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Geotechnics / Environment / Groundwater

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Project 99688.00
27 May 2020
R.001.Rev1
HDS

Attention: Mr Anthony Peters

Email: a.peters@councilapproval.com.au

Preliminary Geotechnical Investigation
Alterations and Additions
16 Marshall Crescent, Beacon Hill

1. Introduction

This letter report presents the results of a preliminary geotechnical investigation undertaken by Douglas Partners Pty Ltd (DP) for proposed alterations and additions at 16 Marshall Crescent, Beacon Hill. The work was commissioned by Mr Anthony Peters of Council Approval Experts Pty Ltd, on behalf of Zoe and Martin Jenkins (owners) on 29 April 2020, and was undertaken in accordance with DP's proposal SYD200436 dated 28 April 2020. It is understood that the report is to accompany a Development Application (DA) to Northern Beaches Council (Council).

The preliminary Architectural drawing prepared by Furness & Co. Pty Ltd (trading as Spanline Home Additions: Drawing J20092-201 Site Plan 1B, dated 27 May 2020), indicates that the proposed development will include:

- Removal of a pathway along the front of the residence and the existing driveway;
- Construction of a new extension on the southern side of the residence;
- Construction of a carport on the eastern side of the residence; and
- Construction of a new driveway to link the carport to the street (Marshall Crescent).

The investigation included an inspection of the site and rock outcrops by an engineering geologist, drilling of two boreholes using hand tools, seven dynamic penetrometer tests, and probing for the top of rock using a steel rod. Details of the field work are given in the report, together with preliminary comments on geotechnical issues considered to be relevant to the project. Additional geotechnical investigation is likely to be required during the detailed design phase of the project. The scope of this investigation did not include sampling and testing for Waste Classification or Contamination Assessment purposes.

This report should be read in conjunction with the attached Standard Notes, 'About This Report'.

2. Site Description

The irregular-shaped site (known as Lot 97 in DP 204344) is located on the northern side of Marshall Crescent. The site slopes up from Marshall Crescent to a relatively level area covered with grass (i.e. the development footprint), which is adjacent to the existing residence, car garage and swimming pool. This 'steps up' a further 2.5 m to another relatively level area on the northern (rear) portion of the property. Brick boundary walls are present along the north-eastern and southern property boundaries, with only minor level differences on either side of the walls. Photographs of the site are presented on Plates 1 to 5, attached.

Inferred outcrops of medium to high strength sandstone were exposed on the southern, sloping part of the site near the street frontage (refer attached Photographs 1 and 2, Plate 1), and also within and to either side of the 3-level residence (refer Photograph 10 on Plate 5). The residence on the site appears to have been constructed over a 'step' in the rock outcrop (~2.5 m high). The surrounding properties are also occupied by residential dwellings.

Based on the drawing supplied, the site covers an area of approximately 569 m^2. Based on site measurements using a differential GPS, levels on the eastern, lower part of the site (relative to the Australian Height Datum) range between RL80.6 m (near the start of the driveway) and RL82.1 m (within the footprint of the proposed extension). It is noted that these levels vary to those shown on the drawing supplied by between 0.4 m and 1.4 m (lower).

The near-level areas of the site appear to have been raised / filled with a shallow thickness of either sand or sandy clay fill materials. Various service trenches were indicated to pass through the site (using electromagnetic scanning and ground penetrating radar detection methods), with a terracotta pipe and clayey gravel / aggregate backfill observed within the side of borehole BH2.

Groundwater seepage was not observed during the field work within the grass-covered areas of the site, or over the surfaces of the rock outcrops, however, a higher soil moisture content was observed within the north-eastern part of the development footprint (i.e. for the proposed carport). This area of the site is downslope of a hot water heater, stormwater pipes and a rock outcrop.

3. Geology

Reference to the Sydney 1:100 000 Geological Sheet indicates that the site is underlain by Hawkesbury Sandstone, of Triassic age. Hawkesbury Sandstone typically comprises horizontally bedded and vertically jointed, massive and cross-bedded, medium to coarse grained quartz sandstone with occasional shale or siltstone interbeds.

4. Field Work Methods

The field work was carried out on 6 May 2020 and included the following:

- Probing for the top of rock using a narrow steel rod at six locations (P1 to P6), to depths of between 0.23 m and 0.6 m;
- Two boreholes (BH1 and BH2), drilled using a 100 mm diameter hand auger, to depths of between 0.60 m and 0.62 m;
- Seven dynamic cone penetrometer (DCP) tests, including one test at each borehole, taken to depths of 0.60 m and 0.62 m below the ground surface; and
- Inspection and geological mapping by an engineering geologist.

The test locations were measured relative to site features and are shown on Drawing 1. Position co-ordinates and surface levels were obtained using a differential GPS and are considered to be accurate to within 0.1 m.

5. Field Work Results

5.1 Geological Mapping

Outcrops of medium to high strength sandstone at the ground surface were observed at multiple locations on the site (refer annotations on Drawing 1), including:

- on the eastern and western sides of the existing driveway (i.e. on the southern part of the site);
- north of the swimming pool and to either side of the residence; and
- within the approximate centre of the residence, within an internal stairwell.

The outcrop on the eastern side of the residence was measured to be up to 2.3 m high, and with the exposed face measured to have a strike / dip of 071°/81°S. The outcrop on the western side of the residence appeared to have a similar orientation. The development footprint interacts with these surface outcrops only within the vicinity of the existing driveway.

5.2 Boreholes, Probes and Dynamic Penetrometer Tests

The typical profile encountered within the boreholes comprised:

FILL:	Moist, loose silty sand and medium dense sand fill (with plastic fragments and gravel) within the proposed footprint of the extension (0.37 m thick), or firm / loose and moist to wet sandy clay and clayey gravel fill within the proposed footprint of the carport (0.3 m thick);
Silty SAND:	Moist to wet, fine and medium grained, medium dense silty sand with organic matter and roots, possibly colluvial soil or relict topsoil (0.2 m thick: Borehole BH1 only); over

Clayey SAND: Moist to wet, fine and medium grained, medium dense clayey sand, with low or medium plasticity clay fines and gravel, residual soil; over

SANDSTONE: inferred low or medium strength sandstone. The boreholes and some of the probes and penetrometer tests (i.e. P1, P2, P3, P6, DCP1, DCP2, DCP5 and DCP7) were terminated on equipment refusal at depths measured to be in the range 0.30 m to 0.64 m (which is inferred to be the top of the underlying bedrock).

The number of blow counts for dynamic cone penetrometer testing (per 150 mm penetration depth) is used to assess the density/consistency of the soils.

