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Integrated Practical Solutions

Report on
Geotechnical Investigation

Taronga Reptile and Amphibian Conservation Centre
Taronga Zoo

Prepared for
Taronga Conservation Society Australia

Project 99931.00
July 2021

Douglas Partners
Geotechnics / Environment / Groundwater

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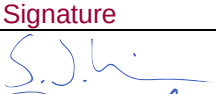
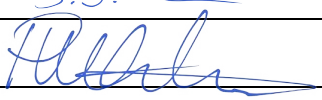
The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		6 July 2021
Reviewer		6 July 2021

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Report on Geotechnical Investigation
Taronga Reptile and Amphibian Conservation Centre
Taronga Zoo

1. Introduction

This report presents the results of a geotechnical investigation undertaken for the proposed Reptile and Amphibian Conservation Centre project at Taronga Zoo. The work was commissioned by the Taronga Conservation Society Australia and was undertaken in accordance with Douglas Partners' proposal SYD201344.001.Rev1 dated 8 December 2020.

It is understood that a new reptile and amphibian conservation centre is proposed in the central part of the zoo and covers the current meerkat exhibit and area to the west and north west of the exhibit. The proposed development will involve the demolition of various structures, some earthworks, and construction of the new facility which has terraced floor levels and is up to three storeys high at its southern frontage.

Geotechnical investigation was undertaken to provide information on subsurface conditions on the site and included the drilling of four cored boreholes and five dynamic cone penetration tests (DCPs), as well as laboratory testing and engineering analysis. Details of the field work and comments relating to design and construction are provided in this report.

Douglas Partners (DP) also undertook a preliminary site investigation for contamination assessment purposes, the results of which are outlined in the *Report on Preliminary Site Investigation (Contamination)* for Project 99931.00.R.004 dated July 2021.

2. Site Description

The development covers the area to the east of the existing gorilla exhibit, it extends from the eastern boundary of the gorilla exhibit about 100 m to the intersection of the upper and lower paths. The majority of the proposed building is located within the current meerkat exhibit and sloping area to the west and north west of the exhibit, from the southern edge of the upper road / walkway about 30 m south to the northern edge of the lower road / walkway. There are some concrete paths, a shed, some historical aviaries and the meerkat enclosure located within the proposed development area. It also appears that a deep stormwater pipe runs down the west of the site. It is understood that a historical seal pool was previously located within the site but has now been backfilled.

The site is located on a Hawkesbury Sandstone slope which has been landscaped for its current use. The site has been terraced with several retaining walls and sandstone outcrops and cuttings in the area of the works. Ground surface levels nearby the area range from about RL 45 m to RL 53 m AHD. The higher levels were encountered at the crest of the slope near the upper road / walkway.

The portion of the site proposed for redevelopment is shown on Drawing R1 in Appendix B.

3. Geology and Hydrogeology

The *Sydney 1:100 000 Geological Series Sheet* shows that the site is underlain by Hawkesbury Sandstone which typically comprises medium to coarse-grained quartz sandstone with minor shale and laminite lenses. An extract from the geological map is shown in Figure 1.

Figure 1: Extract from geological map

The regional groundwater table is likely to be well below the bedrock surface. Near-surface Hawkesbury Sandstone generally exhibits low permeabilities which result in very low groundwater yields. Groundwater use from this aquifer is therefore unlikely to be significant.

Groundwater is likely to follow the surface topography and flow to the south.

4. Field Work Methods

Four cored boreholes (RA1 to RA4) were drilled to depths of between 5.5 m and 12.0 m using a Hanjin D8 drilling rig. The boreholes were commenced using solid flight augers to drill through the soil to the top of rock. Soon after rock was encountered, the bores were advanced using NMLC-sized diamond core drilling equipment to obtain 50 mm diameter continuous samples of the rock for identification and strength testing purposes.

Five dynamic cone penetration tests (DCPs) were carried out to refusal at depths of between 0.3 m and 2.4 m in the sloping area that was inaccessible to the drilling equipment.

Note the coverage of the boreholes and DCPs was limited to the west portion of the site due to access constraints and to focus on the proposed building footprint.

Coordinates and levels for all test locations apart from RA5 to RA7 were determined using a differential GPS (dGPS) receiver. Due to heavy vegetation and interference from buildings the dGPS could not be used for RA5 to RA7 so levels at these test locations were estimated from the Details and Levels Plan (By: Hammond Smeallie & Co Pty Ltd, DWG No: TZ Master Survey with Infrastructure_MGA, Revision B, Dated 8/8/2017) provided by Taronga Conservation Society Australia. The test locations are shown on Drawing R1 in Appendix B.

