Douglas Partners
Geotechnics | Environment | Groundwater

Report on
Geotechnical Investigation

Proposed Residential Development
28 – 32 Somerset Street
Kingswood

Prepared for
Zeftco Pty Ltd

Project 85085.00
October 2015

Integrated Practical Solutions

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
Author		13 October 2015
Reviewer		13 October 2015

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Table of Contents

Report on Geotechnical Investigation
Proposed Residential Development
28 – 32 Somerset Street, Kingswood

1. Introduction

This report presents the results of a geotechnical investigation undertaken for a proposed residential development at 28 – 32 Somerset Street, Kingswood. The investigation was commissioned by Pure Projects Pty Ltd on behalf of Zeftco Pty Ltd.

It is understood that the proposed development involves the construction a 5 storey building with two basement levels. Excavation to depths of approximately 6 m to 7 m will be required.

The investigation included the drilling of six cored boreholes and the installation of one groundwater well. Details of the field work undertaken are given in the report, together with comments on design and construction issues.

A contamination preliminary site investigation (PSI) was conducted in conjunction with the geotechnical investigation and has been reported separately (Project 85085.00.R.001).

2. Site Description

The site is located on the eastern side of Somerset Street, on the corner with Hargrave Street. The site comprises three residential lots, with the two northern lots each occupied by a single storey weatherboard house. The southern lot was vacant and covered with grass at the time of the investigation.

The site slopes gently towards the east, with site levels ranging from RL 49.3 m to RL 47.5 m (relative to Australian Height Datum).

3. Geology

Reference to the Sydney 1:100 000 Series Geological Sheet indicates the site is underlain by Bringelly Shale which typically comprises shale, carbonaceous claystone, laminite and fine to medium grained lithic sandstone. The geological mapping was confirmed by the field work which identified residual soils overlying shale.

4. Field Work Methods

The field work for the investigation included six boreholes (BH1 to BH6) drilled using a truck-mounted drilling rig. The borehole locations are shown on Drawing 1 in Appendix B.

The boreholes were drilled through soil to depths of 2.9 m to 4.5 m using solid flight augers and rotary drilling methods. The boreholes were then continued to depths of 10.0 m to 11.6 m using diamond core drilling equipment to obtain continuous core samples of the bedrock.

The boreholes were logged and sampled by a geotechnical engineer. The rock cores recovered from the boreholes were photographed, followed by Point Load Strength Index (Is_{50}) testing on selected samples.

A groundwater monitoring well was installed in BH4 to a depth of 10.0 m to monitor the static water levels during the investigation period.

A rising head permeability test was conducted in the monitoring well in BH4. The water within the well was pumped out and then the rise in the water level was measured at regular intervals as the water level recharged.

Borehole coordinates were approximated from Google Earth and the surface levels were interpolated from the supplied site survey drawing.

5. Field Work Results

Details of the subsurface conditions encountered in the investigation are given in the borehole logs in Appendix C, together with colour photographs of the rock core and notes defining classification methods and descriptive terms.

5.1 Boreholes

The sequence of subsurface materials encountered within the boreholes, in increasing depth order, may be summarised as follows:

Filling:	Generally silty clay filling with some gravel and some sand filling (BH4 only) to depths of 0.2 m to 0.7 m;
Clay:	Firm clay overlying stiff to very stiff clay in the east of the site (BH1, BH3 and BH5) and stiff to very stiff clay in the west (BH2, BH4 and BH6) to depths of 2.7 m to 4.3 m; and
Shale:	Extremely low to very low strength shale to depths of 4.5 m to 6.0 m overlying low and then medium strength shale. Some medium to high strength shale was encountered below 9.5 m in BH5.

No free groundwater was observed during augering of the boreholes to maximum depths of 2.5 m. The use of water during rotary drilling and coring precluded further groundwater measurements during drilling.

The water level in the monitoring well installed in BH4 was measured at 2.5 m depth (RL 45.2) on 9 October 2015.

5.2 Permeability Test

A rising head permeability test was carried out in the monitoring well in BH4. The monitoring well was pumped and the rise in water level then measured at regular intervals. The average hydraulic conductivity was assessed to be 2.6×10^{-8} m/s (0.0022 m/day).

6. Laboratory Testing

Selected samples of the rock core were tested in the laboratory to determine the Point Load Strength Index (Is_{50}) values to assist with the rock strength classification. The results of the testing are shown on the borehole logs at the appropriate depth. The Is_{50} values for the rock ranged from 0.2 MPa to 1.4 MPa, indicating that the rock samples tested were of very low to high strength.

7. Geotechnical Model

Geotechnical cross-sections (Section A-A' and B-B') showing the interpreted subsurface profile are presented as Drawings 2 and 3 respectively, in Appendix B. These sections show the interpreted geotechnical divisions of underlying soil and rock. The interpreted boundaries shown on the section are accurate at the borehole locations only and layers shown diagrammatically on this drawing are inferred strata boundaries only. Reference should be made to the borehole logs for more detailed information and descriptions of the soil and rock.

The rock encountered in the cored boreholes has been classified in accordance with the procedures given in Reference 1, which use a combination of rock strength and fracture spacing to divide the rock into five classes ranging from Class I (medium to high strength and very few defects) to Class V (extremely low to very low strength and/or highly fractured). The interpreted depth and Reduced Level (RL) at the top of the rock classes are shown in Table 1.

Table 1: Summary of Depths (and Reduced Levels) to Top of Rock Strata

Borehole	Surface RL (AHD)	Depth *(RL)* to Shale Rock Class (m)		
		Class V-IV	Class III	Class II
BH1	48.4	2.7 *(45.7)*	4.5 *(43.9)*	5.3 *(43.1)*
BH2	47.7	4.3 *(43.4)*	6.1 *(41.6)*	**
BH3	48.6	2.7 *(45.9)*	4.7 *(43.9)*	5.8 *(42.8)*
BH4	47.7	3.5 *(44.2)*	6.1 *(41.6)*	**
BH5	48.8	3.0 *(45.8)*	-	6.0 *(42.8)*
BH6	48.1	3.2 *(44.9)*	-	6.2 *(41.9)*

Notes: Rock classification is based on Reference 1.
Bracketed numbers are the Reduced Level (to AHD) for the top of the stratum.
** Class II rock has been assessed as not encountered in BH2 and BH4 due to weak seams (i.e. core loss) and fracture spacing.

It should be noted that closely fractured zones and weak seams or bands can occur within higher strength rocks and the classification may reduce in these areas. Some zones of higher strength rock have been down-rated due to the presence of significant defects or weak seams observed in the rock cores (e.g. medium strength shale at base of BH2 and BH4 being down-rated to Class III). It is possible that some of the core loss and fractured zones are drilling induced.

It is expected that the permanent groundwater table would be well below the proposed bulk excavation. Water was measured at 2.5 m depth (RL 45.2) in the groundwater well installed in BH4, 22 days after installation. Ongoing monitoring of the well in BH4 should be carried out to assess likely fluctuations.

8. Proposed Development

Based on the architectural plans by Plus Architecture Sydney Pty Ltd (dated 7 October 2015), it is understood that the proposed development involves the construction a 5 storey building with two basement levels.

The lower basement floor level is at RL 42.7 m, and will require excavation to depths of approximately 6 m to 7 m. Deeper localised excavations are expected for footings and lift wells.

Details of structural loads have not been provided, however based on previous experience, the column working loads for the 5 storey building may be in the order of 3,000 kN to 4,000 kN.

9. Comments

9.1 Site Preparation and Earthworks

9.1.1 Excavation Conditions

It is expected that the basement will require the excavation of soils and extremely low to very low strength shale (Class V-IV), with some low and medium strength shale in the western side of the site (Class III and II).

Excavation of soil and extremely low to low strength rock should be achievable using conventional earthmoving equipment. It is anticipated that excavation of medium strength rock will require moderate to heavy ripping with a large bulldozer.

9.1.2 Dilapidation Surveys

Dilapidation surveys should be carried out on surrounding buildings and pavements that may be affected by the basement construction. The dilapidation surveys should be undertaken before the commencement of any excavation work in order to document any existing defects so that any claims for damage due to construction related activities can be accurately assessed.

9.1.3 Disposal of Excavated Material

All excavated materials will need to be disposed of in accordance with the recommendations presented in DP's PSI report (Project 85085.00.R.001) and with the provisions of the current legislation and guidelines including the *Waste Classification Guidelines* (EPA, 2014).

9.2 Excavation Support

Due to the close proximity of the excavation to the site boundaries, the excavation will need to be cut vertically and will require temporary shoring during construction. Temporary batters are not considered possible for the proposed excavation on this site.

9.2.1 Retaining/Shoring Walls

Vertical excavations within the soils and extremely low to low strength shale (Class V to III) will require both temporary and permanent lateral support during and after excavation. A bored soldier pile shoring wall with shotcrete infill panels would be suitable where there are no movement sensitive structures in close proximity to the excavation. Typically, soldier piles are spaced at approximately 2 m to 3 m centres, however, closer spaced piles may be required to reduce wall movements, or prevent collapse of infill materials, where pavements, structures or services are located in close proximity to the excavation.

Shoring piles should be founded at least 1.0 m below the base of the bulk excavation level (or any perimeter drainage trenches or footings) in order to provide lateral restraint at the base of the excavation and to avoid the risk of adversely inclined joints or wedges undermining the bases of the piles.

It is anticipated that one to two rows of anchors may be required to provide lateral restraint to shoring piles for the basement excavation. Shoring will need to be designed to support earth pressures and surcharge loads and will may also consider potential rock wedges, however they are unlikely to be encountered in the majority of the excavation that extends through extremely low to very low strength shale.

9.2.2 Earth Pressure Design

Design for lateral earth pressures may be based on the parameters given in Table 2. For situations where only minor lateral movements are acceptable, such as the support of sensitive structures or services, an increased pressure based on "at-rest" conditions should be adopted, depending on the level of restraint required. A uniform pressure of 10 kPa should be adopted for the support of Class III to Class II rock between soldier piles and to account for minor joint wedges that may become mobilised, although the extent of this rock strata is expected to be limited on this site.