It is noted that DCP and probe refusal can occur upon encountering rock, or on very dense sand, tree roots or other obstructions. Further investigation using a drilling rig will be required to confirm the depth and strength of rock on the site, if required for the detailed design. Having said this, the inferred rock is reasonably consistent with the observed outcrops on the site.

The tabulated results of the inferred depth to the top of rock from the probes and DCPs are presented in Table 1.

Table 1: Inferred Depth to the Top of Rock, from Probes and Dynamic Cone Penetrometer Testing

Test Location	Surface Elevation (RL m)	Depth (m)	Elevation (RL m)	Proposed Portion of Development
P1	82.1	0.53	81.6	Extension
P2	82.1	0.39	81.7	Extension
P3	82.1	0.6	81.5	Extension
P4	82.2	0.23[1]	82.0[1]	Extension
P5	82.3	0.32[1]	82.0[1]	Carport
P6	81.9	0.35	81.6	Driveway
DCP1	82.1	0.6	81.5	Extension
DCP2	82.1	0.5	81.6	Extension
DCP3	82.1	0.25[1]	81.9[1]	Extension
DCP4	82.2	0.3[1]	81.9[1]	Extension
DCP5	82.3	0.64	81.7	Carport
DCP6	82.4	0.34[1]	82.1[1]	Carport
DCP7	81.8	0.30	81.5	Driveway

Notes: (1) inferred premature refusal on cobbles or gravel layers.

Free groundwater was not observed during the site work, however, the soil in Borehole BH2 (on the eastern part of the site: proposed carport footprint) was observed to be moist to wet above the top of the rock.

The site layout and test locations, together with the outline of the proposed excavation and building footprints, are shown on Drawing 1. The borehole logs and DCP results sheets are also attached.

6. Proposed Development

Based on the supplied preliminary Architectural drawing, it is understood that the proposed development includes:

- Removal of both a pathway along the front of the residence and the existing concrete driveway;
- Construction of a new extension on the southern side of the residence;
- Construction of a carport on the eastern side of the residence (assumed to be a 'slab on ground' construction); and
- Construction of a new driveway to link the carport with Marshall Crescent (also assumed to be a 'slab on ground' construction).

The drawing provided does not show the proposed floor levels for each of the new additions, however, it has been assumed that they will be similar to the existing surface levels. It is anticipated that localised excavations (including for footings) will be required for the proposed driveway, carport, for the proposed extension, and for the relocation of buried services (where required).

7. Geotechnical Model

The geotechnical model for the site is a 'stepped' site with an overall slope to the south, with sandy and clayey fill materials overlying a shallow thickness of either silty sand or clayey sand, over medium to high strength sandstone (which is exposed in the central and southern parts of the site). The current soil thickness across the site within the proposed development footprint (prior to any excavation) varies between 0.3 m and 0.64 m (thickness increasing away from Marshall Crescent).

8. Comments

8.1 Site Preparation

It is expected that site preparations will include the removal of concrete driveway slabs, small trees / garden beds, re-location or encasement (where required) of buried services, and re-grading of the existing slope for the proposed driveway. It is recommended that the layer of sandy clay fill beneath the proposed carport footprint also be removed.

The generally moist to wet condition of the soil indicates that attention to drainage will be required for the proposed development areas, to control any surface or sub-surface seepage and to minimise the potential for ponding of water within the site (such as behind or around footings), and the potential for softening of the foundation material (e.g. beneath the car port). Careful attention should be given to the drainage outlet conditions, to ensure that neighbouring properties are not adversely affected by the installed drainage measures.

The minimal thickness of soil at the site indicates that on-site disposal (such as within absorption trenches) is not likely to be suitable for this site.

For areas of the site where concrete slabs are cast onto soil (possibly including the driveway and the carport), the underlying soil will need to be compacted to a minimum density ratio of 95% (relative to Standard compaction) to minimise settlement and the potential for cracking of slabs. If site levels are to be raised then it is recommended that the fill comprise granular materials (which are free of inclusions such as organic matter / roots or cobbles), placed and compacted in layers not exceeding 150 mm (loose) thickness.

All materials to be removed from the site will need to be disposed of in accordance with current NSW Environment Protection Authority (EPA) regulations. Under the NSW EPA Waste Classification Guidelines (2014) a waste/fill receiving site must be satisfied that materials received meet the environmental criteria for the proposed land use. This includes filling and virgin excavated natural materials (VENM), such as may be removed from this site. Accordingly, environmental testing will need to be carried out to classify spoil prior to disposal. The type and extent of testing undertaken will depend on the final use or destination of the spoil, and requirements of the receiving site.

8.2 Groundwater

Free groundwater was not observed during the field work, however, it is likely to occur as seepage over the top of rock, particularly following periods of rainfall. Given that the site is located on a hill, such seepage over the top of rock is likely to be perched water, and it is expected that the permanent groundwater table will be located well below the proposed limit of the localised excavations. Groundwater levels are known to fluctuate depending upon the prevailing weather conditions and downslope drainage conditions.

8.3 Excavation Conditions

As the soil within the development footprint is indicated to be generally either loose / firm or medium dense and the existing residence appears to be founded on rock, it is suggested that footings for the proposed extension be founded on the underlying rock, to minimise the potential for total and differential settlement.

Excavations for footings founded on rock are expected to be required through up to about 0.6 m soil over low or medium strength sandstone. Localised excavations for footings or concrete slabs to depths of up to 0.6 m are expected to be temporarily stable, however, if they are to remain open for a time period of more than 2 days then the excavation sides should be battered back to a grade not steeper than 1.5H:1V.

Excavation of soil should be readily achieved using conventional earthmoving equipment such as tracked excavators, however, excavation into medium strength sandstone (if required) will require the use of rock hammers or rock saws. If rock hammers are used it will be necessary to monitor and control vibrations to avoid damage to adjacent structures. Excavation contractors should make their own assessment based on their equipment capabilities and operator skills.

8.4 Foundations

The strength of the sandstone underlying the development footprint was not confirmed during the investigation, however, shallow footings for the extension founded on the underlying sandstone could be designed on the basis of an allowable bearing pressure of 1000 kPa, assuming each of the footings are bearing uniformly on insitu low strength (or better) sandstone. It is suggested that footing excavations be inspected by a geotechnical consultant, to confirm that strata of suitable bearing capacity and stability has been reached. Settlements of footings founded on rock are considered to be negligible.

If footings are located in areas of the site which are to be raised using compacted fill, it is suggested that the footings be taken down to the rock to minimise the potential for differential settlement. Further geotechnical advice should be sought to refine the footing design when further details are known.

