roadbase slag	
1.0	FILLING - black silty clayey coarse sand and gravel, generally very loose	S 3,1,1 N=2
1.90		
2.0	SILTY SAND - very loose brown and grey silty sand, clayey in parts	
2.20		
2.40	SILTY CLAY - stiff black to dark grey silty clay	
2.5		S 0,1,1, for 200mm
3.0 3.00	SILTY SAND - very loose dark grey to black medium grained silty sand with shells	3.0 N=2
3.50	SILTY CLAY - stiff brown and grey silty clay, sandy in parts	
4.0	SILTY SAND - very loose dark grey to black coarse grained silty sand with shells; clayey in parts	4.0 S 0,0,0 4.5 N=0
5.0		
5.25		5.20 S 5.27 20 for 70mm
6.0	SANDSTONE - medium strong to strong slightly fractured light grey medium grained sandstone	
7.0		
8.0		
9.0		
9.40		
10.0	BORE DISCONTINUED AT 9.40 METRES	

Drilling: AUGER, ROTARY, MUD, CASING, CORING

WATER OBSERV.

DIAGRAM

UNDRAINED SHEAR STRENGTH (kPa)

SOIL CONSISTENCY — cohesive: VERY SOFT, SOFT, FIRM, STIFF, VERY STIFF, HARD; non.coh.: VERY LOOSE, LOOSE, MED.DENSE, DENSE, VERY DENSE

CORE REC. %: 100

ROCK STRENGTH: EXT.WEAK, VERY WEAK, WEAK, MED.STRONG, STRONG, VERY STRONG

+ SHEAR VANE
X POCKET PENETROMETER
O LABORATORY TRIAXIAL

RIG GM

DRILLER Schultz

LOGGED R. Lloyd

REMARKS

core type NMLC

dip of hole Vertical

azimuth -

Sampling and in situ testing

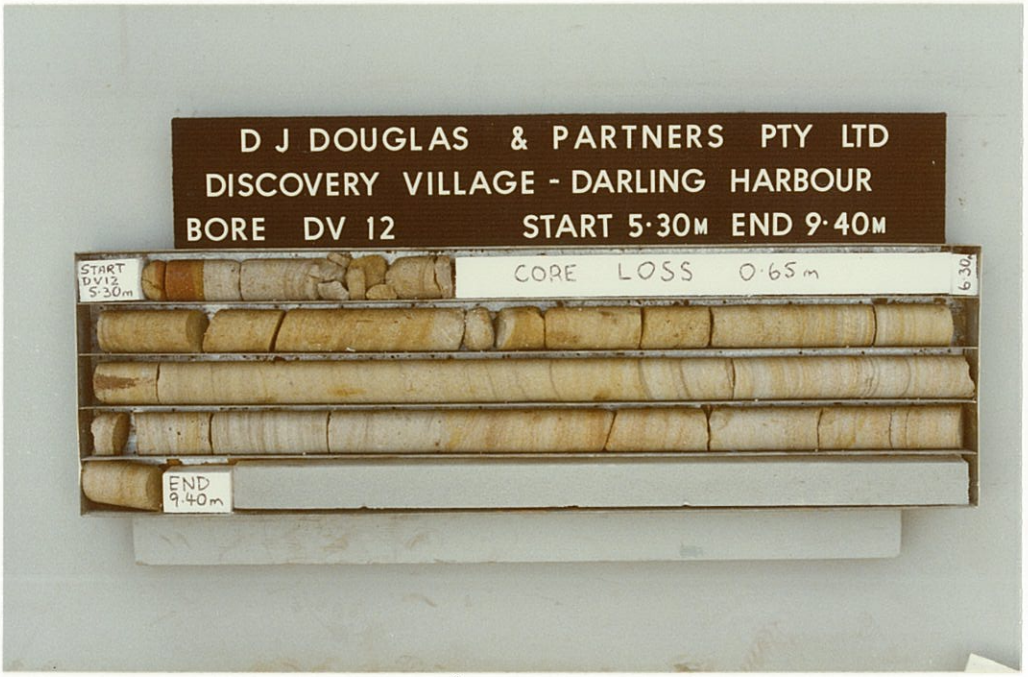
A AUGER
S STANDARD PENETRATION TEST
U mm TUBE
V1 VANE SHEAR TEST - (140x170mm)
V2 VANE SHEAR TEST - (100x50mm)
P PRESSUREMETER TEST
W WATER PRESSURE TEST

Water observations

free water observed

standing water level after hours.

D.J.Douglas & Partners


D J DOUGLAS & PARTNERS PTY LTD
DISCOVERY VILLAGE - DARLING HARBOUR
BORE DV 12 START 5·30M END 9·40M
START DV12 5·30m
CORE LOSS 0·65m
END 9·40m

TEST BORE REPORT

CLIENT WARGON CHAPMAN & PARTNERS PTY. LTD.

SITE DISCOVERY VILLAGE

LOCATION DARLING HARBOUR DEVELOPMENT

BORE No. DV 13

DATE 17/7/86

CONTRACT No. SSI/9710

SURFACE LEVEL 2.31 M

DATUM AHD

DEPTH R.L.	Description of Strata	SAMPLING & IN SITU TESTING
0.60	FILLING - aggregate, concrete and rubble	
1.0	FILLING - ash, slag and sand, generally very loose to medium dense	S 2,6,4 N=10
1.50		
2.0	FILLING - grey and red brown sandy clay sand and sandstone rubble, generally loose to medium dense	S 2.2 10,11,4 N=15
2.40		2.6
3.0		
3.60		
4.0 3.90	SAND - very loose grey medium grained sand with shells	
	SILTY CLAY - stiff grey silty clay with organic matter, sandy in parts	S 1,1,2 N=3
4.60		
5.0 5.00	SANDY CLAY - very stiff grey coarse grained sandy clay	S 5.20 20 for 30mm
	SANDSTONE - weak to medium strong slightly fractured light grey medium grained sandstone	5.23
6.0		
7.00	*7.10 m to 7.60 m subvertical joint	CORE REC. % 95
	*7.65 m clay seam 2mm	
8.0		
8.25	BORE DISCONTINUED AT 8.25 METRES	
9.0		

WATER OBSERV. | Drilling: AUGER, ROTARY, MUD, CASING, CORING | DIAGRAM | UNDRAINED SHEAR STRENGTH (kPa) | SOIL CONSISTENCY: cohesive (VERY SOFT, SOFT, FIRM, STIFF, VERY STIFF, HARD); non.coh. (VERY LOOSE, LOOSE, MEDDENSE, DENSE, VERY DENSE) | CORE REC. % | ROCK STRENGTH (EXT.WEAK, VERY WEAK, WEAK, MED.STRONG, STRONG, VERY STRONG)