All surcharge loads should be allowed for in the shoring design including building footings, inclined slopes behind the wall, traffic and construction related activities.

Table 2: Recommended Design Parameters for Shoring Systems

Material	Unit Weight (kN/m^3)	Earth Pressure Coefficient		Effective Cohesion c' (kPa)	Effective Friction Angle (Degrees)
		Active (K_a)	At Rest (K_o)		
Filling and Residual Clay	20	0.3	0.5	5	20
Class IV-V Shale	21	0.2	0.3	10	25
Class III and Class II Shale	22	10 kPa uniform	10 kPa uniform	20	25

Shoring walls should be designed for full hydrostatic pressures unless drainage of the ground behind impermeable walls can be provided. Drainage could comprise 150 mm wide strip drains pinned to the face at 1 m to 2 m centres behind shotcrete in-fill panels. The base of the strip drains should extend out from the shoring wall to allow any seepage to flow into a perimeter toe drain which is connected to the stormwater drainage system.

9.2.3 Passive Resistance

Passive resistance for piles founded below the base of the bulk excavation (including allowance for services or footings) may be based on the ultimate passive restraint values provided in Table 3. These ultimate values will need to incorporate a factor of safety to limit the wall movement that is required to mobilise the full passive resistance. The top 0.5 m of the socket should be ignored due to possible disturbance (e.g. over-excavation) and tolerance effects.

Table 3: Passive Resistance Values

Foundation Stratum	Ultimate Passive Pressure (kPa)
Class V-IV Shale	1,000
Class III and Class II Shale	1,500

9.2.4 Ground Anchors

The design of temporary and permanent ground anchors for the support of excavations may be carried out on the basis of the maximum bond stresses given in Table 4.

Table 4: Recommended Bond Stresses for Rock Anchor Design

Material Description	Maximum Allowable Bond Stress (kPa)	Maximum Ultimate Bond Stress (kPa)
Class V- IV Shale	75	150
Class III Shale	100	200
Class II Shale	300	500

The parameters given in Table 4 assume that the drilled holes are clean and adequately flushed. The anchors should be bonded behind a line drawn up at 45 degrees from the base of the shoring, and "lift-off" tests should be carried out to confirm the anchor capacities. It is suggested that ground anchors should be proof loaded to 125% of the design working load and locked-off at no higher than 80% of the working load.

It is anticipated that the building will support the basement excavation over the long term and therefore the ground anchors are expected to be temporary only. The use of permanent anchors would require careful attention to corrosion protection including full column grouting and the use of an internal corrugated sheathing over the full length of the anchor. A detailed specification would need to be prepared for the installation and stressing of permanent anchors.

9.2.5 Excavation Induced Ground Movements

There is a possibility that horizontal movements due to stress relief will occur during the excavation works. Based on published literature and recent experience, the lateral deflections for vertical excavations supported by shoring could be in the order of 0.05% to 0.1% of the excavation height, which corresponds with approximately 3 – 7 mm for a 7 m depth of excavation.

9.3 Groundwater and Seepage

The basement excavation is expected to be above the groundwater table, however, seepage should be expected along the top of rock and along bedding planes and defects in the rock, particularly after periods of wet weather.

During construction and in the long term, it is anticipated that seepage into the excavation should be readily controlled by perimeter drains connected to a "sump-and-pump" system. A drained basement will require permanent subfloor drainage below the basement floor slab to direct seepage to the stormwater drainage system.

It is possible that iron oxides will precipitate from any seepage, possibly leading to a build-up of an iron-oxide sludge. Allowance for periodic cleaning of such sludge should be made in the long-term maintenance requirements.

Excavations for pile foundations / shoring will likely encounter some seepage inflows and allowance should be made to remove water prior to cleaning and pouring concrete, or to 'tremie' pour/pump concrete to the base of the pile excavations.

9.4 Foundations

It is expected that bulk excavation for the basement will expose Class V-IV shale along the eastern side, grading to Class III-II on the west. It may be preferable to found all footings onto Class III or better rock, and this will likely require deep pad footings in the east of the site or shallow bored piles.

Recommended maximum design pressures for the various rock strata are presented in Table 5. The foundation design parameters given in this table assume that the footing excavations are clean and free of loose debris.

Table 5: Recommended Design Parameters for Foundation Design

Foundation Stratum	Maximum Allowable		Maximum Ultimate		Young's Modulus E (MPa)
	End Bearing (kPa)	Shaft Adhesion (Compression) (kPa)	End Bearing (kPa)	Shaft Adhesion (Compression) (kPa)	
Class V-IV	1000	75	3000	150	150
Class III	2500	250	6,000	350	300
Class II	3500	350	10,000	600	500

Notes: Rock classification is based on Reference 1.
Shaft adhesion applicable for the design of bored piers, uncased over rock socket length, where adequate sidewall cleanliness and roughness is achieved.

Foundations proportioned on the basis of the allowable bearing pressures in Table 5 would be expected to experience total settlements of less than 1% of the footing size / pile diameter under the applied working load, with differential settlements between adjacent columns expected to be less than half of this value.

All footings and pile excavations should be inspected by a geotechnical engineer prior to the placement of steel and concrete.

9.5 Seismic Loading

In accordance with AS1170-2007 “Structural Design Actions, Part 4: Earthquake Actions in Australia” a hazard factor (Z) of 0.08 and a site subsoil Class C_e is considered to be appropriate for the site.

10. Limitations

Douglas Partners (DP) has prepared this report for the Proposed Residential Development at 28 – 32 Somerset Street, Kingswood, in accordance with DP's proposal SYD151079 Rev 1 dated 16 September 2015. The report is provided for the exclusive use of Zeftco Pty Ltd for this project only and for the purposes as described in the report. It should not be used for other projects or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP’s field testing has been completed.

DP’s advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached 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 unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from 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.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical and groundwater components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

References

1. Pells, P.J., Mostyn, G. and Walker, B.F. *"Foundations on Sandstone and Shale in the Sydney Region"*. Australian Geomechanics Journal, Vol. No. 33 Part 3, Dec. 1998.

Appendix A

About this Report

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.

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This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

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.

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

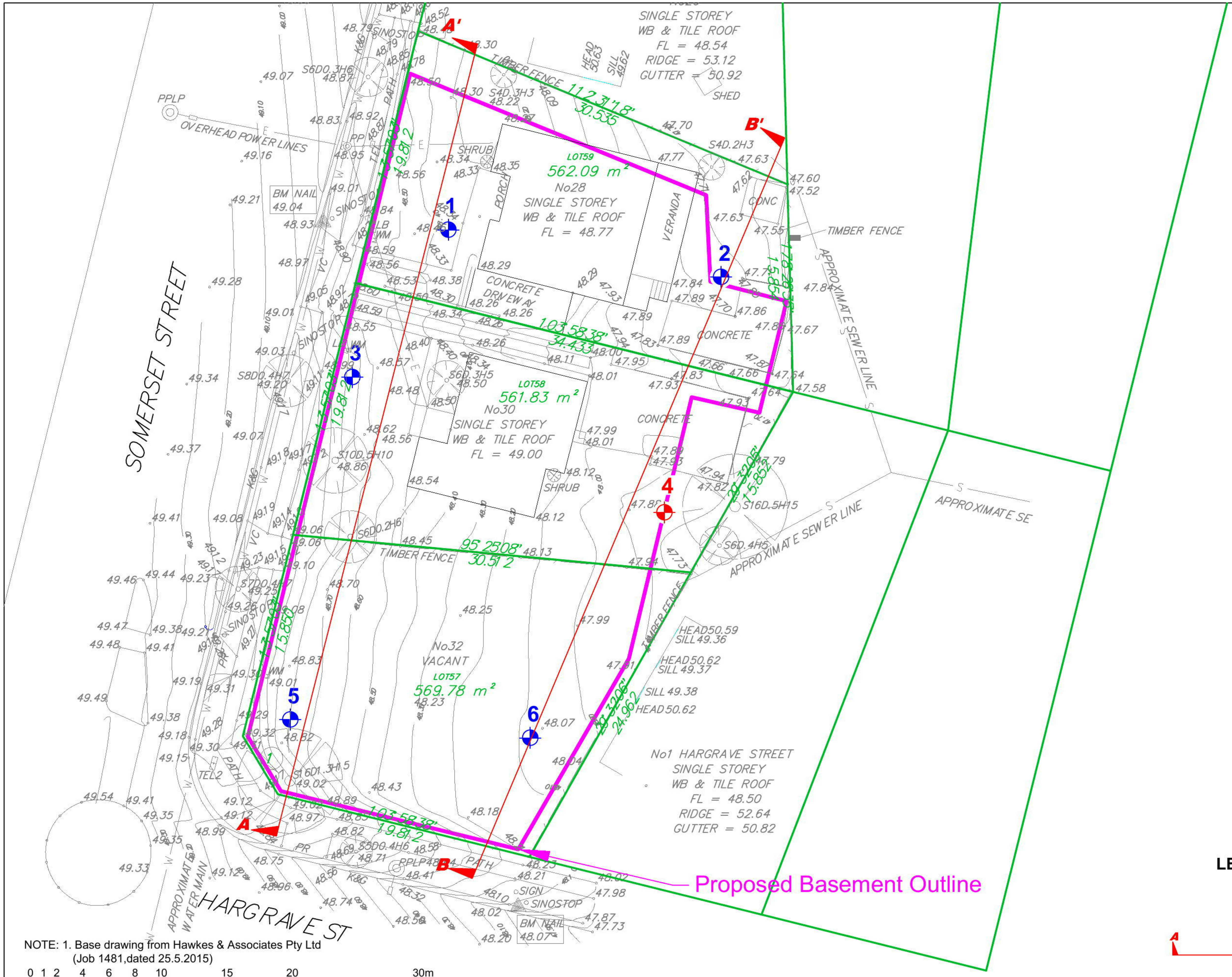
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate 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.