5. Field Work Results

The subsurface conditions encountered in the boreholes are presented in the borehole logs in Appendix C. Notes defining descriptive terms and classification methods are included in Appendix A. The boreholes encountered:

- **FILL** – typically concrete over sandy fill to depths of about 2.1 m in the upper boreholes RA1 and RA2, typically synthetic grass or pavers over gravelly or clayey sand and clay fill to depths of about 1.1 m in the lower boreholes RA3 and RA4, overlying
- **SANDSTONE BEDROCK** – sandstone bedrock from depths of between 1.1 m to 2.1 m to the base of the bores at 5.5 m to 12.0 m depth. The rock was generally medium and high strength.

Natural soils were not encountered in the boreholes.

Table 1 summarises the levels at which the different materials were encountered in the current boreholes.

Table 1: Summary of Material Strata Levels

Stratum	RL of Top of Stratum (m, AHD)			
	RA1	RA2	RA3	RA4
Ground Surface / Top of Fill	52.7	52.6	45.6	45.8
Typically Medium / High Strength Sandstone*	50.6	50.5	43.5	43.7
Base of Borehole	48.5	48.4	41.4	41.6

Groundwater was not observed whilst augering in any of the boreholes. The use of water as a drilling fluid during NMLC diamond coring of the bedrock precluded further observation of the groundwater levels below the bedrock surface during the field work.

Five DCPs were carried out in the sloping area that was inaccessible to drilling equipment. Assuming the DCPs refused on rock, these would indicate that the depth to rock in that area is about 0.3 m to 2.4 m. This will require confirmation during construction.

Whilst undertaking the field work, mapping of outcropping rock and areas of obvious fill was completed. Observable rock outcrops are shown in Drawing R1 in Appendix B. Areas of deeper fill were

encountered in boreholes RA1 and RA3; it is likely deeper fill may be encountered where filling has been required to achieve current site levels, for example at the top of cuttings and batters and in any natural gullies and possibly historical pools that may have previously run through the site.
Note the field work and inspections was limited to the

6. Laboratory Testing

Thirty-seven (37) samples selected from the rock core were tested for axial point load strength index (Is_{50}). The results typically ranged between 0.7 MPa and 2.2 MPa which correspond to medium strength and high strength rock, respectively. These Is_{50} values suggest unconfined compressive strength (UCS) values in excess of 40 MPa for the samples of high strength rock tested. One Is_{50} value was 5.9 MPa corresponding to very high strength rock.

Two soil samples were tested in a NATA accredited laboratory for measurement of electrical conductivity, pH, and chloride and sulphate ion concentrations in order to assess the aggressivity of the site soils to buried concrete and steel. Two additional tests were undertaken for pH as part of the testing for the PSI. The laboratory results are included in Appendix D, with the results summarised in Table 2.

Table 2: Aggressivity Testing of Soil Samples

Borehole	Depth (m)	Strata Description	pH	Conductivity (µS/cm)	Cl (mg/kg)	SO_4 (mg/kg)
RA1	1.4 - 1.5	Fill	7.9	-	-	-
RA3	0.5 – 0.6	Fill	9.0	-	-	-
RA3	0.9 – 1.0	Fill	9.6	410	290	120
RA4	0.9 – 1.0	Fill	8.2	600	710	33

Notes: Cl = Chloride ion concentration, SO_4 = Sulphate ion concentration.

7. Geotechnical Model

The site appears to be underlain by varying depths of fill overlying sandstone bedrock. The bedrock was generally medium strength or high strength. The regional groundwater table is likely to be well below the bedrock surface.

Geotechnical cross-sections are provided in Drawings R2 and R3 in Appendix B.

8. Proposed Development

It is understood that a new reptile and amphibian conservation centre is proposed in the central part of the zoo and covers the meerkat exhibit and area to the west and north west of the exhibit. The proposed development will involve the demolition of various structures, some earthworks, and construction of the

new facility which has terraced floor levels and is up to three storeys high at its southern frontage. The floor level is RL 45.7 m and based on current site levels and sections provided it expected that excavation to depths of up to 5 m will be required. Some fill will also be required.

The geotechnical issues that may be relevant to the proposed development include excavation, excavation support, site preparation, groundwater, and foundations.