9. Geotechnical Monitoring During Construction

It is suggested that geotechnical advice should be sought at the following construction stages:

- Prior to commencement of construction – review of the structural drawings;
- At commencement of excavation – inspections to confirm site stability is maintained, and to confirm that design assumptions are appropriate; and
- Following preparation of the foundation excavations – to confirm the founding materials are suitable for the design bearing pressures.

10. Limitations

Douglas Partners (DP) has prepared this report for this project at 16 Marshall Crescent, Beacon Hill, in accordance with DP's proposal SYD200436 dated 28 April 2020 and commissioned on 29 April 2020 by Mr Anthony Peters of Council Approval Experts Pty Ltd on behalf of Zoe and Martin Jenkins (owners).

The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Zoe and Martin Jenkins or their agents for this project only and for the purposes as described in the report. It should not be used by or be relied upon for other projects or purposes on the same or other site 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 and/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 and/or testing locations. The advice may also be limited by budget constraints imposed by others.

This report must be read in conjunction with all of the attached pages 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 / groundwater components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Please contact the undersigned if you have any questions on this matter.

Yours faithfully
Douglas Partners Pty Ltd

Huw Smith
Associate

Reviewed by

Scott Easton
Principal

Attachments:
About this Report
Site photographs – Plates 1 to 5
Site and Test Location Plan – Drawing 1
Sampling Methods
Soil Descriptions
Symbols and Abbreviations
Borehole Logs and Photographs of recovered soil
Dynamic Penetrometer Test Results

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

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.

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.

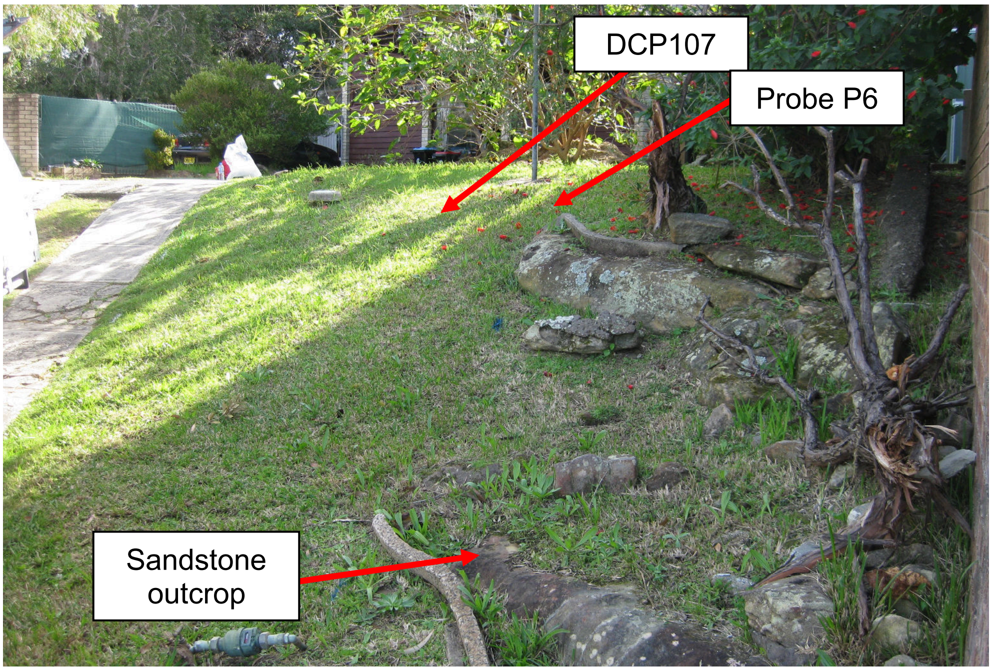
Information for Contractual Purposes

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

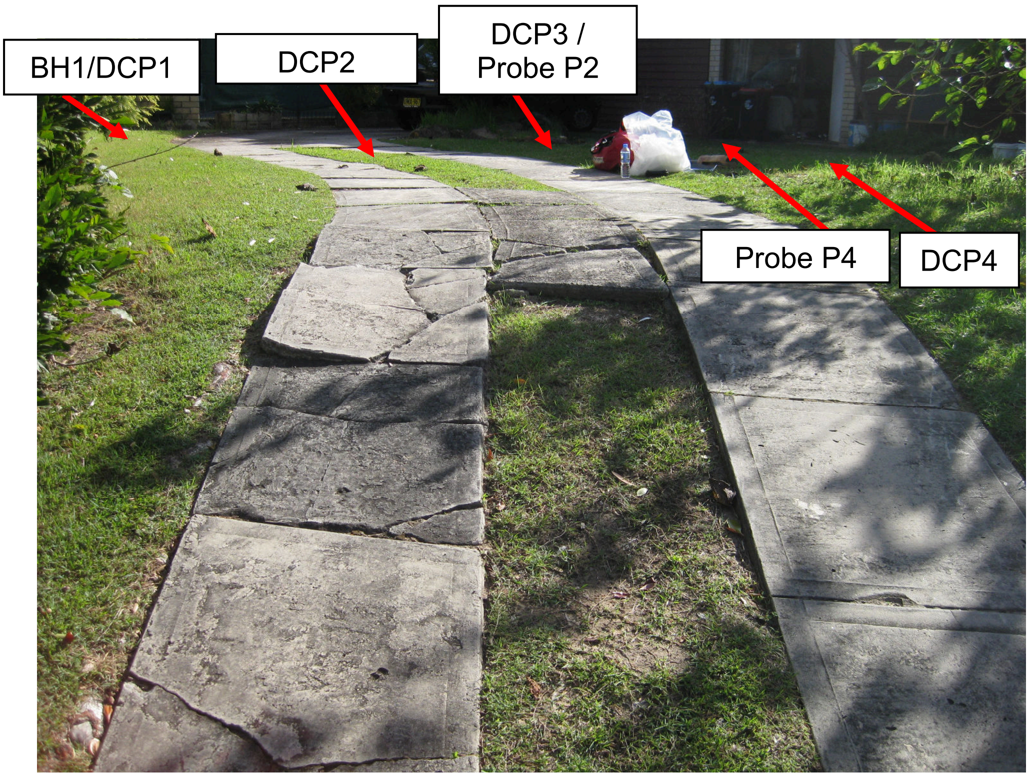
The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Photograph 1 – View to the west from the street frontage and property boundary. Sandstone outcrop was present at this boundary.



Photograph 2 – View north-west along the north-eastern property boundary with 17 Marshall Crescent, towards the location of test location DCP7. Sandstone outcrop is present in this area of the site.