+ SHEAR VANE
X POCKET PENETROMETER
O LABORATORY TRIAXIAL

RIG Pioneer 2

DRILLER Crowe

LOGGED R. Lloyd

REMARKS

core type NMLC

dip of hole Vertical

azimuth -

Sampling and in situ testing

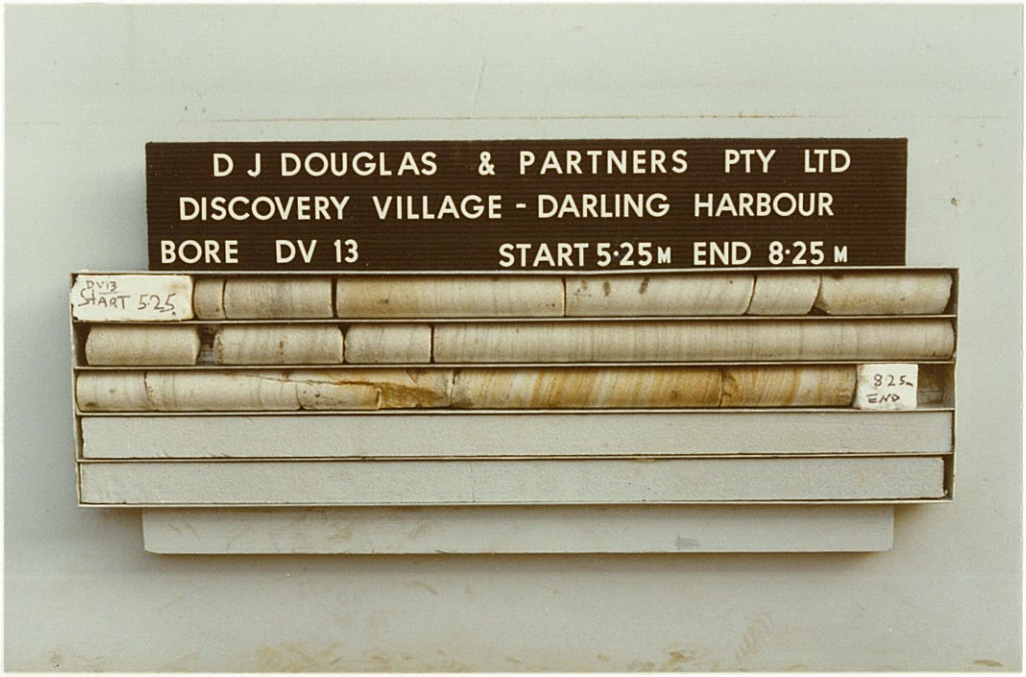
A AUGER
S STANDARD PENETRATION TEST
U mm TUBE
V1 VANE SHEAR TEST - (140x170mm)
V2 VANE SHEAR TEST - (100x50mm)
P PRESSUREMETER TEST
W WATER PRESSURE TEST

Water observations

free water observed

standing water level after hours.

D.J.Douglas & Partners


D J DOUGLAS & PARTNERS PTY LTD
DISCOVERY VILLAGE - DARLING HARBOUR
BORE DV 13 START 5·25 M END 8·25 M
DV13
START 5·25
8·25m
END

TEST BORE REPORT

CLIENT WARGON CHAPMAN & PARTNERS PTY. LTD.

SITE DISCOVERY VILLAGE

LOCATION DARLING HARBOUR DEVELOPMENT

BORE No. DV119

DATE 20/2/87

CONTRACT No. SSI/9710/2

SURFACE LEVEL 2.41M

DATUM AHD

DEPTH R.L.	Description of Strata
0.50	FILLING - dark brown to brown sand, gravel and concrete rubble
0.80	
1.0	FILLING - yellow brown to brown fine to medium grained sandy clay, some gravel, Generally soft to firm
4.0	SANDY CLAY - very soft dark grey sandy marine clay with some shells
4.95	SANDSTONE - weak to medium strong yellow brown fine to medium grained sandstone
5.00	BORE DISCONTINUED AT 5.00 METRES

Drilling: AUGER

WATER OBSERV.

SOIL CONSISTENCY — cohesive: VERY SOFT, SOFT, FIRM, STIFF, VERY STIFF, HARD; non.coh.: VERY LOOSE, LOOSE, MED.DENSE, DENSE, VERY DENSE

UNDRAINED SHEAR STRENGTH (kPa)

SAMPLING & IN SITU TESTING

- S 2,1,2 N = 3
- S 2,4,2 N = 6
- S 1,0,0 N = 0
- S Hammer rebound

RQD / CORE REC. %

ROCK STRENGTH: EXT.WEAK, VERY WEAK, WEAK, MED.STRONG, STRONG, VERY STRONG

+ SHEAR VANE
X POCKET PENETROMETER
○ LABORATORY TRIAXIAL

RIG McDermott Drilling B40L

DRILLER Z. Yanakievski

LOGGED W. Milne-Home

REMARKS TC Bit refusal at 5.00m

core type

dip of hole

azimuth

Sampling and in situ testing

A AUGER
S STANDARD PENETRATION TEST
U mm TUBE
V1 VANE SHEAR TEST - (140x170mm)
V2 VANE SHEAR TEST - (100x50mm)
P PRESSUREMETER TEST
W WATER PRESSURE TEST

Water observations

free water observed

standing water level after hours.

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TEST BORE REPORT

PAGE 1 OF 2

BORE No. DC 16

CLIENT WARGON CHAPMAN & PARTNERS PTY. LTD.