9. Comments

9.1 Excavation

Excavation for the proposed development may be required within fill and sandstone bedrock of medium to high strength, noting that some weaker and stronger bands may be present. Excavation in the fill and any soil or very low and low strength sandstone encountered should be readily achievable using a hydraulic excavator with bucket attachment. Excavation in medium and high strength sandstone will require ripping, hammering and/or sawing. Rock strengths in excess of 40 MPa (UCS) were encountered in the boreholes and stronger bands (such as the one encountered towards the base of RA4) are also present.

It should be noted that any off-site disposal of spoil will generally require assessment for re-use or classification in accordance with current *Waste Classification Guidelines* (NSW EPA, 2014).

9.2 Excavation Support

Excavations in fill and any soil or very low and low strength rock if encountered, will not be able to stand vertically for extended periods of time but may be able to be supported by temporary batters where space permits. A maximum temporary batter slope of 1.5(H):1(V) is recommended for excavations of up to 3 m depth in these materials where they are above the water table, and where not subjected to surcharge loads. Permanent batters should be flattened to no steeper than 2(H):1(V). The medium and high strength rock should be able to stand vertically providing adverse jointing is not present.

Retaining walls (temporary and/or permanent) will be required in some areas of the site and could be designed using the material and strength parameters outlined in Table 3.

Table 3: Material and Strength Parameters for Retaining Structures

Material	Bulk Unit Weight (kN/m^3)	K_a	K_o	Poisson's Ratio	Young's Modulus (MPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Ultimate Passive Earth Pressure (kPa)
Fill	20	0.4	0.6	0.35	10	0	30	-
VLS Sandstone	22	0.2[1]	0.3[1]	0.3[1]	50	30	32	750[2]
MS/HS Sandstone	23	0[1]	0[1]	0.25[1]	500	100	35	3000[2]

Notes: 1. Unless unfavourably jointed; 2 Only below ground level and where jointing is favourable; MS = medium strength; HS = high strength; K_a = coefficient of active earth pressure; K_o = coefficient of earth pressure at rest;

A triangular lateral earth pressure distribution could be assumed for cantilevered walls. Lateral pressures due to surcharge loads from sloping ground surfaces, adjacent buildings, construction machinery and vehicles should be included where relevant. Hydrostatic pressure acting on the retaining walls should also be included in the design where adequate drainage is not provided behind the full height of the walls.

9.3 Site Preparation

Areas of the site that require filling to raise site levels should be stripped of vegetation and existing fill materials prior to proof-rolling with a minimum 10 t steel smooth drum roller (soil subgrades only). Any areas exhibiting significant heaving should be assessed by a geotechnical engineer to determine any rectification measures that may be required. Proof-rolling will not be required if the subgrade is low, medium or high strength sandstone bedrock.

Approved fill should then be placed on the prepared subgrade in 250 mm thick layers and be compacted to achieve a dry density ratio of at least 98% relative to Standard compaction. This density criteria could be relaxed to a dry density ratio of at least 95% relative to Standard compaction in areas that are not required to support structures or pavements. The moisture content of the fill should be within 2% of optimum if it exhibits clay-like properties. Density testing should be undertaken in accordance with the provisions of AS 3798 – 2007 *Guidelines on earthworks for commercial and residential developments*.

The subgrade in areas where fill is not required should also be prepared in accordance with the above advice if they are required to support structures or pavements.

Pavements could be designed on the basis of a design subgrade CBR of 12% for the sandy and gravelly materials provided that the subgrade is prepared in accordance with the advice provided above. The design subgrade CBR should be lowered to 3% for clayey materials.

9.4 Groundwater

The regional groundwater table is expected to be well below the bedrock surface and flow in a southerly direction towards Athol Bay. However, some seepage through and along strata boundaries should be expected and this should be considered in the design of the drainage systems on the site. Seepage may also need to be removed from footing and pile excavations prior to pouring concrete.

9.5 Foundations

It is 'good engineering practice' to uniformly support a multi-storey building such as that proposed on natural material of uniform strength to reduce the potential for differential settlement, especially considering the variability and depth of the fill at the site. Foundation systems will depend on the proposed bulk excavation level. It is expected that shallow footings or short piles or a combination of both would be required to bear on bedrock.

Footings and piles could be designed using the information provided in Table 4.

Table 4: Allowable Design Parameters for Spread Footings and Bored Piles in Sandstone

Material Description	Allowable End Bearing Pressure	Allowable Shaft Adhesion [1] (kPa)
MS/HS Sandstone	3500	300

Notes: Only for piles where adequate socket-roughness has been achieved; MS = medium strength; HS = high strength

Foundations proportioned on the basis of the allowable bearing pressures in Table 4 would be expected to experience total settlements of less than 1% of the pile diameter, or minimum footing dimension, under the applied working load, with differential settlements between adjacent columns expected to be less than half of this value.