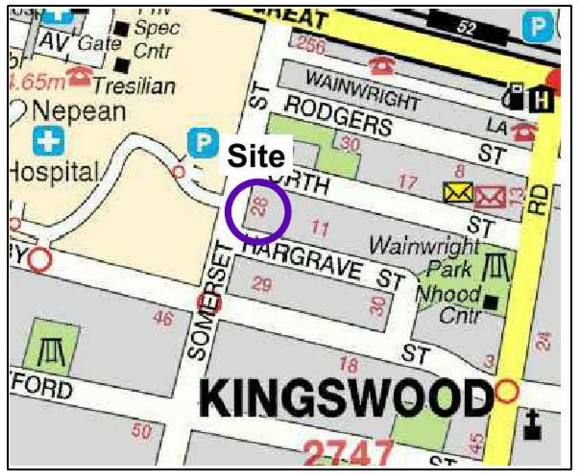
Site Inspection

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

Drawings





Locality Plan

NOTE: 1. Base drawing from Hawkes & Associates Pty Ltd
(Job 1481,dated 25.5.2015)

0 1 2 4 6 8 10 15 20 30m

1:300 @ A3

LEGEND

- Cored Borehole and Monitoring Well
- Cored Borehole
- A — A' Geotechnical Cross Section A-A'

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Zeftco Pty Ltd

OFFICE: Sydney DRAWN BY: PSCH

SCALE: 1:300 @ A3 DATE: 9.10.2015

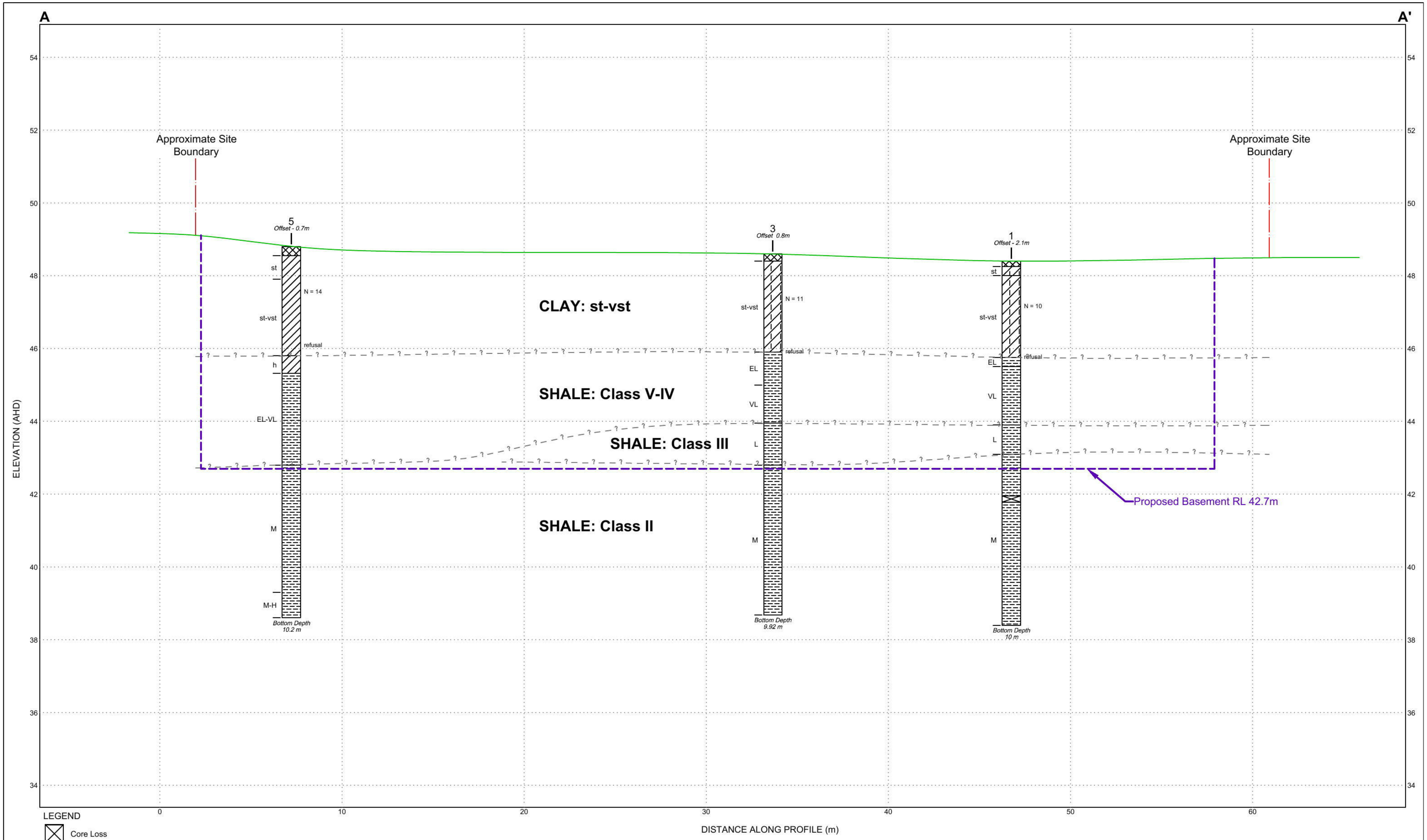
TITLE: **Test Location Plan**
Proposed Residential Development
28-32 Somerset Street, KINGSWOOD

N

PROJECT No: 85085.00

DRAWING No: 1

REVISION: 0



LEGEND

☒ Core Loss
▨ Silty Clay
▨ Clay
▦ Filling
☰ Shale

NOTE:

1. Subsurface conditions are accurate at borehole locations. Variations in subsurface conditions may occur between borehole locations. Interpreted strata boundaries are approximate and should be used as a guide only.
2. Summary logs only. Should be read in conjunction with detailed logs.
3. Rock classification is based on: "Foundations on Sandstone and Shale in the Sydney Region" by Pells, P.J., Mostyn, G. and Walker, B.F. Australian Geomechanics Journal, Vol. No. 33 Part 3, Dec. 1998.

ROCK STRENGTH
EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High

SOIL STRENGTH/CONSISTENCY
f - Firm
st - Stiff
vst - Very stiff
h - Hard

TESTS / OTHER
N - Standard penetration test value
▽ - Water level
- ? - - Inferred Geology

0 4
Horizontal Scale (metres)

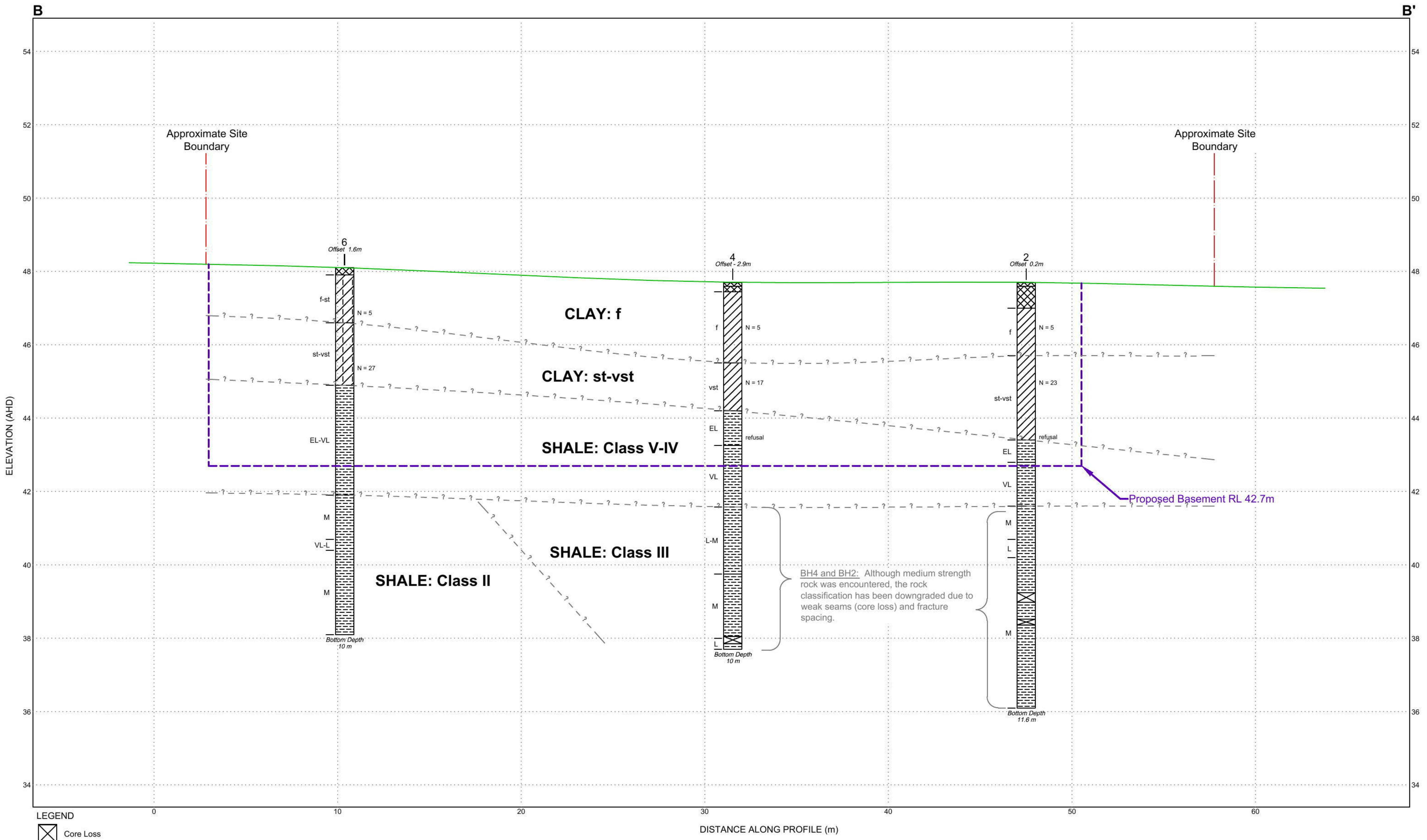
Vertical Exaggeration = 2.0

Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT: Zeftco Pty Ltd	
OFFICE: Sydney	DRAWN BY: LJH
SCALE: 1:200 (H) 1:400 (V) @ A3	DATE: 12.10.2015

TITLE: **Section A-A': Interpreted Geotechnical Model**
Proposed Residential Development
28-32 Somerset Street, KINGSWOOD

PROJECT No:	85085.00
DRAWING No:	2
REVISION:	1



BH4 and BH2: Although medium strength rock was encountered, the rock classification has been downgraded due to weak seams (core loss) and fracture spacing.