SITE DISCOVERY VILLAGE

LOCATION DARLING HARBOUR DEVELOPMENT

DATE 18/3/87

CONTRACT No. SSI/9710/2

SURFACE LEVEL 2.34 M

DATUM

DEPTH R.L.	WATER OBSERV.	Drilling: AUGER	ROTARY	MUD	CASING	CORING	Description of Strata	DIAGRAM	UNDRAINED SHEAR STRENGTH (kPa)	SOIL CONSISTENCY: cohesive: VERY SOFT / SOFT / FIRM / STIFF / VERY STIFF / HARD	non.coh.: VERY LOOSE / LOOSE / MED.DENSE / DENSE / VERY DENSE	SAMPLING & IN SITU TESTING	RQD / CORE REC. %	ROCK STRENGTH: EXT. WEAK / VERY WEAK / WEAK / MED.STRONG / STRONG / VERY STRONG
0.5							FILLING – dark brown sand filling with brick rubble							
1.0														
1.50							FILLING – dark brown sandy clay filling with rubble, generally firm to stiff					S 4,4,20/50mm Refusal on rubble		
2.0														
2.50							CLAYEY SAND – very loose to loose brown fine to medium grained clayey sand							
3.0 3.00							BORE TO 3.00 METRES See Page 2 for continuation as Dutch Cone							
3.5														

+ SHEAR VANE
X POCKET PENETROMETER
○ LABORATORY TRIAXIAL

RIG B40/Dutch Cone

DRILLER B Lamb

LOGGED A Tzintzios

REMARKS Borehole drilled to 3.0 m and continued as Dutch Cone to 6.9 m

core type

dip of hole

azimuth

Sampling and in situ testing

A AUGER
S STANDARD PENETRATION TEST
U mm TUBE
V1 VANE SHEAR TEST – (140 x 170mm)
V2 VANE SHEAR TEST – (100 x 50mm)
P PRESSUREMETER TEST
W WATER PRESSURE TEST

Water observations

free water observed

standing water level after hours.

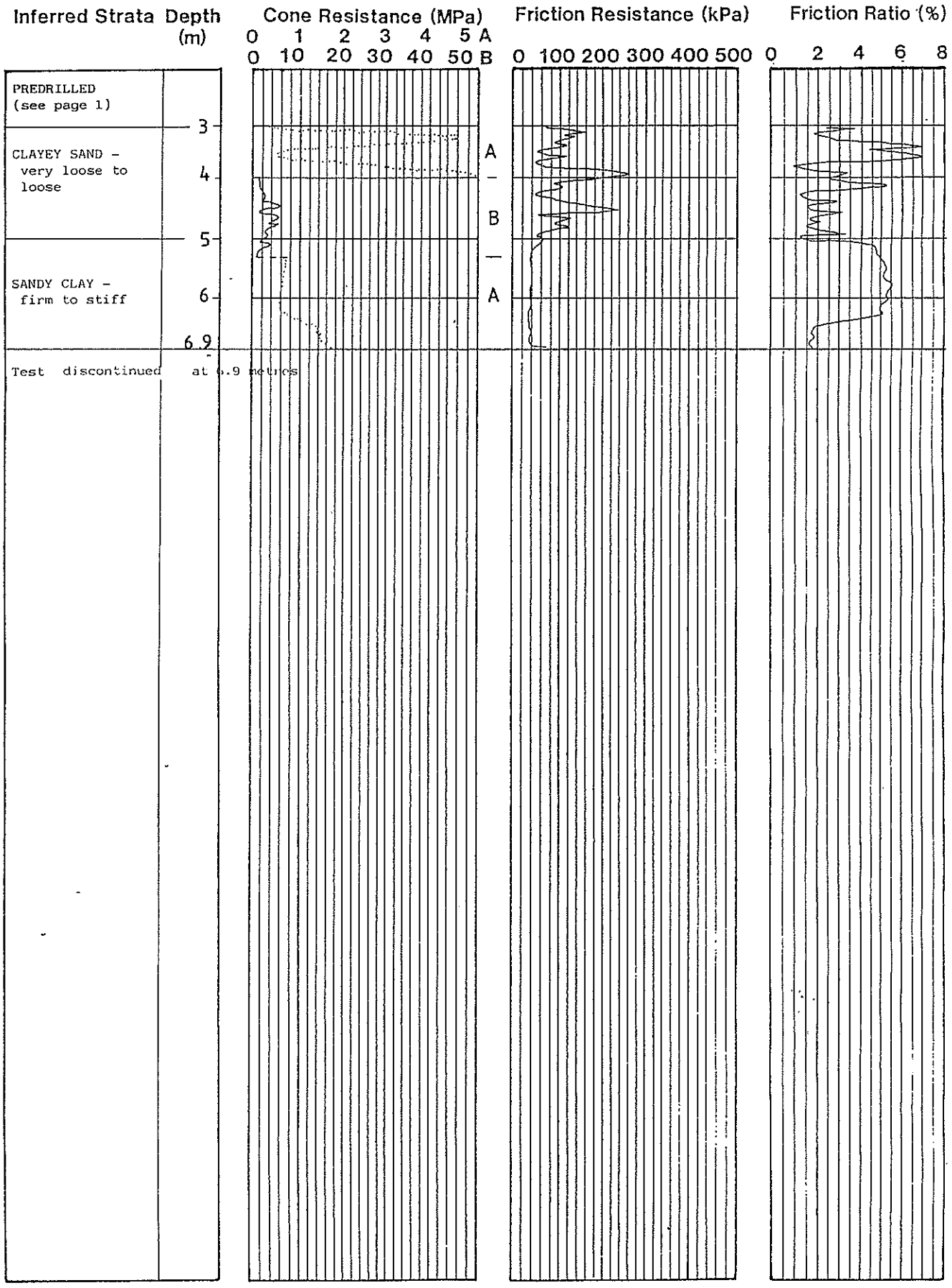
D.J. Douglas & Partners

RESULTS OF CONE PENETROMETER TESTS

CLIENT WARGON CHAPMAN & PARTNERS
SITE DISCOVERY VILLAGE
LOCATION DARLING HARBOUR DEVELOPMENT

DATE 19/3/87
CONTRACT No. SSI/9710/2
SURFACE LEVEL 2.34

TEST No. DC16



Remarks: Cone refusal on inferred medium strong rock

D.J.Douglas & Partners

CLIENT WARGON CHAPMAN & PARTNERS PTY. LTD.

SITE DISCOVERY VILLAGE

LOCATION DARLING HARBOUR DEVELOPMENT

TEST BORE REPORT

BORE No. DC 17

DATE 17/3/87-18/3/87

CONTRACT No. SSI/9710/2

SURFACE LEVEL 2.27 M

DATUM

DEPTH R.L.	Description of Strata	DIAGRAM	SAMPLING & IN SITU TESTING
0.5	FILLING - brown sand filling with ash, brick and sandstone rubble		
1.0			
1.50	FILLING - dark brown sand filling with rubble, generally loose		S 3,3,4 N=7
2.0			
2.50	SANDY CLAY - stiff dark brown sandy clay		
3.0			S 1,4,8 N=12
3.50	CLAYEY SAND - loose dark grey clayey sand		
4.00	BORE TO 4.00 METRES See Page 2 for continuation as Dutch Cone		

Drilling: AUGER, ROTARY, MUD, CASING, CORING

WATER OBSERV.