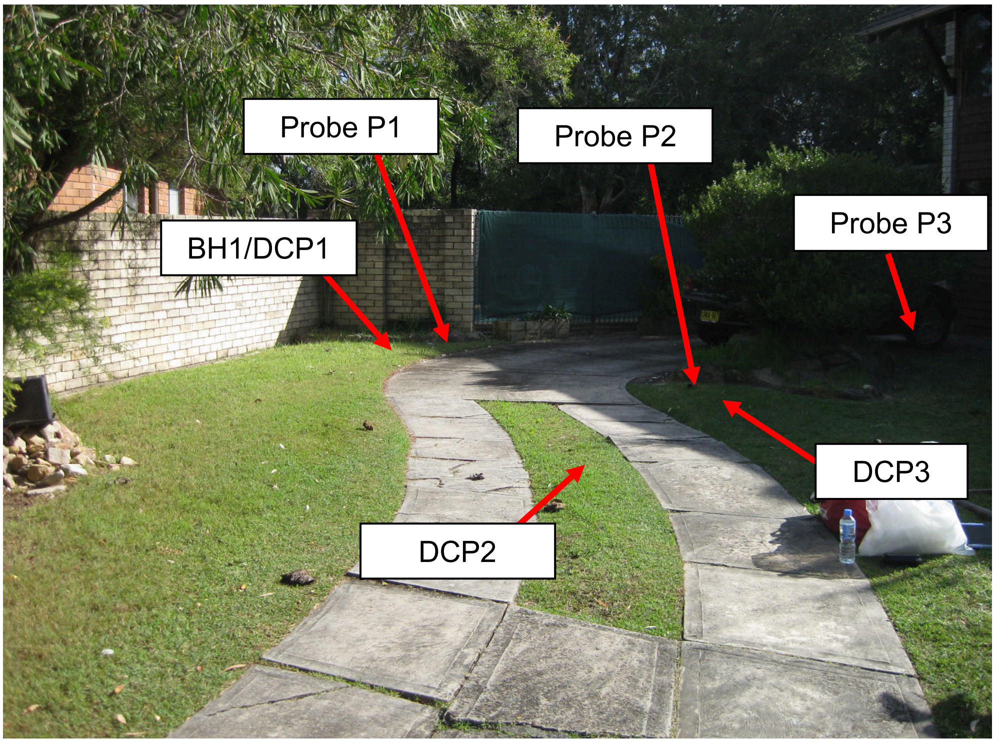
Douglas Partners Geotechnics / Environment / Groundwater	Site Photographs Alterations and Additions 16 Marshall Crescent Beacon Hill	PROJECT:	99688.00
		PLATE No:	1
		REV:	A
	CLIENT: Zoe and Martin Jenkins	DATE:	18 May 20



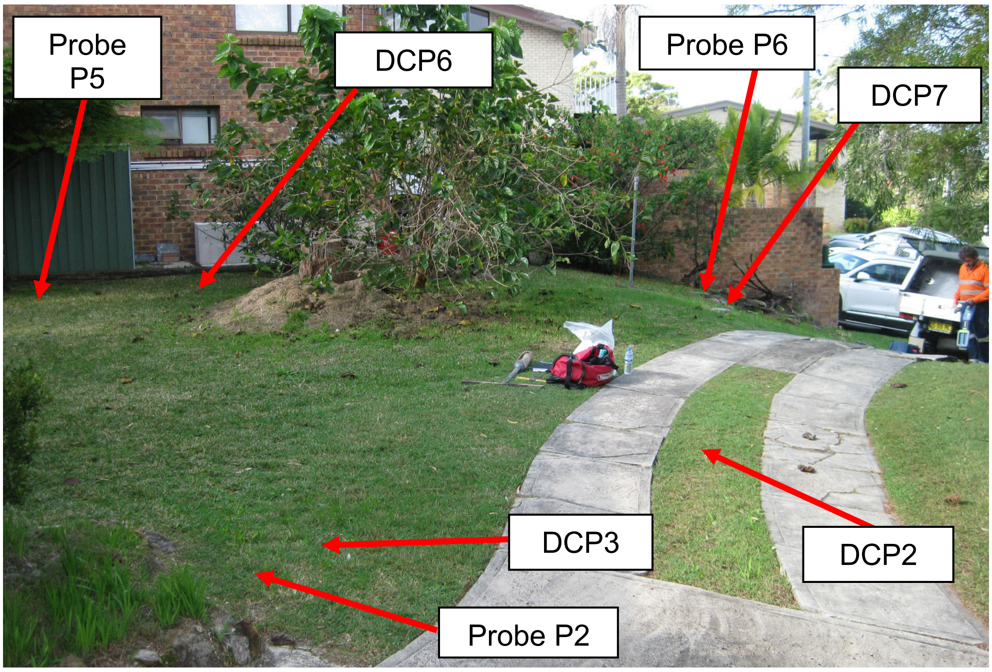
Photograph 3 – View to the west along the concrete driveway, showing its current condition. The positions of test locations are indicated as shown.

Photograph 4 – View north-east towards the north-eastern property boundary with 17 Marshall Crescent. Sandstone outcrop is present in this area of the site.

Douglas Partners Geotechnics / Environment / Groundwater	Site Photographs Alterations and Additions 16 Marshall Crescent Beacon Hill	PROJECT:	99688.00
		PLATE No:	2
		REV:	A
	CLIENT: Zoe and Martin Jenkins	DATE:	18 May 20