Footings should be positioned outside a 45-degree zone of influence from the base of nearby excavation. If this is not possible, the allowable bearing pressure may need to be reduced by up to 60% of the original value, subject to inspection and assessment by a geotechnical engineer.

All new footings should be inspected by an experienced geotechnical professional to check the suitability of the foundation material, and in the case of bored piles the socket roughness and the base cleanliness. Higher bearing pressures could be justified, if required, provided additional testing is undertaken during construction.

9.6 Soil Aggressivity

The results of electrical conductivity, pH, chloride and sulphate analyses indicate that the concentrations within the soil samples analysed are non aggressive to both concrete and steel piles (Table 6.4.2(C) and Table 6.5.2 (C) of AS 2159 – 2009). Reference should be made to Table 6.4.3 of AS 2159 – 2009 to determine minimum concrete cover to steel.

10. Limitations

Douglas Partners (DP) has prepared this report for this project at Taronga Zoo in accordance with DP's proposal SSYD201344.P.001.Rev1 dated 8 December 2020 and acceptance received from Mr Paul Alwis. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Taronga Conservation Society Australia for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. 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 or by site accessibility.

The assessment of atypical safety hazards arising from this advice is restricted to the (geotechnical / environmental / groundwater) components set out in this report and based on known project conditions and stated design advice and assumptions. While some recommendations for safe controls may be provided, detailed 'safety in design' assessment is outside the current scope of this report and requires additional project data and assessment.

Asbestos has not been detected by observation or by laboratory analysis, either on the surface of the site, or in filling materials at the test locations sampled and analysed. Fill containing building demolition materials has been encountered within Taronga Zoo in previous investigations and is indicative of the possible presence of hazardous building materials (HBM), including asbestos at this site.

This report must be read in conjunction with all of the attached 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.

Appendix A

About This Report

About this Report

Douglas Partners

Introduction

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

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

Copyright

Borehole and Test Pit Logs

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

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

Groundwater

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

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

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

Reports

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

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

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

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

About this Report

Site Anomalies

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

Information for Contractual Purposes

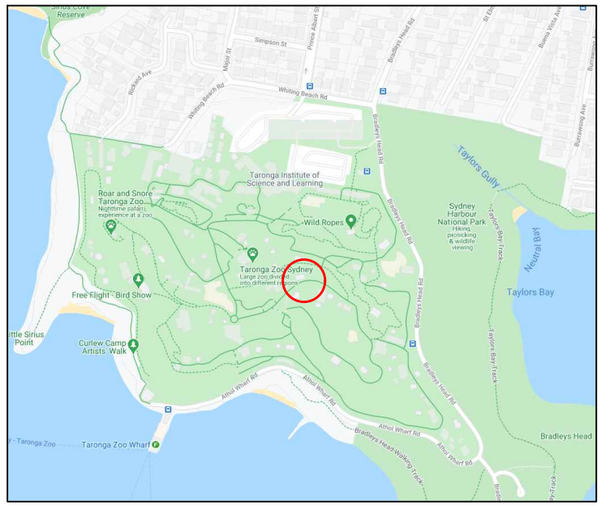
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate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

Site Inspection

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

Appendix B

Drawings



SITE LOCALITY

NOTE:
1: Base image from MetroMap.com.au (Dated 04.12.2020)
2: Proposed building extents and levels were estimated based on the Schematic Design Architectural Drawings (By: DWP Australia Pty Ltd, Project No. RACC 20-0527)

0 5 10 15 20 30 40 60m
1:600 @ A3

LEGEND

- Test Bore Location and Number
- DCP Location and Number
- Rough Outline of Rock Outcrop
- Geological Cross Section
- Site Boundary
- Proposed Building Footprint