UNDRAINED SHEAR STRENGTH (kPa)

SOIL CONSISTENCY — cohesive: VERY SOFT, SOFT, FIRM, STIFF, VERY STIFF, HARD; non.coh.: VERY LOOSE, LOOSE, MED.DENSE, DENSE, VERY DENSE

RQD

CORE REC. %

ROCK STRENGTH: EXT.WEAK, VERY WEAK, WEAK, MED.STRONG, STRONG

+ SHEAR VANE
X POCKET PENETROMETER
O LABORATORY TRIAXIAL

RIG B40

DRILLER B Lamb

LOGGED A Tzintzios

REMARKS Borehole drilled to 4.0 m and continued as Dutch Cone to 6.2 m

Sampling and In situ testing

- A AUGER
- S STANDARD PENETRATION TEST
- U mm TUBE
- V1 VANE SHEAR TEST - (140x170mm)
- V2 VANE SHEAR TEST - (100x50mm)
- P PRESSUREMETER TEST
- W WATER PRESSURE TEST

Water observations

- free water observed
- standing water level after hours.

core type

dip of hole

azimuth

D.J.Douglas & Partner

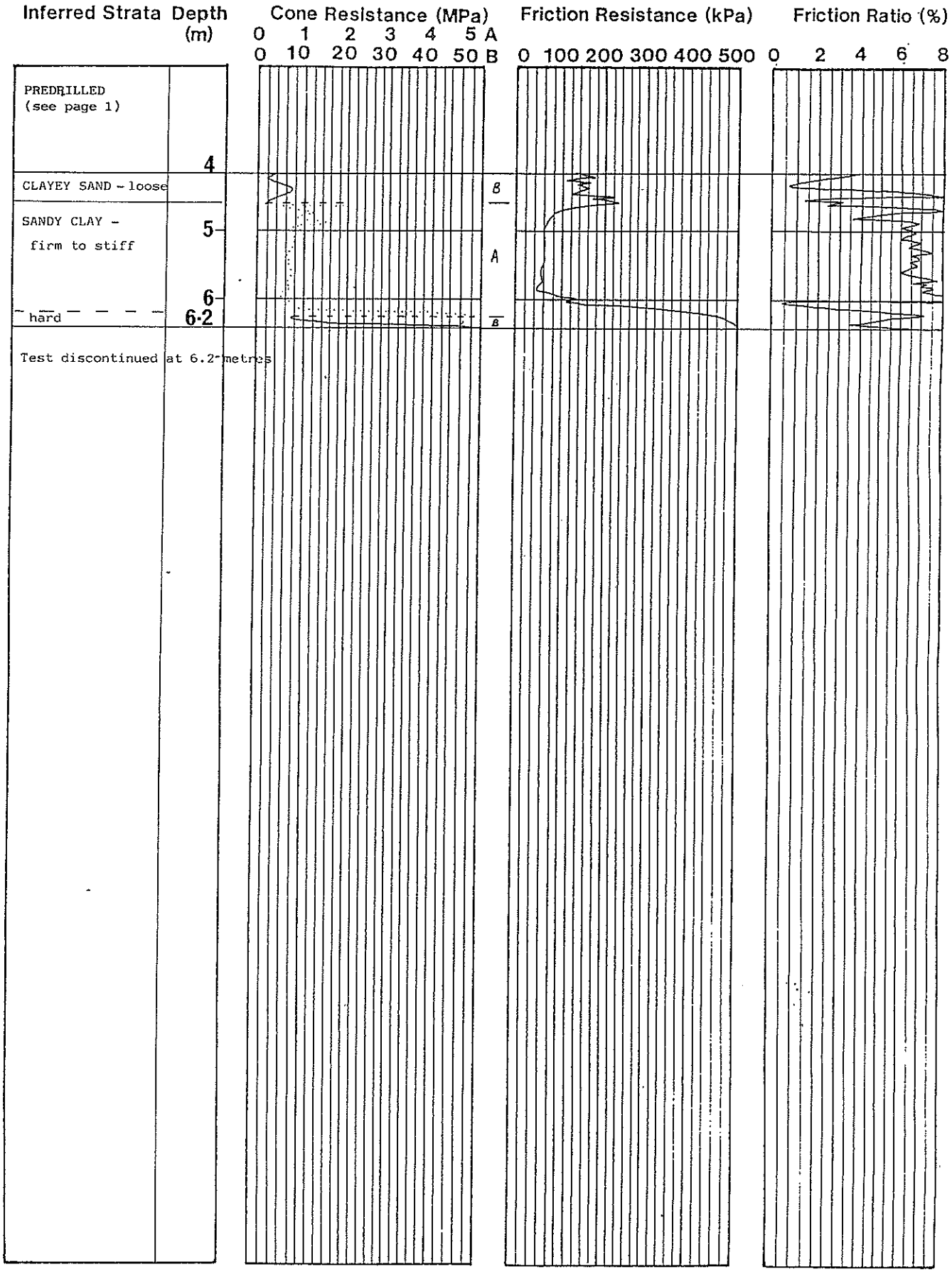
RESULTS OF CONE PENETROMETER TESTS

CLIENT WARGON CHAPMAN & PARTNERS
SITE DISCOVERY VILLAGE
LOCATION DARLING HARBOUR DEVELOPMENT

DATE 20/3/87
CONTRACT No. SSI/9710/2

TEST No. DC17

SURFACE LEVEL 2.30



Remarks: Cone refusal on inferred medium strong rock

D.J.Douglas & Partners

TEST PIT & BORE REPORT
PAGE 1 OF 2

CLIENT WARGON CHAPMAN & PARTNERS PTY. LTD.