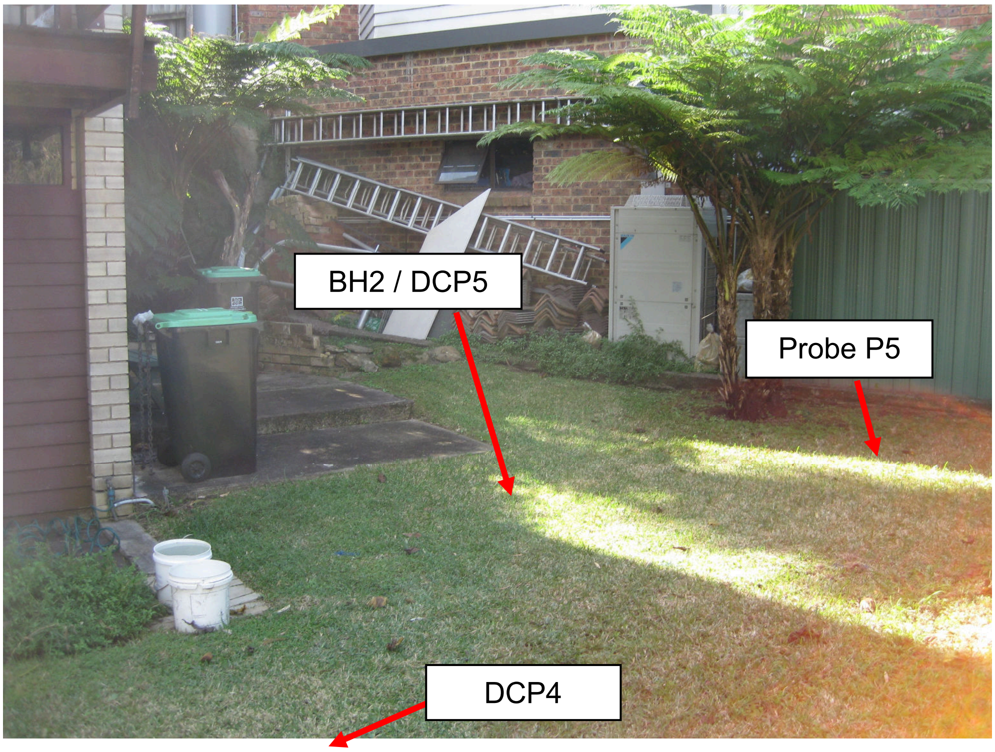


Photograph 5 – View to the west towards a swimming pool (fenced). The positions of test locations are indicated as shown.

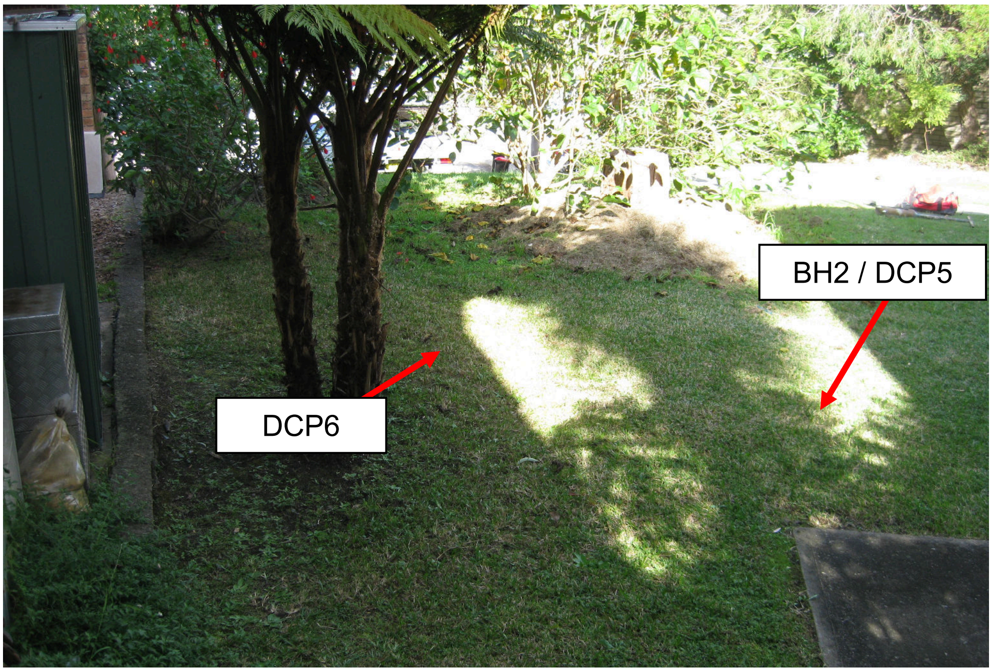


Photograph 6 – View east towards Marshall Crescent. The positions of test locations are indicated as shown.

Douglas Partners Geotechnics / Environment / Groundwater	Site Photographs Alterations and Additions 16 Marshall Crescent Beacon Hill	PROJECT:	99688.00
		PLATE No:	3
		REV:	A
	CLIENT: Zoe and Martin Jenkins	DATE:	18 May 20



Photograph 7 – View to the north towards the north-eastern property boundary. The positions of test locations are indicated as shown.



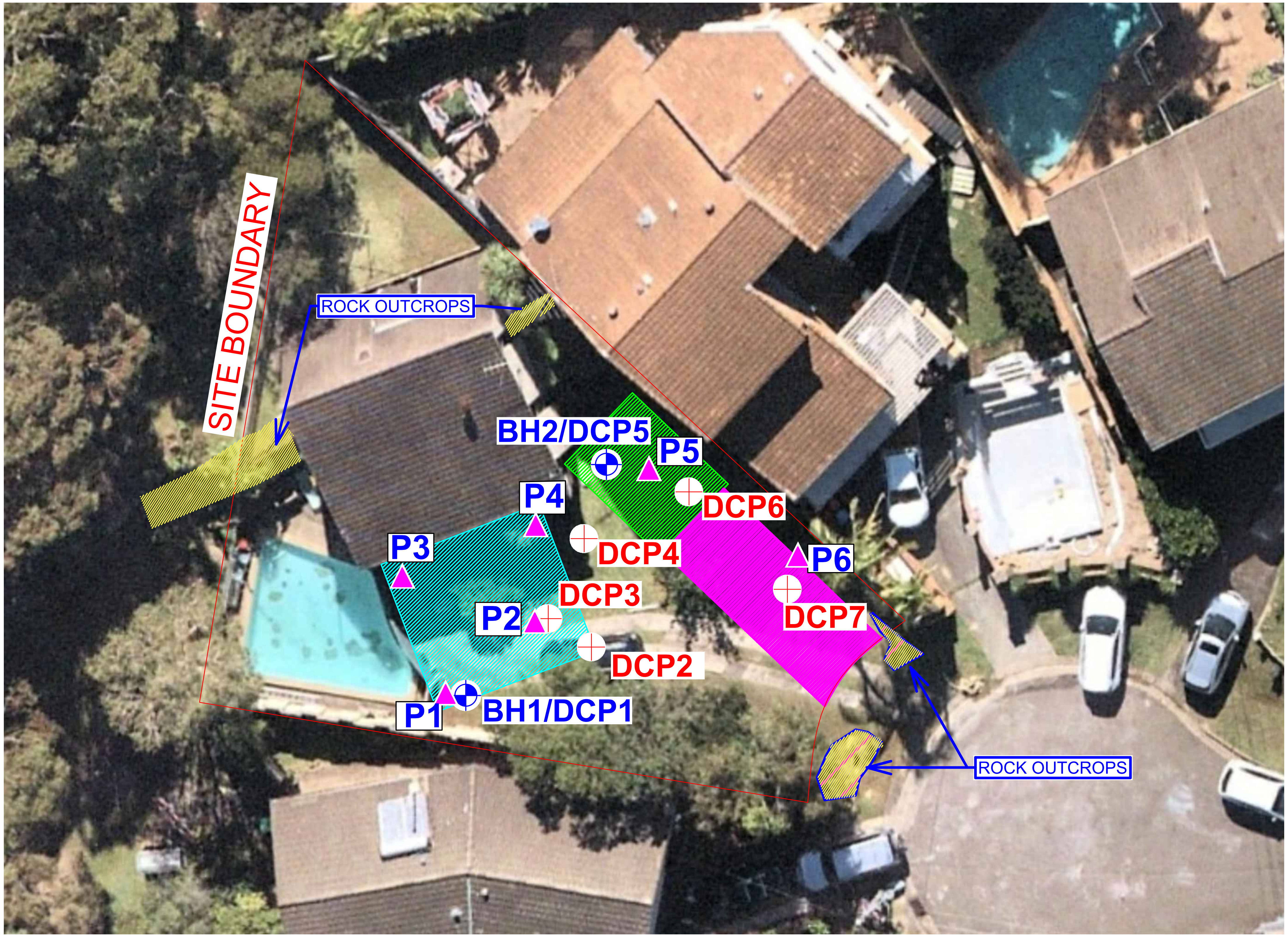
Photograph 8 – View south-east towards Marshall Crescent. The positions of test locations are indicated as shown.