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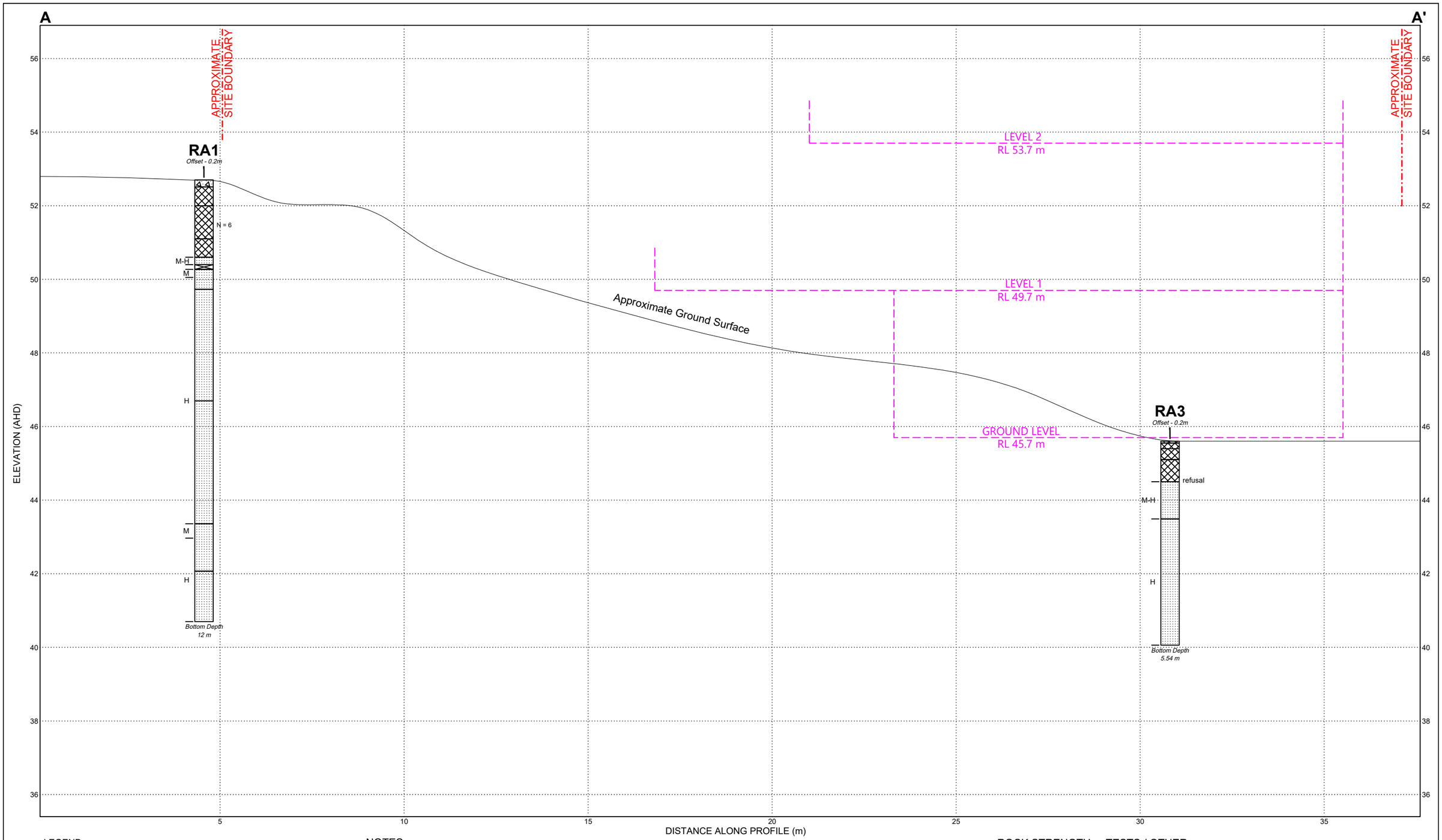
Geotechnics / Environment / Groundwater

CLIENT: Taronga Conservation Society Australia		TITLE: **Test Location Plan** **Taronga Reptile and Amphibian Conservation Centre** **Taronga Zoo, Mosman**
OFFICE: Sydney	DRAWN BY: CJ/MG	
SCALE: 1:600 @ A3	DATE: 06.07.2021	

PROJECT No:	99931.00
DRAWING No:	R1
REVISION:	1



LEGEND

- Core Loss
- Concrete
- Filling
- Sandstone
- Topsoil

NOTES

1. Subsurface conditions are accurate at the borehole locations only. 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 and should be read in conjunction with detailed logs.
3. Surface level are approximate only and were estimated based on the Details and Levels Plan (By: Hammond Smeallie & Co Pty Ltd, DWG No: TZ Master Survey with Infrastructure_MGA, Revision B, Dated 8/8/2017).
4. Proposed building extents and levels were estimated based on the Schematic Design Architectural Drawings (By: DWP Australia Pty Ltd, Project No. RACC 20-0527).