SITE DISCOVERY VILLAGE

LOCATION DARLING HARBOUR DEVELOPMENT

PIT & BORE No. DC 19

DATE 12/3/87 TO 13/3/87

CONTRACT No. SSI/9710/2

SURFACE LEVEL 2.30 M

DATUM

DEPTH R.L.	WATER OBSERV.	Drilling: AUGER	ROTARY	MUD	CASING	CORING	Description of Strata	DIAGRAM	UNDRAINED SHEAR STRENGTH (kPa)	SOIL CONSISTENCY: cohesive: VERY SOFT / SOFT / FIRM / STIFF / VERY STIFF / HARD	non.coh.: VERY LOOSE / LOOSE / MED.DENSE / DENSE / VERY DENSE	SAMPLING & IN SITU TESTING	RQD / CORE REC. %	ROCK STRENGTH: EXT.WEAK / VERY WEAK / WEAK / MED.STRONG / STRONG
0.10							FILLING - asphalt over roadbase							
							CONCRETE - unreinforced							
0.5							FILLING - brown crushed sandstone							
							CONCRETE - 4mm mesh reinforcing							
							FILLING - brown crushed sandstone							
1.0														
1.5			Hand excavation											
2.0														
2.50							CLAYEY SAND - very loose light brown fine to medium grained clayey sand							
3.00							BORE TO 3.00 METRES See Page 2 for continuation as Dutch Cone							
3.5														
4.0														

+ SHEAR VANE
X POCKET PENETROMETER
○ LABORATORY TRIAXIAL

RIG Jackhammer/Backhoe & Hand Excavation/D. Cone DRILLER B Lamb

LOGGED S McCulla

REMARKS Backhoe excavated to 2.5 m then borehole to 3.0 m and continued as Dutch Cone to

Sampling and in situ testing
- A AUGER
- S STANDARD PENETRATION TEST
- U mm TUBE
- V1 VANE SHEAR TEST - (140x170mm)
- V2 VANE SHEAR TEST - (100x50mm)
- P PRESSUREMETER TEST
- W WATER PRESSURE TEST

Water observations
- free water observed
- standing water level after hours.

core type

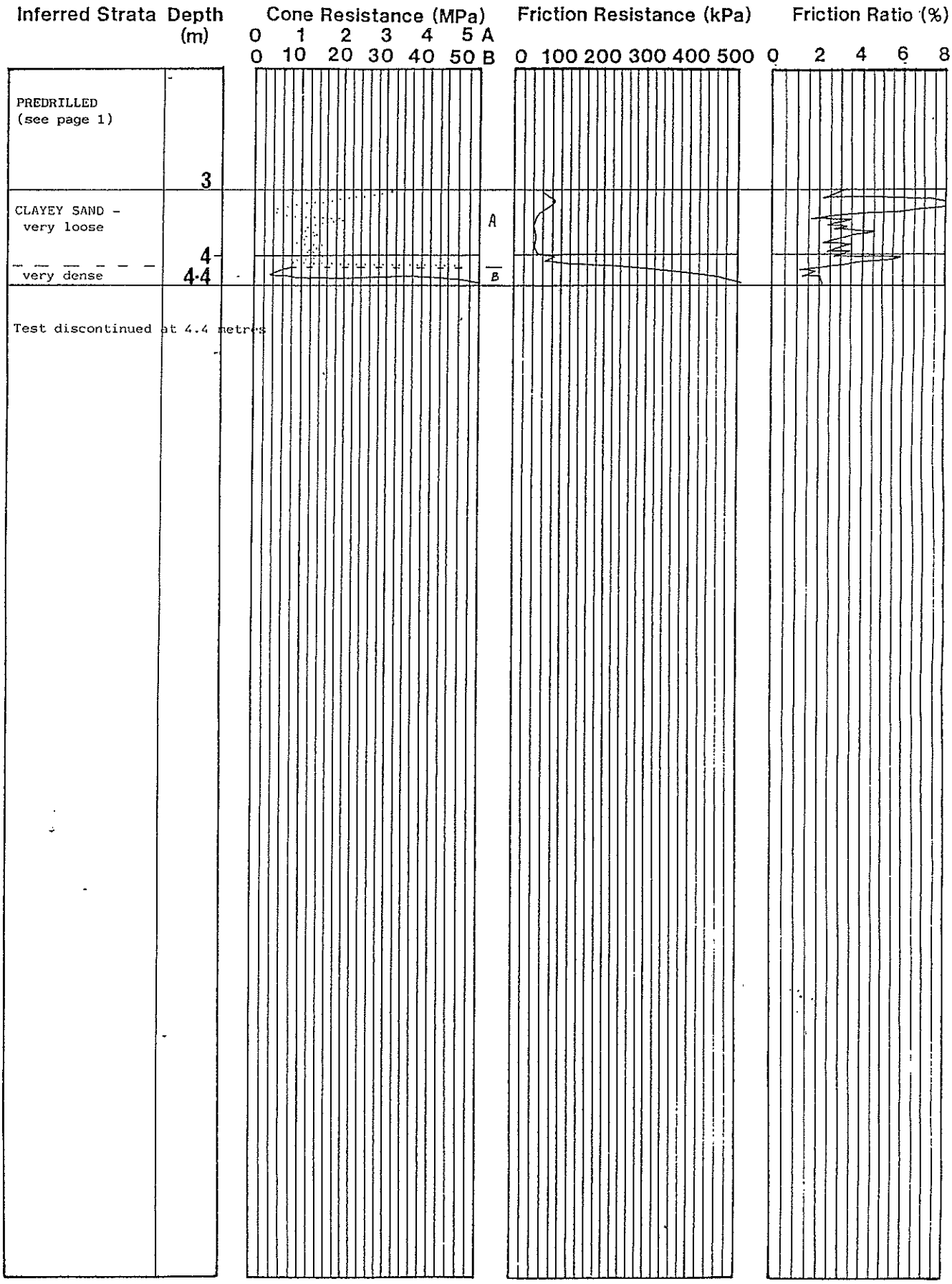
dip of hole

azimuth

D.J.Douglas & Partners

RESULTS OF CONE PENETROMETER TESTS

CLIENT	WARGON CHAPMAN & PARTNERS	DATE 20/3/87	TEST No. DC19 PAGE 2 OF 2
SITE	DISCOVERY VILLAGE	CONTRACT No. SSI/9710/2	
LOCATION	DARLING HARBOUR DEVELOPMENT	SURFACE LEVEL 2.30	



Remarks: Cone refusal on inferred medium strong rock

D.J.Douglas & Partners

TEST BORE REPORT

CLIENT WARGON CHAPMAN & PARTNERS PTY. LTD.