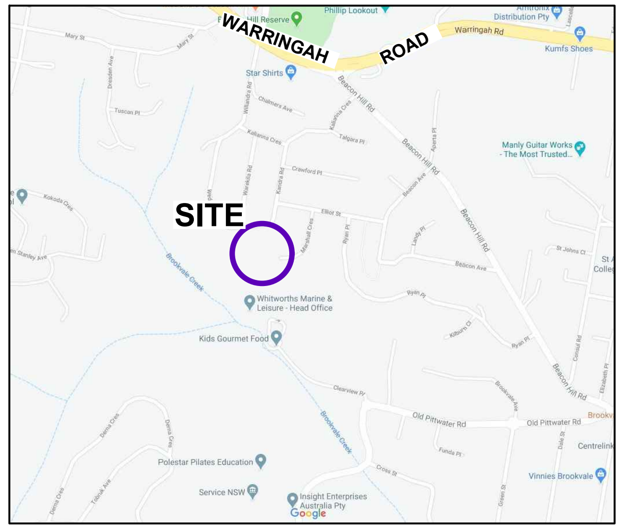
Douglas Partners Geotechnics / Environment / Groundwater	Site Photographs Alterations and Additions 16 Marshall Crescent Beacon Hill	PROJECT:	99688.00
		PLATE No:	4
		REV:	A
	CLIENT: Zoe and Martin Jenkins	DATE:	18 May 20

Photograph 9 – View to the south towards the southern property boundary.

Photograph 10 – View along the eastern side of the residence at 16 Marshall Crescent (towards the north), showing a sandstone outcrop passing through the site. Both residences on 16 Marshall Crescent and 17 Marshall Crescent appear to be founded on the rock outcrop at this location.

Douglas Partners Geotechnics / Environment / Groundwater	Site Photographs Alterations and Additions 16 Marshall Crescent Beacon Hill	PROJECT:	99688.00
		PLATE No:	5
		REV:	A
	CLIENT: Zoe and Martin Jenkins	DATE:	18 May 20





Locality Plan

0 1 2 3 4 6 8 10 15 20m

1:200 @ A3

NOTE:
1: Base image from NearMaps (Dated 18.04.2020)

LEGEND

- Borehole and Dynamic Cone Penetrometer Test Location
- Dynamic Cone Penetrometer Test
- P1 Probe test location
- Proposed Outline of New Driveway
- Proposed Alterations and Additions
- Proposed Outline of New Carport
- Outline of sandstone outcrop (approximate)

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Zoe and Martin Jenkins		TITLE: **Site and Test Location Plan**	PROJECT No: 99688.00
OFFICE: Sydney	DRAWN BY: BZ/HDS	**Proposed Alterations and Additions**	DRAWING No: 1
SCALE: 1:200 @ A3	DATE: 18.5.2020	**16 Marshall Crescent, Beacon Hill**	REVISION: 0

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

Douglas Partners

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are generally based on Australian Standard AS1726:2017, Geotechnical Site Investigations. 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	19 - 63
Medium gravel	6.7 - 19
Fine gravel	2.36 – 6.7
Coarse sand	0.6 - 2.36
Medium sand	0.21 - 0.6
Fine sand	0.075 - 0.21

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

The proportions of secondary constituents of soils are described as follows:

In fine grained soils (>35% fines)

Term	Proportion of sand or gravel	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	>30%	Sandy Clay
With	15 – 30%	Clay with sand
Trace	0 - 15%	Clay with trace sand

In coarse grained soils (>65% coarse)
- with clays or silts

Term	Proportion of fines	Example
And	Specify	Sand (70%) and Clay (30%)
Adjective	>12%	Clayey Sand
With	5 - 12%	Sand with clay
Trace	0 - 5%	Sand with trace clay

In coarse grained soils (>65% coarse)
- with coarser fraction

Term	Proportion of coarser fraction	Example
And	Specify	Sand (60%) and Gravel (40%)
Adjective	>30%	Gravelly Sand
With	15 - 30%	Sand with gravel
Trace	0 - 15%	Sand with trace gravel

The presence of cobbles and boulders shall be specifically noted by beginning the description with ‘Mix of Soil and Cobbles/Boulders’ with the word order indicating the dominant first and the proportion of cobbles and boulders described together.

Soil Descriptions

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
Friable	Fr	-

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	Density Index (%)
Very loose	VL	<15
Loose	L	15-35
Medium dense	MD	35-65
Dense	D	65-85
Very dense	VD	>85

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;
- Extremely weathered material – formed from in-situ weathering of geological formations. Has soil strength but retains the structure or fabric of the parent rock;
- Alluvial soil – deposited by streams and rivers;
- Estuarine soil – deposited in coastal estuaries;
- Marine soil – deposited in a marine environment;
- Lacustrine soil – deposited in freshwater lakes;
- Aeolian soil – carried and deposited by wind;
- Colluvial soil – soil and rock debris transported down slopes by gravity;
- Topsoil – mantle of surface soil, often with high levels of organic material.
- Fill – any material which has been moved by man.

Moisture Condition – Coarse Grained Soils

For coarse grained soils the moisture condition should be described by appearance and feel using the following terms:

- Dry (D) Non-cohesive and free-running.
- Moist (M) Soil feels cool, darkened in colour.

  Soil tends to stick together.

  Sand forms weak ball but breaks easily.
- Wet (W) Soil feels cool, darkened in colour.

  Soil tends to stick together, free water forms when handling.