LEGEND

☒ Core Loss
▨ Silty Clay
▨ Clay
☒ Filling
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NOTE:

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0 4
Horizontal Scale (metres)

Vertical Exaggeration = 2.0

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CLIENT: Zeftco Pty Ltd		
OFFICE: Sydney	DRAWN BY: LJH	
SCALE: 1:200 (H) 1:400 (V)	@ A3	DATE: 12.10.2015

TITLE: **Section B-B': Interpreted Geotechnical Model**
Proposed Residential Development
28-32 Somerset Street, KINGSWOOD

PROJECT No: 85085.00
DRAWING No: 3
REVISION: 1

Appendix C

Results of Field Work

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.

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.

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:

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

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

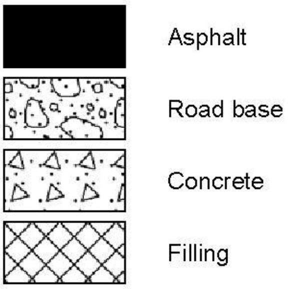
fg	fragmented
bnd	band
qtz	quartz

July 2010

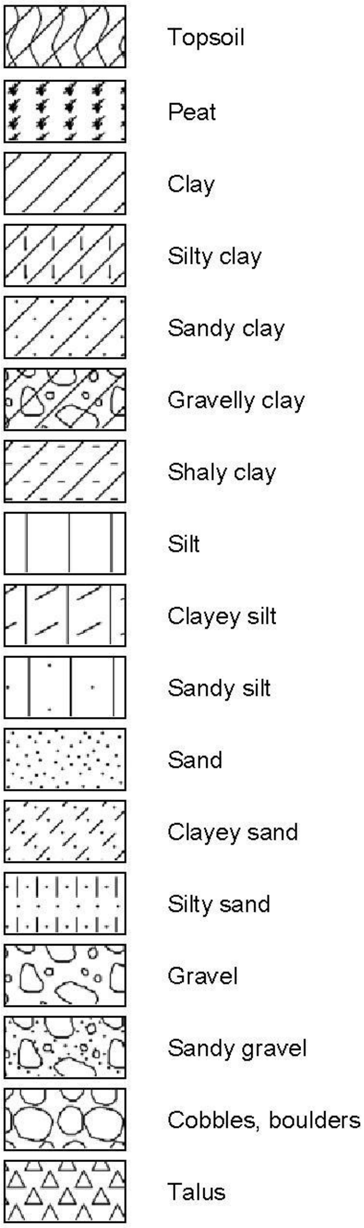
Symbols & Abbreviations

Graphic Symbols for Soil and Rock

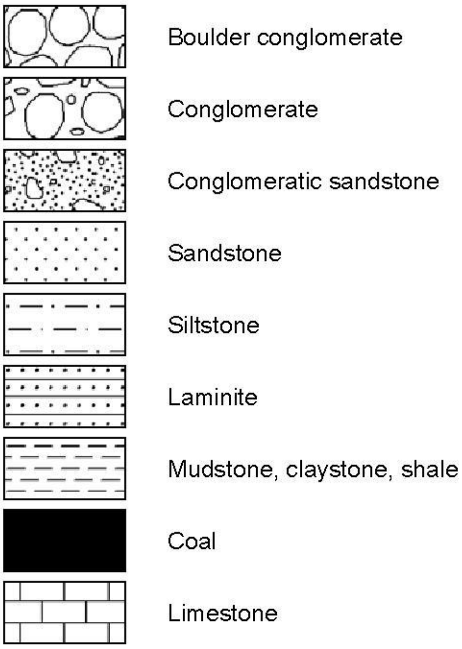
General


- Asphalt
- Road base
- Concrete
- Filling

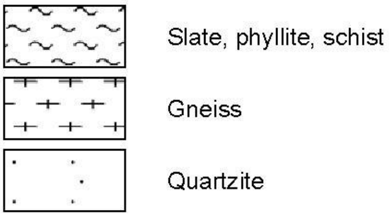
Soils


- 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

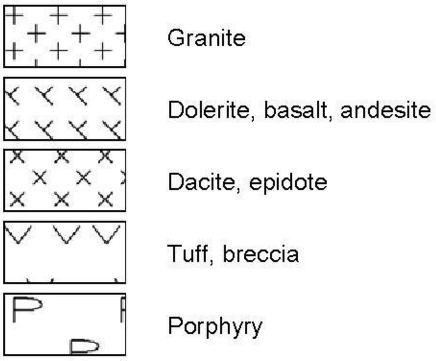
Sedimentary Rocks


- Boulder conglomerate
- Conglomerate
- Conglomeratic sandstone
- Sandstone
- Siltstone
- Laminite
- Mudstone, claystone, shale
- Coal
- Limestone

Metamorphic Rocks


- Slate, phyllite, schist
- Gneiss
- Quartzite

Igneous Rocks

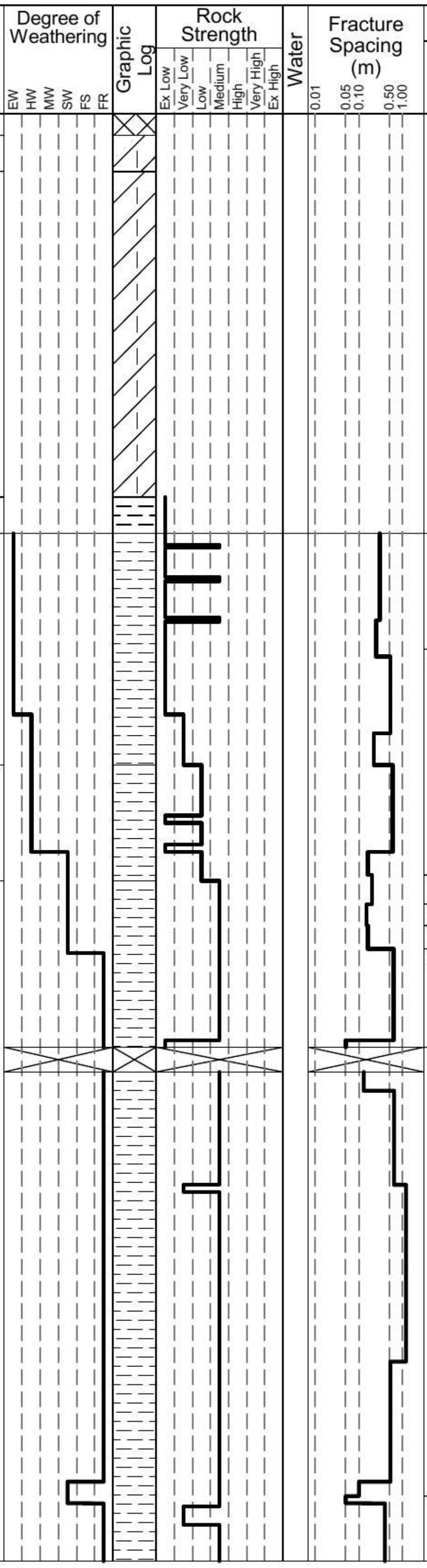

- Granite
- Dolerite, basalt, andesite
- Dacite, epidote
- Tuff, breccia
- Porphyry

BOREHOLE LOG

CLIENT: Zeftco Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: 28-32 Somerset Street, Kingswood

SURFACE LEVEL: 48.4 AHD
EASTING: 288449
NORTHING: 6262070
DIP/AZIMUTH: 90°/--

BORE No: 1
PROJECT No: 85085
DATE: 21 - 23/9/2015
SHEET 1 OF 1



Depth (m)	Description of Strata	Discontinuities B - Bedding J - Joint S - Shear F - Fault	Type	Core Rec. %	RQD %	Test Results & Comments
0.15	FILLING - brown, silty clay (topsoil) filling with some rootlets, humid		E			
0.4	SILTY CLAY - stiff, brown mottled red-brown and grey, silty clay, MC<PL, apparently moderate to high plasticity		E E			
	SILTY CLAY - stiff to very stiff, brown mottled red-brown, silty clay with a trace of ironstone gravel and rootlets, MC<PL, apparently moderate to high plasticity	Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping 0°- 10°	S			2,4,6 N = 10
			S			10,25/90mm refusal
2.65	SHALE - extremely low strength, light grey-brown shale					
2.9	SHALE - very low then very low strength, extremely then highly weathered, slightly fractured, light grey and red-brown, shale with some medium strength ironstone bands	3.2m: J70°, un, ro, fe 3.5m: J50° & 70°, st, ro, cly 3.7m: B0°, fe	C	100	0	pp >600
		4.28 & 4.5m: B (x2) 0°, cly	C	94	78	
4.5	SHALE - low strength, highly then slightly weathered, slightly fractured, grey-brown shale					PL(A) = 0.2
5.3	SHALE - medium strength, slightly weathered and fresh, slightly fractured and unbroken, grey shale	5.2 & 5.26m: B (x2) 0°, cly, 5mm 5.26m: J80°, ti 5.46m: B0°, fe, cly, 5mm 5.61m: B5°, fe, cly 5.77m: J50°, pl, sm, cln				PL(A) = 0.4 PL(A) = 0.4
6.62		6.4-6.45m: Cs 6.45m: CORE LOSS: 170mm				
		7.4-7.46m: Cs 8.62m: J80°, ti 9.45m: J85°, un, ro, cly 9.55m: J45°, pl, sm, cly	C	100	92	PL(A) = 0.4 PL(A) = 0.6 PL(A) = 0.4
10.0	Bore discontinued at 10.0m					

RIG: Hand tools/DT100 **DRILLER:** SM/JS **LOGGED:** JS/SI **CASING:** HW to 2.5m