ROCK STRENGTH

M - Medium
H - High
VH- Very High

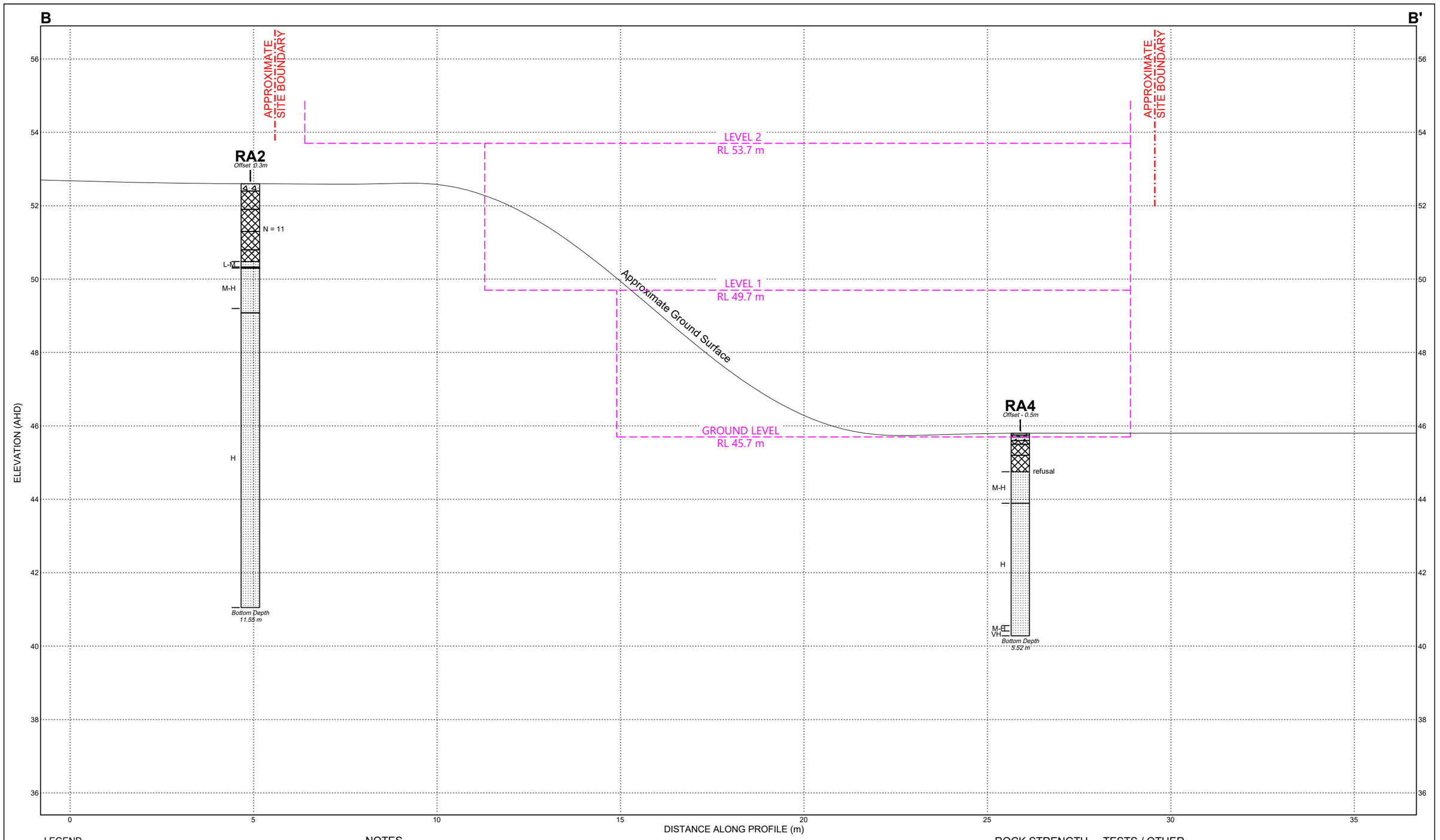
TESTS / OTHER

N - Standard penetration test value
— ? — — - Interpreted geotechnical boundary

0 2
Horizontal Scale (metres)
Natural Scale

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Taronga Conservation Society Australia		TITLE: **Geotechnical Cross Section A-A'**	PROJECT No: 99931.00
OFFICE: Sydney	DRAWN BY: MG	**Taronga Reptile and Amphibian Conservation Centre**	DRAWING No: R2
SCALE: 1:100 (H) 1:100 (V) @ A3	DATE: 06.07.2021	**Taronga Zoo, Mosman**	REVISION: 1



LEGEND

- Core Loss
- Concrete
- Filling
- Pavers
- Sandstone

NOTES

1. Subsurface conditions are accurate at the borehole locations only. 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 and should be read in conjunction with detailed logs.
3. Surface level are approximate only and were estimated based on the Details and Levels Plan (By: Hammond Smeallie & Co Pty Ltd, DWG No: TZ Master Survey with Infrastructure_MGA, Revision B, Dated 8/8/2017).
4. Proposed building extents and levels were estimated based on the Schematic Design Architectural Drawings (By: DWP Australia Pty Ltd, Project No. RACC 20-0527).