SITE DISCOVERY VILLAGE

LOCATION DARLING HARBOUR DEVELOPMENT

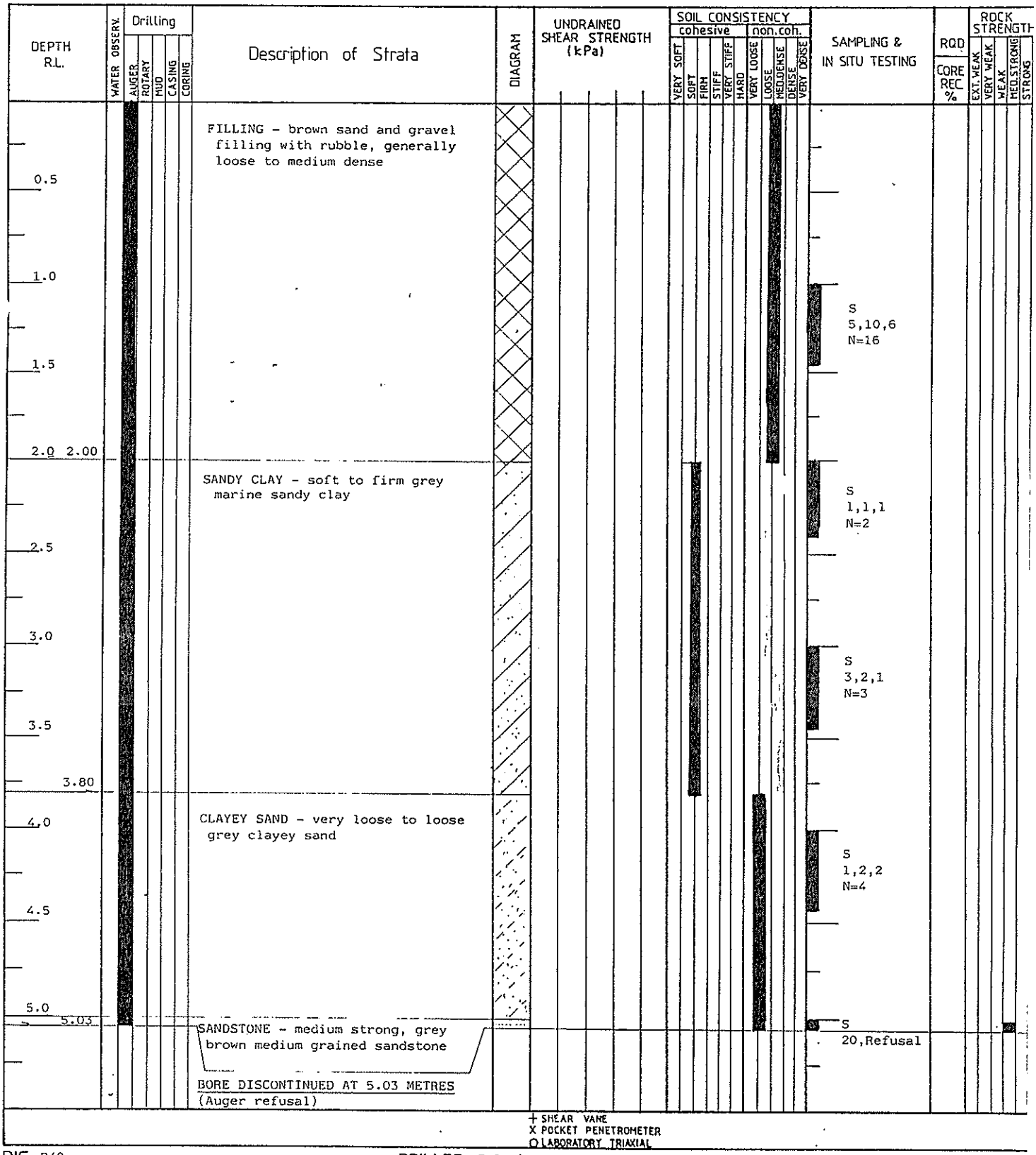
BORE No. DC 21

DATE 20/3/87

CONTRACT No. SSI/9710/2

SURFACE LEVEL 2.45 M

DATUM



RIG B40

DRILLER B Lamb

LOGGED MAA

REMARKS Auger refusal at 5.03 m

core type

dip of hole Vertical

azimuth

Sampling and in situ testing

A AUGER
S STANDARD PENETRATION TEST
U mm TUBE
V1 VANE SHEAR TEST - (140x170mm)
V2 VANE SHEAR TEST - (100x50mm)
P PRESSUREMETER TEST
W WATER PRESSURE TEST

Water observations

free water observed

standing water level after hours.