Moisture Condition – Fine Grained Soils

For fine grained soils the assessment of moisture content is relative to their plastic limit or liquid limit, as follows:

- 'Moist, dry of plastic limit' or 'w <PL' (i.e. hard and friable or powdery).
- 'Moist, near plastic limit' or 'w ≈ PL (i.e. soil can be moulded at moisture content approximately equal to the plastic limit).
- 'Moist, wet of plastic limit' or 'w >PL' (i.e. soils usually weakened and free water forms on the hands when handling).
- 'Wet' or 'w ≈LL' (i.e. near the liquid limit).
- 'Wet' or 'w >LL' (i.e. wet of the liquid limit).

Rock Descriptions

Douglas Partners

Rock Strength

Rock strength is defined by the Unconfined Compressive Strength and it 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 Point Load Strength Index $Is_{(50)}$ is commonly used to provide an estimate of the rock strength and site specific correlations should be developed to allow UCS values to be determined. The point load strength test procedure is described by Australian Standard AS4133.4.1-2007. The terms used to describe rock strength are as follows:

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

* Assumes a ratio of 20:1 for UCS to $Is_{(50)}$. It should be noted that the UCS to $Is_{(50)}$ ratio varies significantly for different rock types and specific ratios should be determined for each site.

Degree of Weathering

The degree of weathering of rock is classified as follows:

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

Rock Descriptions

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 occasional fragments
Fractured	Core lengths of 30-100 mm with occasional shorter and longer sections
Slightly Fractured	Core lengths of 300 mm or longer with occasional sections of 100-300 mm
Unbroken	Core contains very few fractures

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 stronger. 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

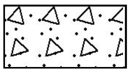
Symbols & Abbreviations

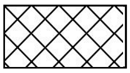
Graphic Symbols for Soil and Rock

General

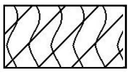
 Asphalt

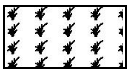
 Road base

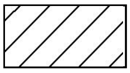
 Concrete

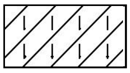
 Filling

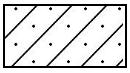
Soils

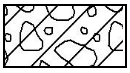
 Topsoil

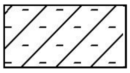
 Peat

 Clay

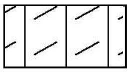
 Silty clay

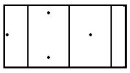
 Sandy clay

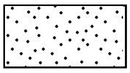
 Gravelly clay

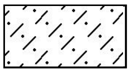
 Shaly clay

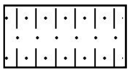
 Silt

 Clayey silt

 Sandy silt

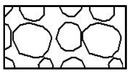
 Sand

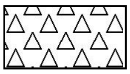
 Clayey sand

 Silty sand

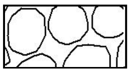
 Gravel

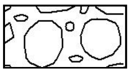
 Sandy gravel

 Cobbles, boulders

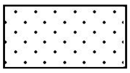
 Talus

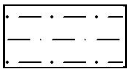
Sedimentary Rocks

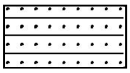
 Boulder conglomerate

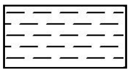
 Conglomerate

 Conglomeratic sandstone

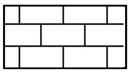
 Sandstone

 Siltstone

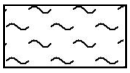
 Laminite

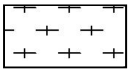
 Mudstone, claystone, shale

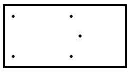
 Coal

 Limestone

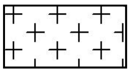
Metamorphic Rocks

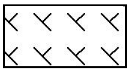
 Slate, phyllite, schist

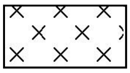
 Gneiss

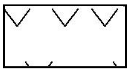
 Quartzite

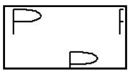
Igneous Rocks

 Granite

 Dolerite, basalt, andesite

 Dacite, epidote

 Tuff, breccia

 Porphyry

BOREHOLE LOG

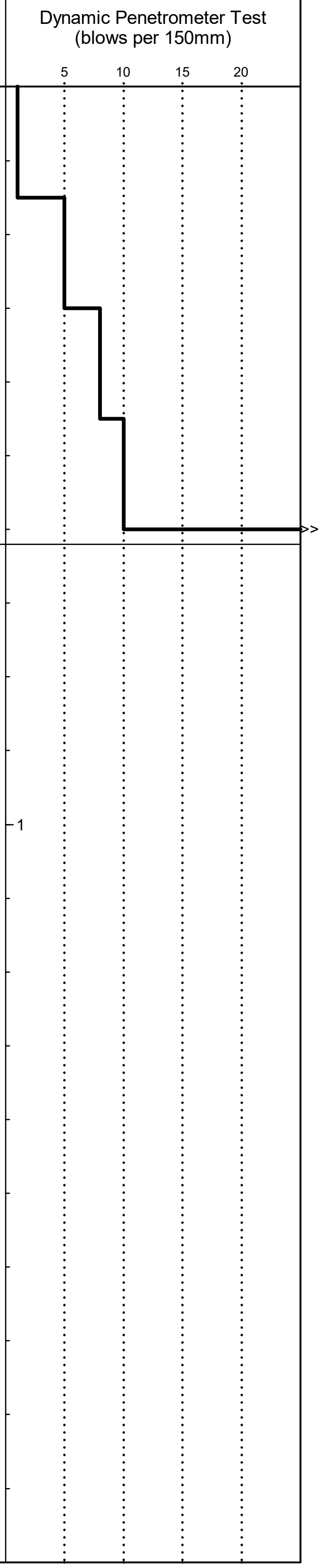
CLIENT: Zoe and Martin Jenkins
PROJECT: Alterations and Additions
LOCATION: 16 Marshall Crescent, Beacon Hill

SURFACE LEVEL: 82.1 AHD
EASTING: 338955.6
NORTHING: 6263179.7
DIP/AZIMUTH: 90°/--

BORE No: BH1
PROJECT No: 99688.00
DATE: 6/5/2020
SHEET 1 OF 1

Depth (m)	Description of Strata	Type	Depth	Sample	Results & Comments	Water
0.05	FILL/Silty SAND: fine and medium, dark brown, trace fine roots, moist, generally in a loose condition		0.05			
	FILL/SAND: fine and medium, dark brown, moist, generally in a loose to medium dense condition	D				
	At 0.2m: with plastic, concrete and igneous gravel		0.2			
0.37	Below 0.3m: grading to fine to coarse, brown, trace clay and gravel, generally in a medium dense condition	D	0.3			
0.57	Silty SAND SM: fine and medium, dark brown with black mottle, trace roots, organic matter, and fine quartz and sandstone gravel, moist to wet, medium dense, possible colluvium	D	0.37			
0.62	Clayey SAND SC: fine and medium, mottled grey and orange-brown, medium plasticity fines, trace fine roots, moist, medium dense, residual	D	0.57			
	Bore discontinued at 0.62m - Refusal on inferred sandstone bedrock		0.62			

RL: 82, 81 | Depth: 1



RIG: Hand Tools **DRILLER:** HDS **LOGGED:** HDS **CASING:** Uncased
TYPE OF BORING: Hand Auger to 0.62 m
WATER OBSERVATIONS: No free groundwater observed
REMARKS: Grass cover at surface. Completed adjacent to Dynamic Cone Penetrometer test DCP1.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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

Photograph C1 – View of soils excavated from Borehole BH1, with the top of the soil profile commencing from the left of the field of view.