ROCK STRENGTH

- L - Low
- M - Medium
- H - High
- VH- Very High

TESTS / OTHER

- N - Standard penetration test value
- — ? — — - Interpreted geotechnical boundary

Horizontal Scale (metres)
0 2
Natural Scale

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Taronga Conservation Society Australia		TITLE: **Geotechnical Cross Section B-B'**	PROJECT No: 99931.00
OFFICE: Sydney	DRAWN BY: MG	**Taronga Reptile and Amphibian Conservation Centre**	DRAWING No: R3
SCALE: 1:100 (H) 1:100 (V) @ A3	DATE: 06.07.2021	**Taronga Zoo, Mosman**	REVISION: 1

Appendix C

Results of Field Work

Sampling Methods

Douglas Partners

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.

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 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:

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

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

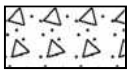
Symbols & Abbreviations

Graphic Symbols for Soil and Rock

General


Asphalt


Road base

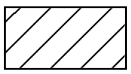

Concrete


Filling

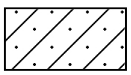
Soils


Topsoil

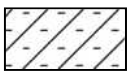

Peat

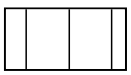

Clay

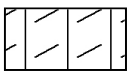

Silty clay

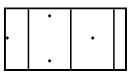

Sandy clay

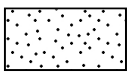

Gravelly clay

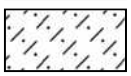

Shaly clay

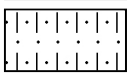

Silt


Clayey silt

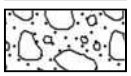

Sandy silt

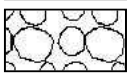

Sand

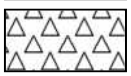

Clayey sand


Silty sand


Gravel


Sandy gravel


Cobbles, boulders

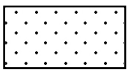

Talus

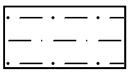
Sedimentary Rocks

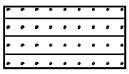

Boulder conglomerate

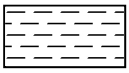

Conglomerate


Conglomeratic sandstone

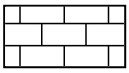

Sandstone


Siltstone

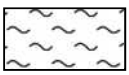

Laminite

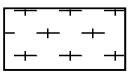

Mudstone, claystone, shale


Coal


Limestone

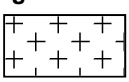
Metamorphic Rocks

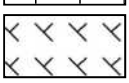

Slate, phyllite, schist

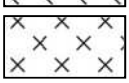

Gneiss

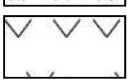

Quartzite

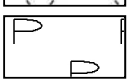
Igneous Rocks


Granite


Dolerite, basalt, andesite


Dacite, epidote


Tuff, breccia


Porphyry

BOREHOLE LOG

CLIENT: Taronga Conservation Society Australia
PROJECT: Reptile and Amphibian Project
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 52.7 AHD
EASTING: 337342
NORTHING: 6253797
DIP/AZIMUTH: 90°/--