TYPE OF BORING: Hand auger to 0.6m; Solid flight auger to 2.5m; Rotary to 2.9m; NMLC-Coring to 10.0m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: Water loss from 4.0m to 5.0m

SAMPLING & IN SITU TESTING LEGEND

A Auger sample
B Bulk sample
BLK Block sample
C Core drilling
D Disturbed sample
E Environmental sample
G Gas sample
P Piston sample
U_x Tube sample (x mm dia.)
W Water sample
▷ Water seep
▼ Water level
PID Photo ionisation detector (ppm)
PL(A) Point load axial test Is(50) (MPa)
PL(D) Point load diametral test Is(50) (MPa)
pp Pocket penetrometer (kPa)
S Standard penetration test
V Shear vane (kPa)

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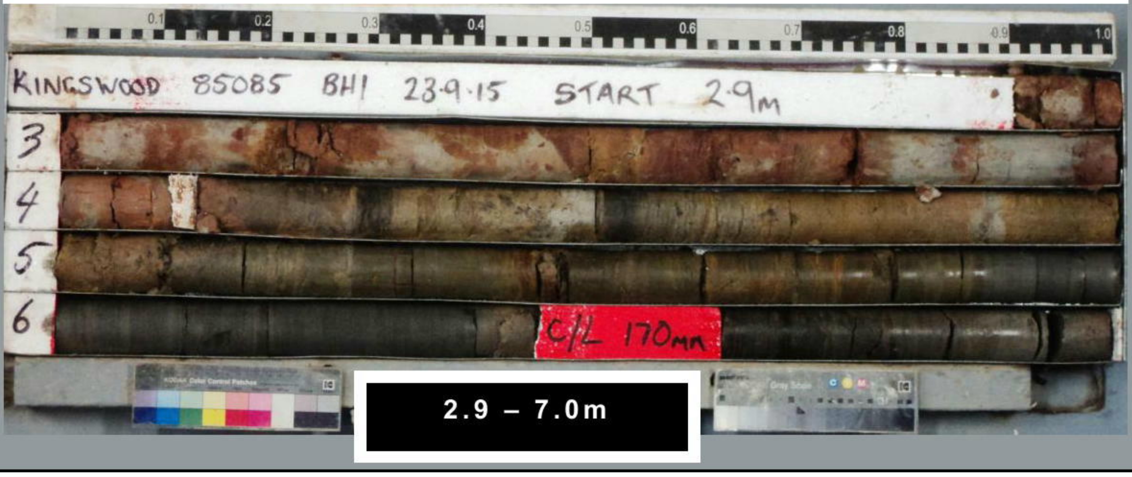
DOUGLAS PARTNERS PTY LTD

PROPOSED RESIDENTIAL DEVELOPMENT - KINGSWOOD

BORE 1 PROJECT 85085 SEP 2015

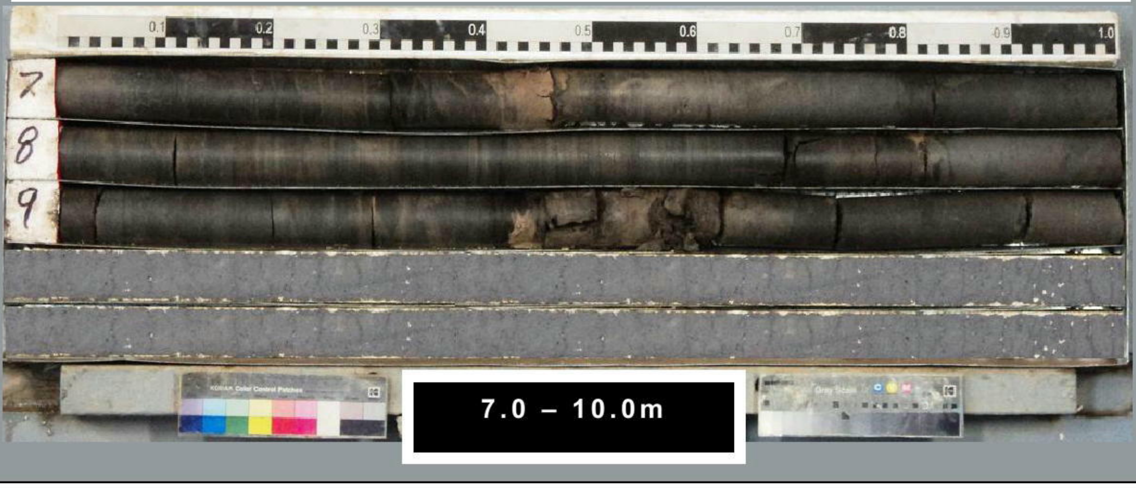


2.9 – 7.0m

DOUGLAS PARTNERS PTY LTD

PROPOSED RESIDENTIAL DEVELOPMENT - KINGSWOOD

BORE 1 PROJECT 85085 SEP 2015



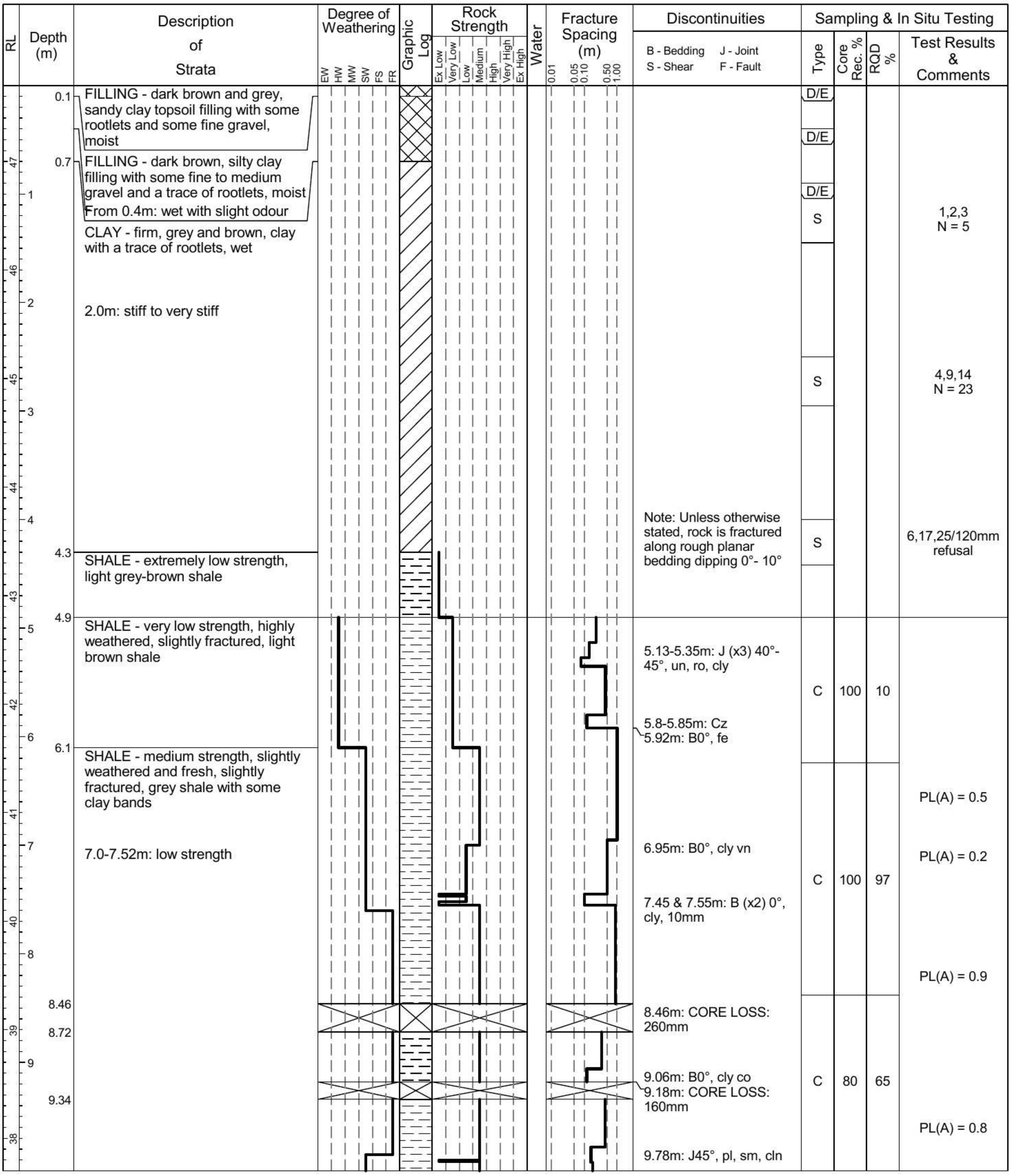
7.0 – 10.0m

BOREHOLE LOG

CLIENT: Zeftco Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: 28-32 Somerset Street, Kingswood

SURFACE LEVEL: 47.7 AHD
EASTING: 288470
NORTHING: 6262064
DIP/AZIMUTH: 90°/--

BORE No: 2
PROJECT No: 85085
DATE: 17 - 21/9/2015
SHEET 1 OF 2



Depth (m)	Description of Strata	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
0.1	FILLING - dark brown and grey, sandy clay topsoil filling with some rootlets and some fine gravel, moist		D/E D/E			
0.7	FILLING - dark brown, silty clay filling with some fine to medium gravel and a trace of rootlets, moist From 0.4m: wet with slight odour		D/E			
	CLAY - firm, grey and brown, clay with a trace of rootlets, wet		S			1,2,3 N = 5
2	2.0m: stiff to very stiff		S			4,9,14 N = 23
		Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping 0°- 10°	S			6,17,25/120mm refusal
4.3	SHALE - extremely low strength, light grey-brown shale					
4.9	SHALE - very low strength, highly weathered, slightly fractured, light brown shale	5.13-5.35m: J (x3) 40°-45°, un, ro, cly 5.8-5.85m: Cz 5.92m: B0°, fe	C	100	10	
6.1	SHALE - medium strength, slightly weathered and fresh, slightly fractured, grey shale with some clay bands 7.0-7.52m: low strength	6.95m: B0°, cly vn 7.45 & 7.55m: B (x2) 0°, cly, 10mm	C	100	97	PL(A) = 0.5 PL(A) = 0.2 PL(A) = 0.9
8.46 8.72 9.34		8.46m: CORE LOSS: 260mm 9.06m: B0°, cly co 9.18m: CORE LOSS: 160mm 9.78m: J45°, pl, sm, cln	C	80	65	PL(A) = 0.8