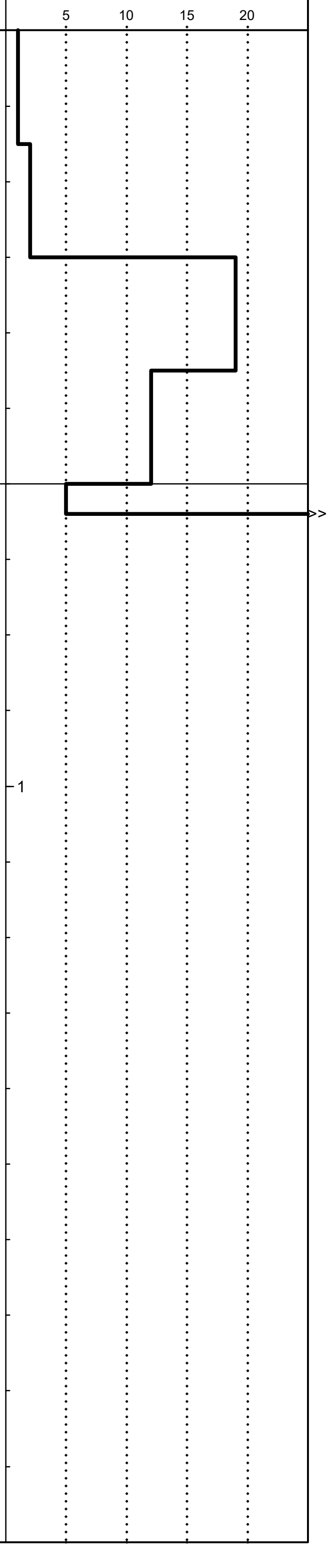
Douglas Partners Geotechnics / Environment / Groundwater	Detailed Photographs Alterations and Additions 16 Marshall Crescent Beacon Hill	PROJECT:	99688.00
		PLATE No:	C1
		REV:	A
	CLIENT: Zoe and Martin Jenkins	DATE:	18 May 20

BOREHOLE LOG

CLIENT: Zoe and Martin Jenkins	**SURFACE LEVEL:** 82.3 AHD	**BORE No:** BH2	
PROJECT: Alterations and Additions	**EASTING:** 338960.9	**PROJECT No:** 99688.00	
LOCATION: 16 Marshall Crescent, Beacon Hill	**NORTHING:** 6263190.9	**DATE:** 6/5/2020	
	DIP/AZIMUTH: 90°/--	**SHEET** 1 OF 1	

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
	0.0	FILL/Sandy CLAY: medium plasticity, dark brown, fine and medium, trace silt and fine roots, w~PL, generally in a soft condition		D	0.0–0.15			
	0.15	FILL/Clayey GRAVEL: medium, dark brown, angular igneous aggregate, low plasticity fines, with sand, trace roots, moist to wet, loose Between 0.2m and 0.28m: terracotta pipe within side of borehole		D	0.15–0.3			
82	0.3	Clayey SAND SC: fine and medium, mottled orange-brown and grey, low plasticity fines, with fine and medium sandstone gravel, moist to wet, medium dense, residual Below 0.47m: grading to mottled orange-brown and red-brown, with gravel		D	0.3–0.45			
				D	0.5–0.6			
	0.6	Bore discontinued at 0.6m - Refusal on inferred low strength sandstone bedrock						
	1							
81								

Dynamic Penetrometer Test (blows per 150mm)



RIG: Hand Tools	**DRILLER:** HDS	**LOGGED:** HDS	**CASING:** Uncased

TYPE OF BORING: Hand Auger to 0.6 m

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Grass cover at surface. Completed adjacent to Dynamic Cone Penetrometer test DCP5.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

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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Photograph C2 – View of soils excavated from Borehole BH102, with the top of the soil profile commencing from the right of the field of view.

Douglas Partners Geotechnics / Environment / Groundwater	Detailed Photographs Alterations and Additions 16 Marshall Crescent Beacon Hill	PROJECT:	99688.00
		PLATE No:	C2
		REV:	A
	CLIENT: Zoe and Martin Jenkins	DATE:	18 May 20

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Geotechnics / Environment / Groundwater

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Results of Dynamic Penetrometer Tests

Client	Zoe and Martin Jenkins	**Project No.**	99688.00
Project	Alterations and Additions	**Date**	6/05/2020
Location	16 Marshall Crescent, Beacon Hill	**Page No.**	1 of 1

Test Locations	DCP 1 (BH1)	DCP 2	DCP 3	DCP 4	DCP 5 (BH2)	DCP 6	DCP 7
Co-ordinates	338955.6E 6263179.7N	338960.3E 6263182.2N	338958.5E 6263184.3N	338960.0E 6263187.2N	338960.9E 6263190.9N	338964.6E 6263189.7N	338969.0E 6263183.9N
RL of Test (m AHD)	82.1	82.1	82.1	82.2	82.3	82.4	81.8
Depth (m)	**Penetration Resistance** Blows/150 mm						
0.00 – 0.15	1	6	1	2	1	1	1
0.15 – 0.30	5	10	13/100	14	2	7	2
0.30 – 0.45	8	12	Ref	Ref	19	8/40	Ref
0.45 – 0.60	10	12/50			12	Ref	
0.60 – 0.75	Ref	Ref			5/40		
0.75 – 0.90					Ref		
0.90 – 1.05							
1.05 – 1.20							
1.20 – 1.35							
1.35 – 1.50							
1.50 – 1.65							
1.65 – 1.80							
1.80 – 1.95							

Test Method AS 1289.6.3.2, Cone Penetrometer ☑
AS 1289.6.3.3, Sand Penetrometer ☐

Tested By HDS
Checked By HDS

Remarks Ref = Refusal
12/50 = 12 blows for 50 mm penetration