D.J.Douglas & Partners

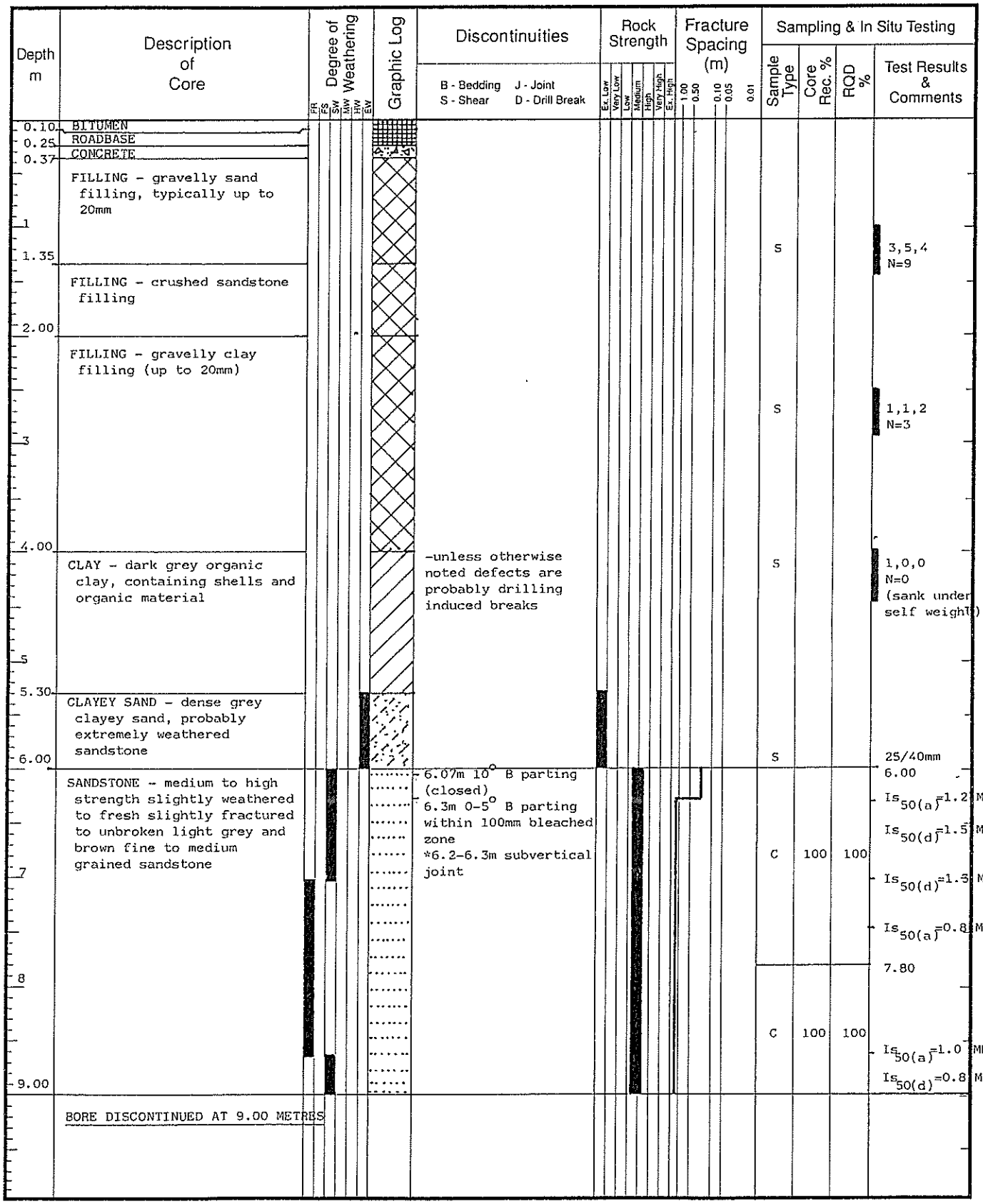
TEST BORE REPORT

DATE 2.11.92

CLIENT KINHILL ENGINEERS | PROJECT No 19013 | BORE No 1

PROJECT THEATRE DEVELOPMENT | SURFACE LEVEL 2.49 AHD | SHEET 1OF 1

LOCATION DARLING HARBOUR | DIP OF HOLE 90° | AZIMUTH



RIG Scout | DRILLER Chittleburgh | LOGGED Klok | CASING NW to 6.00m

TYPE OF BORING Solid flight auger GL to 5.5m then drag bit to 6.00m

WATER OBSERVATIONS Free ground water observed at 2.15m

REMARKS

SAMPLING & IN SITU TESTING

A	auger sample	PL	point load strength $I_s(50)$(MPa)
B	bulk sample	S	standard penetration test
C	core drilling	Ux	x mm dia tube

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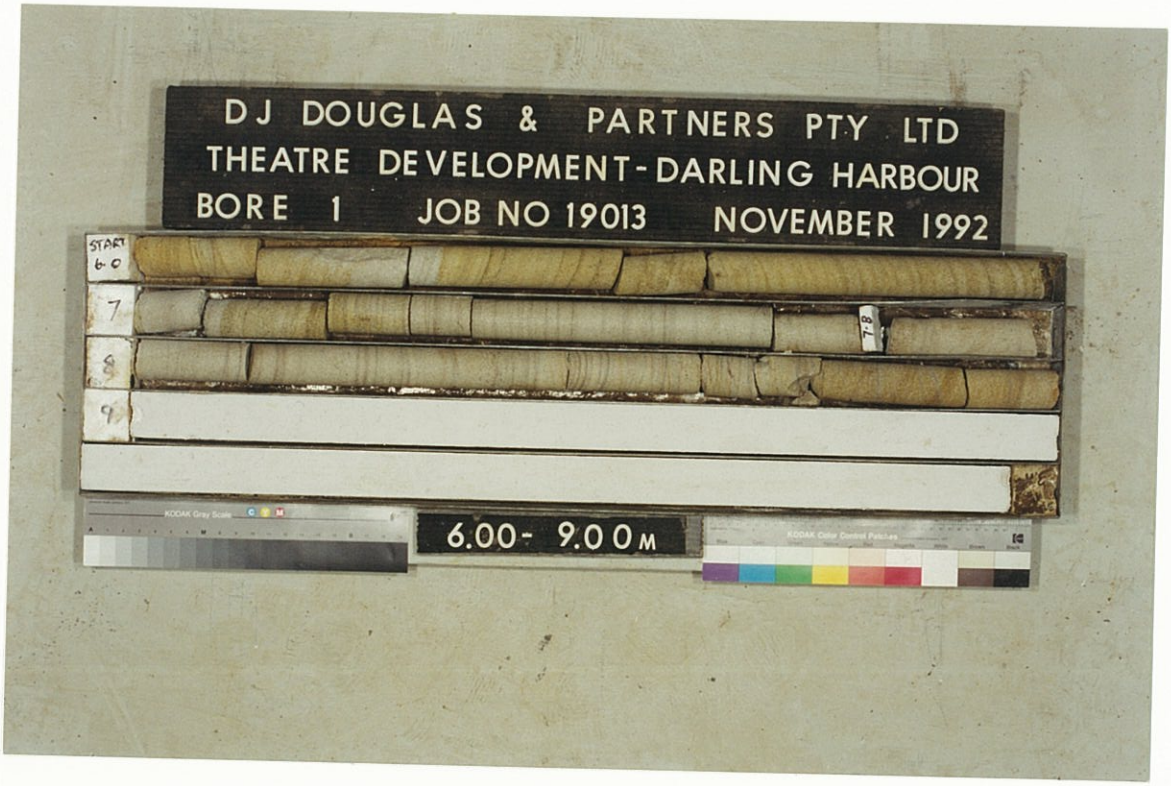

DJ DOUGLAS & PARTNERS PTY LTD
THEATRE DEVELOPMENT - DARLING HARBOUR
BORE 1 JOB NO 19013 NOVEMBER 1992
START 6.0
7
8
9
6.00 - 9.00 M