RIG: Hand tools/DT100 **DRILLER:** SM/JS **LOGGED:** AL/SI **CASING:** HW to 2.5m

TYPE OF BORING: Hand auger to 1.0m; Solid flight auger to 2.5m; Rotary to 4.9m; NMLC-Coring to 11.6m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

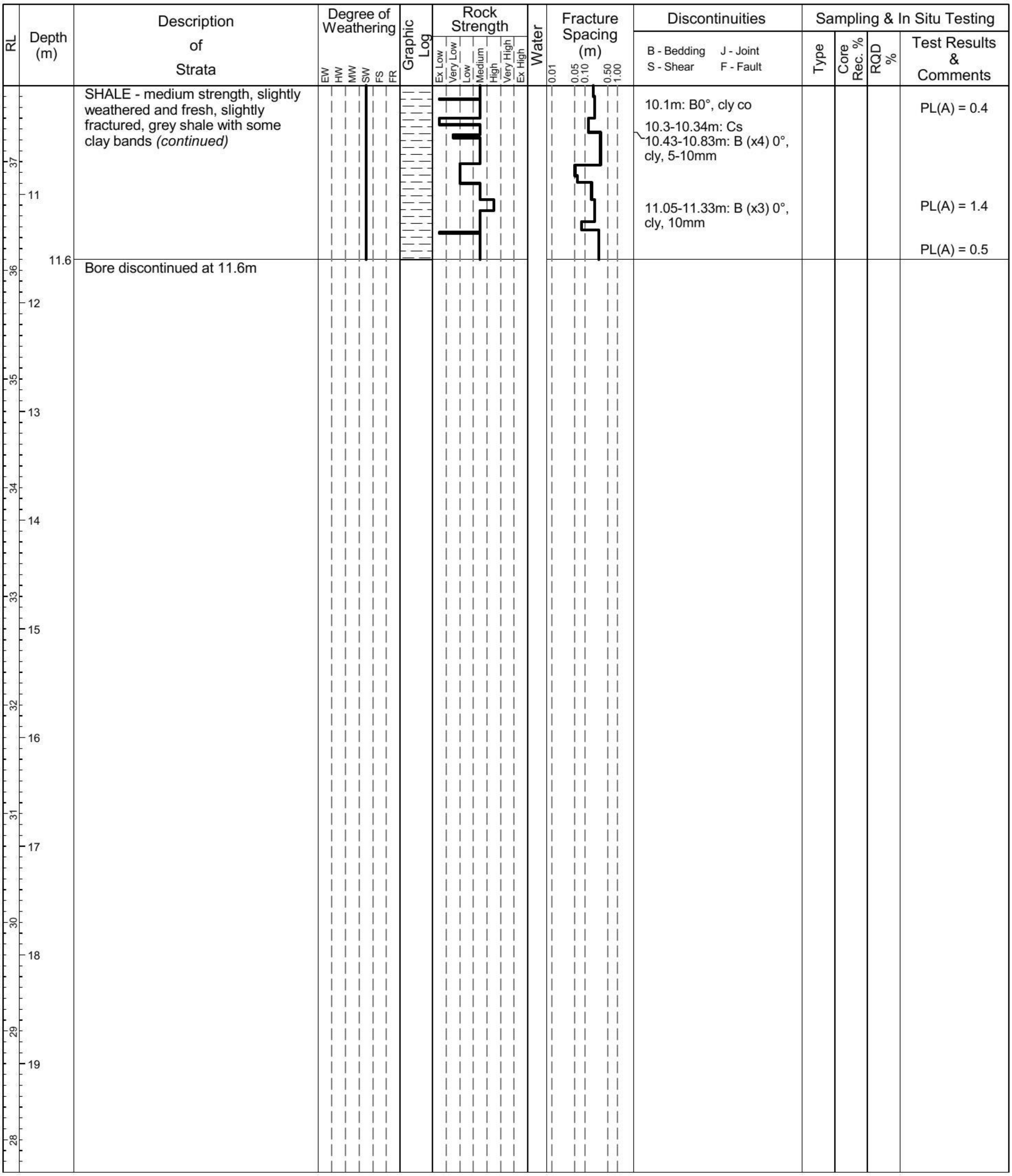
Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Zeftco Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: 28-32 Somerset Street, Kingswood

SURFACE LEVEL: 47.7 AHD
EASTING: 288470
NORTHING: 6262064
DIP/AZIMUTH: 90°/--

BORE No: 2
PROJECT No: 85085
DATE: 17 - 21/9/2015
SHEET 2 OF 2



Depth (m)	Description of Strata	Discontinuities	Type	Core Rec. %	RQD %	Test Results & Comments
	SHALE - medium strength, slightly weathered and fresh, slightly fractured, grey shale with some clay bands *(continued)*	10.1m: B0°, cly co 10.3-10.34m: Cs 10.43-10.83m: B (x4) 0°, cly, 5-10mm 11.05-11.33m: B (x3) 0°, cly, 10mm				PL(A) = 0.4 PL(A) = 1.4 PL(A) = 0.5
11.6	Bore discontinued at 11.6m					

RIG: Hand tools/DT100 **DRILLER:** SM/JS **LOGGED:** AL/SI **CASING:** HW to 2.5m

TYPE OF BORING: Hand auger to 1.0m; Solid flight auger to 2.5m; Rotary to 4.9m; NMLC-Coring to 11.6m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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DOUGLAS PARTNERS PTY LTD

PROPOSED RESIDENTIAL DEVELOPMENT - KINGSWOOD

BORE 2 PROJECT 85085 SEP 2015

4.9- 9.0m

DOUGLAS PARTNERS PTY LTD

PROPOSED RESIDENTIAL DEVELOPMENT - KINGSWOOD

BORE 2 PROJECT 85085 SEP 2015

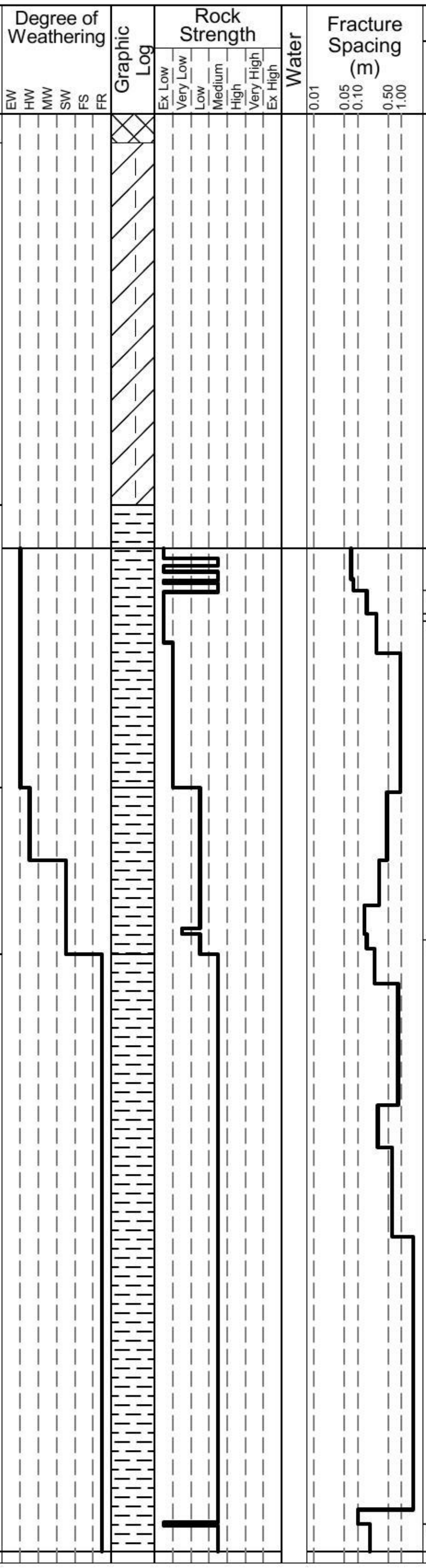
9.0 – 11.6m

BOREHOLE LOG

CLIENT: Zeftco Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: 28-32 Somerset Street, Kingswood

SURFACE LEVEL: 48.6 AHD
EASTING: 288443
NORTHING: 6262058
DIP/AZIMUTH: 90°/--

BORE No: 3
PROJECT No: 85085
DATE: 22/9/2015
SHEET 1 OF 1



RL	Depth (m)	Description of Strata	Discontinuities	Type	Core Rec. %	RQD %	Test Results & Comments
		FILLING - brown, silty clay (topsoil) filling with some rootlets and a trace of gravel, humid		E			
	0.2	SILTY CLAY - stiff to very stiff, brown mottled red-brown and grey, silty clay, MC<PL, apparently moderate to high plasticity		E			
48	1			S			2,4,7 N = 11
47	2		Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping 0°- 10°				
46	2.7	SHALE - extremely low to very low strength, extremely to highly weathered, fractured and slightly fractured, light grey-brown and red-brown, shale with some medium strength ironstone bands		S			13,22,15/30mm refusal
	3		3.07-3.21m: B (x3) 0°, cly, 10mm 3.29m: B0°, cly vn 3.45m: J45°, un, ro, fe 3.5-3.55m: Cs	C	100	0	PL(A) = 0.5
45	4			C	100	0	
44	4.65	SHALE - low strength, highly and slightly weathered, slightly fractured, grey-brown shale	4.68m: B5°, fe, cly 5.15m: B0°, cly, 5mm 5.66-5.7m: Cs 5.70-5.72m: Cs	C	100	92	PL(A) = 0.2 PL(A) = 0.5
43	5.8	SHALE - medium strength, fresh, slightly fractured and unbroken, grey shale	6m: J85°, pl, ro, cln				PL(A) = 0.4
42	7		6.84m: B0°, cly, 10mm 7.13m: J, sv (85°- 90°) pl, ro, cln 7.75m: J60°, un, ro, cln	C	100	100	PL(A) = 0.4
40	9			C	100	99	PL(A) = 0.5 PL(A) = 0.4
39		9.6-9.7m: carbonaceous shale band	9.69m: J35°, un, ro, cln 9.73m: B5°, cly, 10mm				PL(A) = 0.5
	9.92	Bore discontinued at 9.92m					

B - Bedding J - Joint
S - Shear F - Fault

RIG: Hand tools/DT100 **DRILLER:** SM/JS **LOGGED:** JS/SI **CASING:** HW to 2.5m

TYPE OF BORING: Hand auger to 0.5m; Solid flight auger to 2.5m; Rotary to 3.0m; NMLC-Coring to 10.0m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

DOUGLAS PARTNERS PTY LTD

PROPOSED RESIDENTIAL DEVELOPMENT - KINGSWOOD

BORE 3 PROJECT 85085 SEP 2015

3.0 – 7.0m

DOUGLAS PARTNERS PTY LTD

PROPOSED RESIDENTIAL DEVELOPMENT - KINGSWOOD

BORE 3 PROJECT 85085 SEP 2015

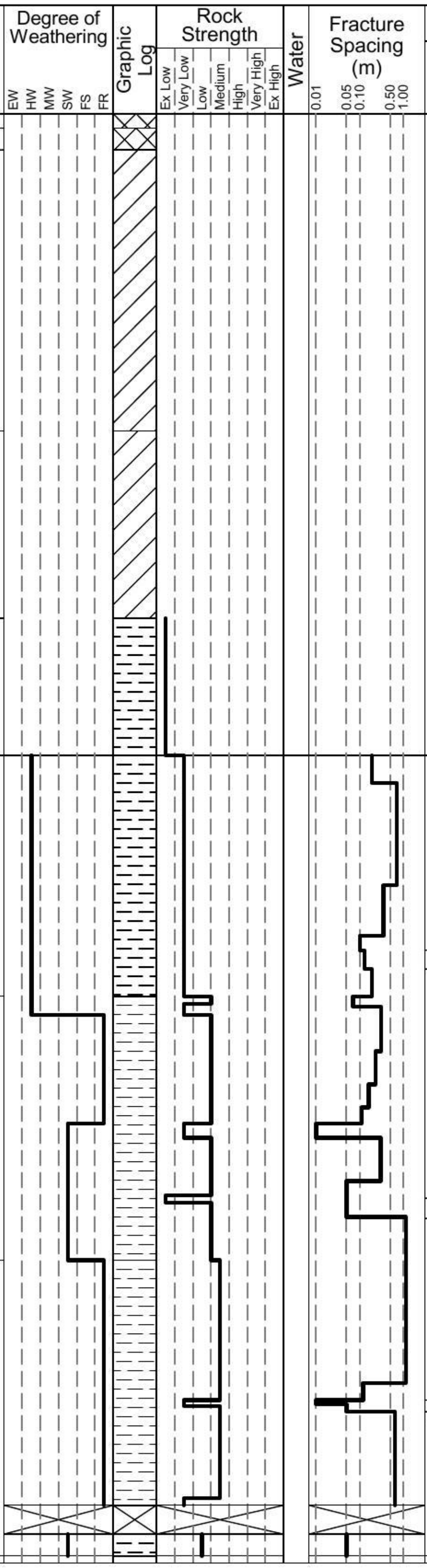
7.0 – 9.92m

BOREHOLE LOG

CLIENT: Zeftco Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: 28-32 Somerset Street, Kingswood

SURFACE LEVEL: 47.7 AHD
EASTING: 288467
NORTHING: 6262048
DIP/AZIMUTH: 90°/--

BORE No: 4
PROJECT No: 85085
DATE: 17/9/2015
SHEET 1 OF 1



Depth (m)	Description of Strata	Discontinuities B - Bedding J - Joint S - Shear F - Fault	Type	Core Rec. %	RQD %	Test Results & Comments
0.1	FILLING - dark brown, fine sand topsoil filling with some rootlets, damp		D/E A			
0.25	FILLING - dark brown, fine sand filling with some medium gravel, damp		D/E A			
	CLAY - firm, brown clay, damp From 0.75m: brown-grey		D A S			2,2,3 N = 5
2.2	CLAY - very stiff, grey clay with some ironstone bands, damp		S			6,8,9 N = 17
3.5	SHALE - extremely low to very low strength, grey and brown shale	Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping 0°- 10°	S			10,18,25/130mm refusal
4.45	SHALE - very low strength, highly weathered, slightly fractured, grey-brown shale	4.64m: B0°, fe, cly, 10mm	C	100	0	
		5.35m: B0°, cly co, 5mm	C	100	0	
		5.7-5.72m: Cs 5.8m: B0°, fe, cly co 5.93m: B0°, fe, cly	C	100	90	PL(A) = 0.3
6.12	SHALE - low to medium strength, slightly weathered and fresh, fractured and slightly fractured, light grey to grey shale	6.12 & 6.19m: B (x2) 0°, fe, cly 6.5 & 6.89m: B0°, cly vn				
		7.0-7.1m: cly	C	100	80	
		7.4m: B0°, cly, 5mm 7.52-7.57m: cly 7.66m: B0°, cly, 10mm				PL(A) = 0.3
7.95	SHALE - medium strength, fresh then slightly weathered, slightly fractured, grey shale					PL(A) = 0.4
		8.8m: J30°, ti 8.92-8.95m: Cz 9m: B0°, cly co 9.85-9.95m: B (x2) 0°, cly, 5mm				PL(A) = 0.5
9.85	9.7-10.0m: low strength band	9.65m: CORE LOSS: 200mm	C	41	0	
10.0	Bore discontinued at 10.0m					

RIG: DT100 **DRILLER:** SM **LOGGED:** AL/SI **CASING:** HW to 2.6m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary to 4.45m; NMLC-Coring to 10.0m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: Standpipe installed to 10.0m (screen 3.0-10.0m; gravel 2.5-10.0m; bentonite 2.0-2.5m; backfill to GL with gatic cover)

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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DOUGLAS PARTNERS PTY LTD

PROPOSED RESIDENTIAL DEVELOPMENT - KINGSWOOD

BORE 4 PROJECT 85085 SEP 2015

4.45 – 9.0m


DOUGLAS PARTNERS PTY LTD

PROPOSED RESIDENTIAL DEVELOPMENT - KINGSWOOD

BORE 4 PROJECT 85085 SEP 2015

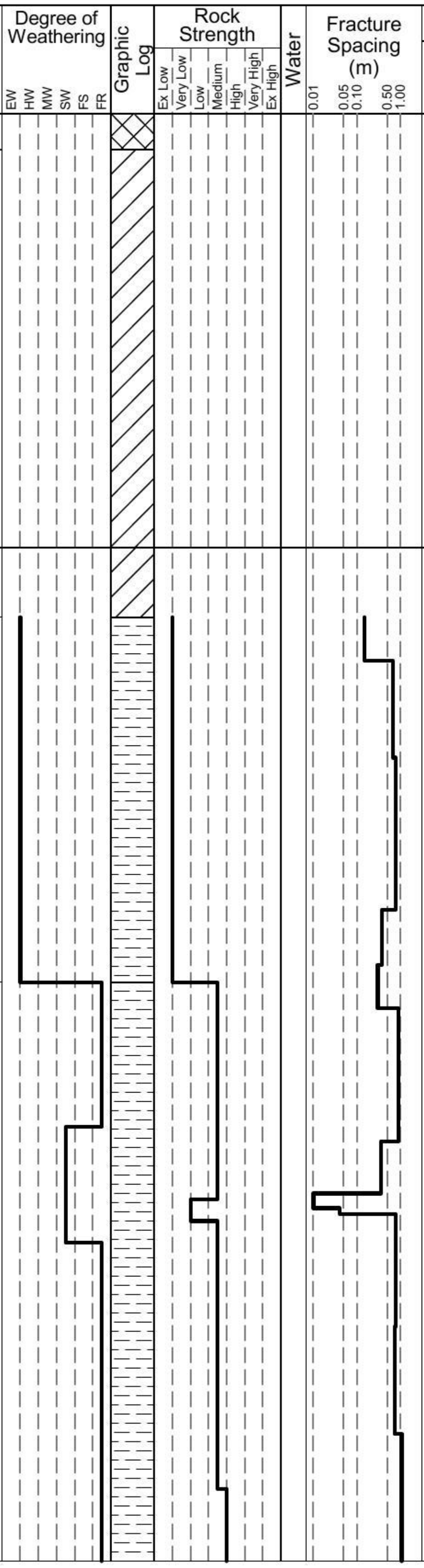
9.0 – 10.0m

BOREHOLE LOG

CLIENT: Zeftco Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: 28-32 Somerset Street, Kingswood

SURFACE LEVEL: 48.8 AHD
EASTING: 288438
NORTHING: 6262032
DIP/AZIMUTH: 90°/--

BORE No: 5
PROJECT No: 85085
DATE: 17/9/2015
SHEET 1 OF 2



Depth (m)	Description of Strata	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
	FILLING - brown, silty, fine sand filling with some rootlets and some fine gravel, humid		D/E			
0.25	CLAY - stiff, red-grey clay, humid		D/E			
	0.9m: stiff to very stiff		S			3,6,8 N = 14
		Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping 0°- 10°				
			S			6,20,25/100mm refusal
3.0	CLAY - hard, light grey and red-brown, clay with ironstone gravel, moist					pp = 550
3.48	SHALE - extremely low to very low strength, extremely to highly weathered, slightly fractured, grey-brown shale	3.63 & 3.78m: B (x2) 5°, cly co	C	100	0	
		4.45m: B0°, cly				
		5.22m: J40°, pl, ro, fe 5.5m: B0°, cly	C	100	10	
6.0	SHALE - medium then medium to high strength, slightly weathered and fresh, slightly fractured and unbroken, grey shale	6.18m: B0°, fe	C	100	100	PL(A) = 0.4
		7.1m: B0°, cly co				PL(A) = 0.4
		7.46-7.56m: fg 7.6-7.63m: Cs				
		8.38m: J85°, un, ro, cln	C	100	95	PL(A) = 0.4
		9.12m: B0°, cly, 10mm				
	9.5-10.2m: interbedded shale/siltstone					PL(A) = 0.6