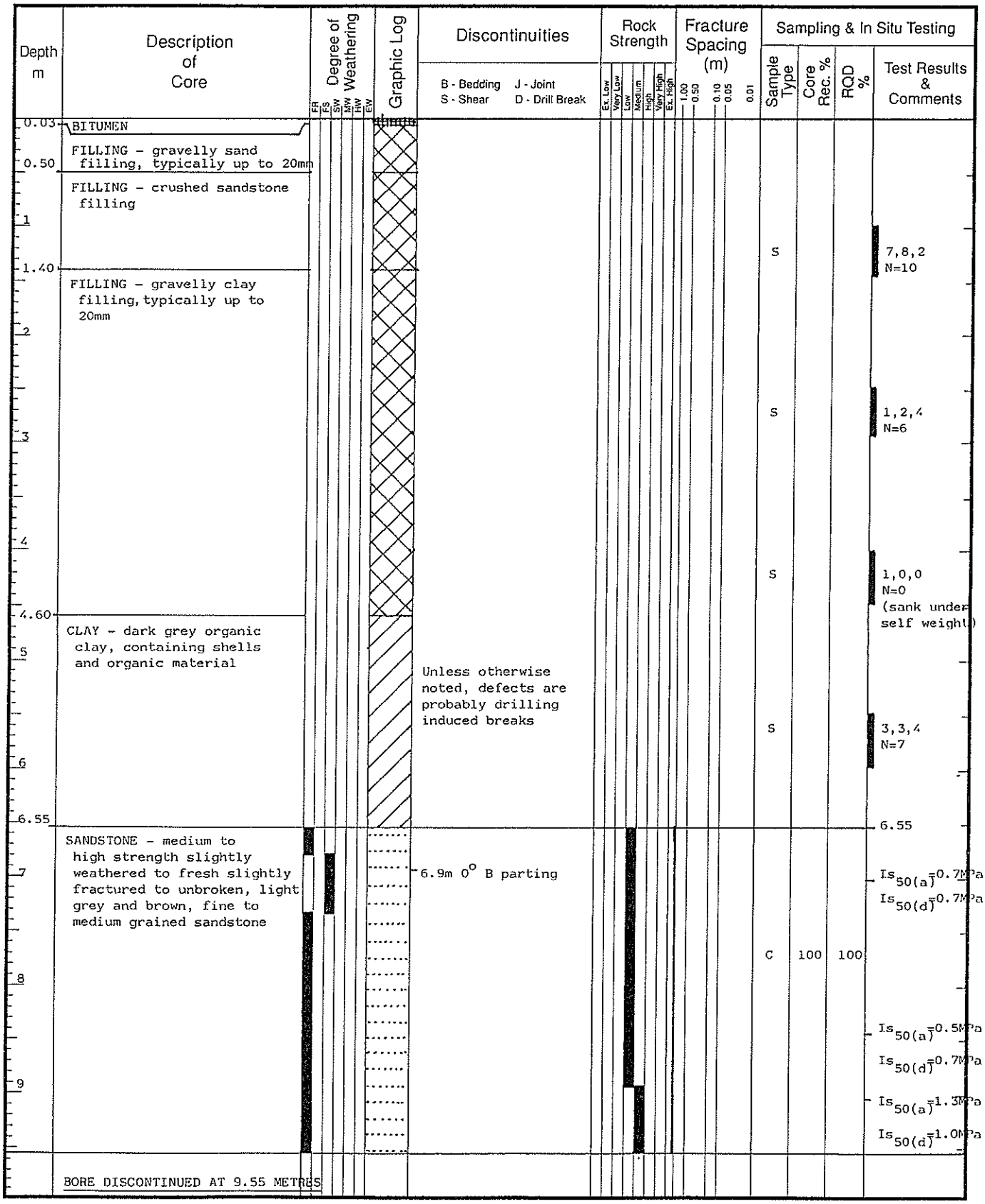
TEST BORE REPORT

DATE 2.11.92

CLIENT KINHILL ENGINEERS
PROJECT No 19013
BORE No 3

PROJECT THEATRE DEVELOPMENT
SURFACE LEVEL 2.59 AHD
SHEET 1 OF 1

LOCATION DARLING HARBOUR
DIP OF HOLE 90°
AZIMUTH



RIG Scout DRILLER Chittleburgh LOGGED Klok CASING NW to 6.00m

TYPE OF BORING Solid flight auger GL to 6.30m, then drag bit to 6.55m, then NQ coring to 9.55m

WATER OBSERVATIONS Free ground water observed at 2.18m

REMARKS

SAMPLING & IN SITU TESTING

A	auger sample	PL	point load strength $I_s(50)$(MPa)
B	bulk sample	S	standard penetration test
C	core drilling	Ux	x mm dia. tube

D.J. Douglas & Partners


DJ DOUGLAS & PARTNERS PTY LTD
THEATRE DEVELOPMENT - DARLING HARBOUR
BORE 3 JOB NO 19013 NOVEMBER 1992
START CORING
B.H. 3 6.55
7
8
9
END BORE 9.55m
6.55 - 9.55 M

TEST BORE REPORT

DATE 3.11.92

CLIENT	KINHILL ENGINEERS	PROJECT No 19013	BORE No 5
PROJECT	THEATRE DEVELOPMENT	SURFACE LEVEL 2.55 AHD	SHEET 1 OF 1
LOCATION	DARLING HARBOUR	DIP OF HOLE 90°	AZIMUTH

Depth m	Description of Core	Degree of Weathering (FR, FS, SW, MW, HW, EW)	Graphic Log	Discontinuities (B - Bedding, J - Joint, S - Shear, D - Drill Break)	Rock Strength (Ex. Low, Very Low, Low, Medium, High, Very High, Ex. High)	Fracture Spacing (m) (1.00, 0.50, 0.10, 0.05, 0.01)	Sampling & In Situ Testing: Sample Type	Core Rec. %	RQD %	Test Results & Comments
0.05	BITUMEN									
0.10	ROADBASE									
0.40	CONCRETE									
	FILLING - gravelly sand filling, typically up to 20mm									
1.10	FILLING - crushed sandstone									
2.60	FILLING - gravelly clay filling, typically up to 20mm									
4.00	CLAY - dark grey organic clay, containing shells and organic material			*Unless otherwise noted, defects are probably drilling induced breaks						
5.35	SANDSTONE - medium to high strength, slightly weathered to fresh, slightly fractured to unbroken, light grey and brown, fine to medium grained sandstone									5.35 $Is_{50(a)}$=0.7 MPa $Is_{50(d)}$=0.6 MPa
							C	100	100	$Is_{50(a)}$=1.3 MPa $Is_{50(d)}$=1.0 MPa
8.35										$Is_{50(a)}$=1.3 MPa $Is_{50(d)}$=1.2 MPa
	BORE DISCONTINUED AT 8.35 METRES									

RIG Scout DRILLER Chittleburgh LOGGED Klok CASING NW to 6.0 m

TYPE OF BORING Solid flight auger GL to 5.15 m, then drag bit to 5.35 m, then NQ coring to 8.35 m

WATER OBSERVATIONS Free ground water observed at 2.40 m

REMARKS

SAMPLING & IN SITU TESTING

A	auger sample	PL	point load strength $I_s(50)$(MPa)
B	bulk sample	S	standard penetration test
C	core drilling	Ux	x mm dia. tube

D.J. Douglas & Partners


DJ DOUGLAS & PARTNERS PTY LTD
THEATRE DEVELOPMENT - DARLING HARBOUR
BORE 5 JOB NO 19013 NOVEMBER 1992
START CORING
B.H.5 5.35
5.35
6
7
8
END BORE 8.35m
SPACER
5.35 - 8.35 M