RIG: Hand tools/DT100 **DRILLER:** AL/SM **LOGGED:** AL/SI **CASING:** HW to 2.5m
TYPE OF BORING: Hand auger to 0.5m; Solid flight auger to 2.5m; Rotary to 3.0m; NMLC-Coring to 10.2m
WATER OBSERVATIONS: No free groundwater observed whilst augering
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Zeftco Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: 28-32 Somerset Street, Kingswood

SURFACE LEVEL: 48.8 AHD
EASTING: 288438
NORTHING: 6262032
DIP/AZIMUTH: 90°/--

BORE No: 5
PROJECT No: 85085
DATE: 17/9/2015
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
									C	100	95	PL(A) = 1
	10.2	Bore discontinued at 10.2m										
38	11											
37	12											
36	13											
35	14											
34	15											
33	16											
32	17											
31	18											
30	19											
29												

RIG: Hand tools/DT100 **DRILLER:** AL/SM **LOGGED:** AL/SI **CASING:** HW to 2.5m
TYPE OF BORING: Hand auger to 0.5m; Solid flight auger to 2.5m; Rotary to 3.0m; NMLC-Coring to 10.2m
WATER OBSERVATIONS: No free groundwater observed whilst augering
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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DOUGLAS PARTNERS PTY LTD

PROPOSED RESIDENTIAL DEVELOPMENT - KINGSWOOD

BORE 5 PROJECT 85085 SEP 2015

3.0 – 7.0m

DOUGLAS PARTNERS PTY LTD

PROPOSED RESIDENTIAL DEVELOPMENT - KINGSWOOD

BORE 5 PROJECT 85085 SEP 2015

7.0 – 10.2m

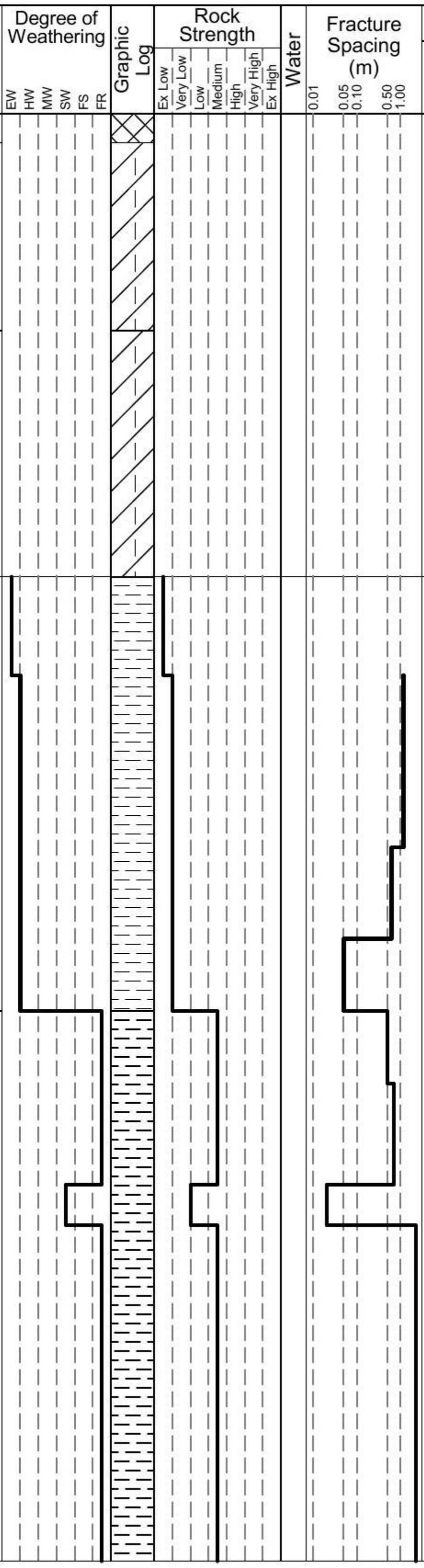
BOREHOLE LOG

CLIENT: Zeftco Pty Ltd
PROJECT: Proposed Residential Development
LOCATION: 28-32 Somerset Street, Kingswood

SURFACE LEVEL: 48.1 AHD
EASTING: 288455
NORTHING: 6262030
DIP/AZIMUTH: 90°/--

BORE No: 6
PROJECT No: 85085
DATE: 22/9/2015
SHEET 1 OF 1

Depth (m)	Description of Strata	Discontinuities B - Bedding J - Joint S - Shear F - Fault	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
0.2	FILLING - brown, silty clay (topsoil) filling with some rootlets		E			
	SILTY CLAY - firm to stiff, grey mottled brown, silty clay with a trace of ironstone gravel, MC~PL, apparently moderate to high plasticity		E			
1.5			S			2,2,3 N = 5
	SILTY CLAY - stiff to very stiff, grey mottled red-brown, silty clay with some ironstone gravel bands, MC<PL, apparently moderate to high plasticity	Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping 0°- 10°	S			7,10,17 N = 27
3.2	SHALE - extremely low then extremely low to very low strength, extremely then extremely to highly weathered, light grey-brown shale		C	100	0	
		5.07-5.09m: Cs	C	100	0	
		5.7-6.2m: B (x8) 0°- 5°, cly co				
6.2	SHALE - medium strength, slightly weathered and fresh, slightly fractured then unbroken, grey shale with some siltstone laminations	6.7m: B0°, fe	C	100	65	PL(A) = 0.4
	7.4-7.68m: very low to low strength	7.4-7.68m: B's 0°, cly co 7.68m: J35°, pl, sm, cly	C	100	93	PL(A) = 0.4 PL(A) = 0.5 PL(A) = 0.4
10.0	Bore discontinued at 10.0m					



RIG: DT100 **DRILLER:** SM **LOGGED:** JS/SI **CASING:** HW to 2.5m

TYPE OF BORING: Solid flight auger (TC-bit) to 2.5m; Rotary to 3.2m; NMLC-Coring to 10.0m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	⊳	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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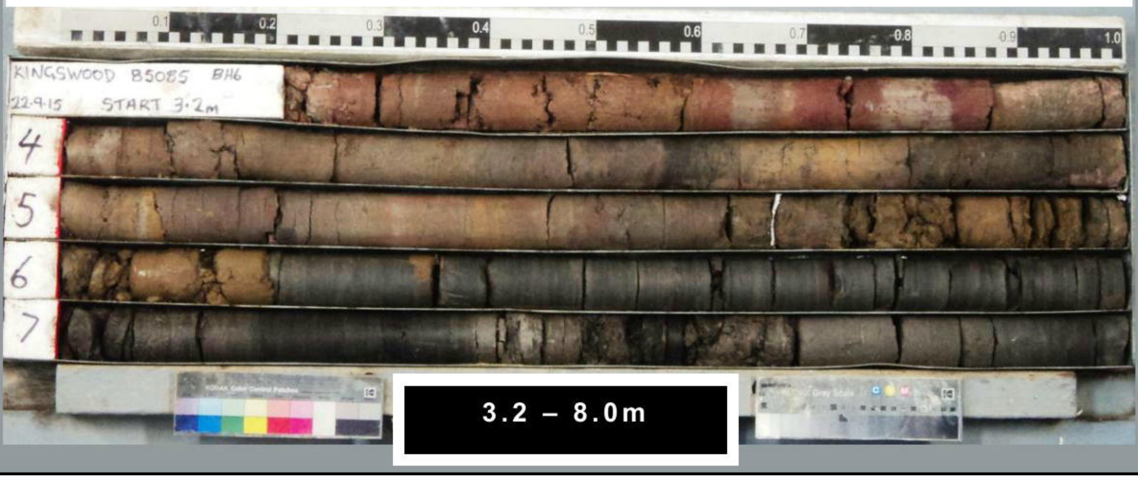
PROPOSED RESIDENTIAL DEVELOPMENT - KINGSWOOD

BORE 6 PROJECT 85085 SEP 2015



3.2 – 8.0m

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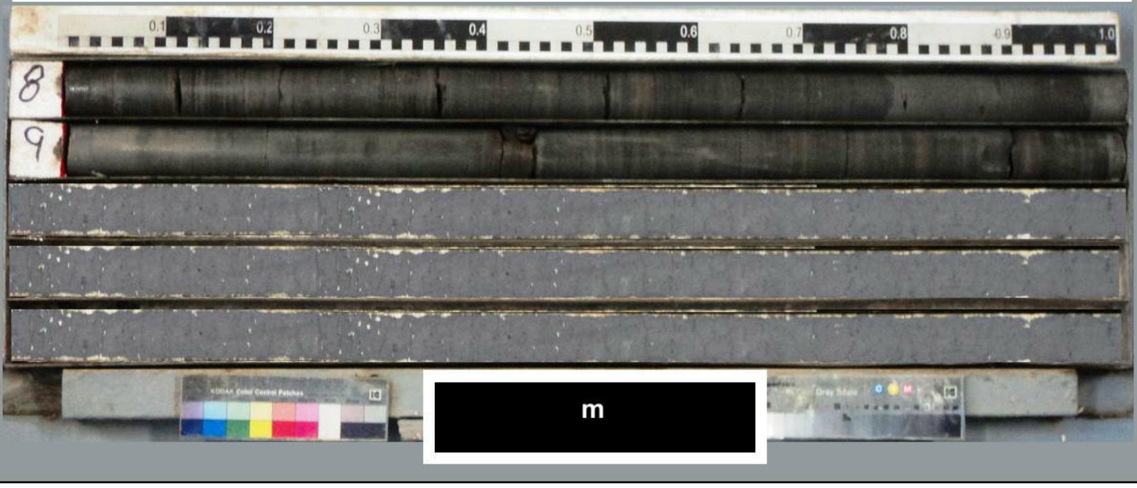
PROPOSED RESIDENTIAL DEVELOPMENT - KINGSWOOD

BORE 6 PROJECT 85085 SEP 2015



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