BORE No: RA1
PROJECT No: 99931.00
DATE: 18/1/2021
SHEET 1 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
52	0.19	ASPHALTIC WEARING COURSE over CONCRETE										
		FILL/Gravelly SAND: fine, grey, fine sandstone gravel, with silt, trace ash, dry, apparently medium dense							A/E			PID<1 ppm
	0.7	FILL/Gravelly SAND: fine to medium, brown, fine sandstone gravel, trace silt, trace ash, dry, apparently medium dense							A/E*			PID<1 ppm
51	1								S/E			3,3,3 N = 6
									A/E			PID<1 ppm
	1.6	FILL/SAND: fine to medium, orange, moist, apparently medium dense							A/E			PID<1 ppm
	2											
	2.1	SANDSTONE: medium to coarse grained, red-brown, medium then high strength, moderately weathered, fractured, Hawkesbury Sandstone						2.3m: CORE LOSS: 130mm	C	68	68	PL(A) = 0.9
50	2.43							2.58m: B0°,pl, ro, cly vn				PL(A) = 1.4
	2.97	SANDSTONE: medium to coarse grained, pale grey, high strength, fresh, slightly fractured, Hawkesbury Sandstone										PL(A) = 1.5
	3							3.48m: B0°, pl, ro, cly co 1mm				
49								3.88m: Ds, 20mm	C	100	99	
	4											PL(A) = 0.7
48		4.64m-4.74m: fine grained, medium to high strength band						4.74m: B0°, pl, ro, cly co 1mm				
	5											PL(A) = 1.4
47	6											
	6.0	SANDSTONE: medium grained, pale grey, high strength, fresh, slightly fractured, Hawkesbury Sandstone						>>				PL(A) = 1.7
46	7								C	100	100	
												PL(A) = 1.4
45	8											
44	9							9m: B0°, pl, ro, cly vn				PL(A) = 1.5
	9.34	SANDSTONE: *as below*						9.34m: J60°, cu, sm, cln	C	100	97	PL(A) = 1.8
43								9.43m: B0°, pl, sm, cly co 5mm				PL(A) = 0.5
								9.54m: B0°, pl, sm, cly vn				PL(A) = 1.1

RIG: Hanjin D8 **DRILLER:** Hagstrom **LOGGED:** KR **CASING:** HQ to 2.1m

TYPE OF BORING: Solid flight auger (TC-bit) to 2.10m, NMLC drilling to 12.00m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: *Blind duplicate taken at 0.8-1.0m (BD6/20210118).

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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BOREHOLE LOG

CLIENT: Taronga Conservation Society Australia
PROJECT: Reptile and Amphibian Project
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 52.7 AHD
EASTING: 337342
NORTHING: 6253797
DIP/AZIMUTH: 90°/--

BORE No: RA1
PROJECT No: 99931.00
DATE: 18/1/2021
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)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
42		SANDSTONE: medium grained with siltstone clasts and bands, pale grey and dark grey, high strength, fresh, slightly fractured, Hawkesbury Sandstone *(continued)*							C	100	97	PL(A) = 1.1
	10.63											
41	11	SANDSTONE: medium to coarse grained, pale grey, high strength, fresh, slightly fractured, Hawkesbury Sandstone										PL(A) = 1.8
									C	100	100	
40	12 12.0	Bore discontinued at 12.0m - Target depth reached										
39	13											
38	14											
37	15											
36	16											
35	17											
34	18											
33	19											

RIG: Hanjin D8 **DRILLER:** Hagstrom **LOGGED:** KR **CASING:** HQ to 2.1m

TYPE OF BORING: Solid flight auger (TC-bit) to 2.10m, NMLC drilling to 12.00m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: *Blind duplicate taken at 0.8-1.0m (BD6/20210118).

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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BORE: RA1 PROJECT: TARONGA JANUARY 2021

2.10 – 6. 00m

BORE: RA1 PROJECT: TARONGA JANUARY 2021

6.00 – 11.00m

BORE: RA1 PROJECT: TARONGA JANUARY 2021

11.00-12.00m

BOREHOLE LOG

CLIENT: Taronga Conservation Society Australia
PROJECT: Reptile and Amphibian Project
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 52.6 AHD
EASTING: 337375
NORTHING: 6253801
DIP/AZIMUTH: 90°/--

BORE No: RA2
PROJECT No: 99931.00
DATE: 19/1/2021
SHEET 1 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
52	0.2	ASPHALTIC WEARING COURSE over CONCRETE										
		FILL/Silty SAND: fine, pale-brown, with sandstone gravel, trace ash, dry, apparently medium dense to dense							A/E			PID<1 ppm
	0.7											
51	1	FILL/SAND: fine, red-brown, with sandstone gravel, silt, trace ash, dry, apparently medium dense to dense							A/E*			PID<1 ppm
									S/E			4,5,6 N = 11
	1.3								A/E			PID<1 ppm
		FILL/SAND: fine to medium, brown, with sandstone gravel, ash, moist, apparently dense										PID<1 ppm
50	1.8								A/E			PID<1 ppm
	2											
	2.12	FILL/Silty SAND: fine to medium, dark brown, with clay, trace fine sandstone gravel, moist, apparently dense						2.23m: B0°, pl, ro, cln	C	92	63	
	2.27							2.27m: CORE LOSS: 30mm				PL(A) = 0.8
	2.3							2.37m: B5°, ir, ro, cly vn				
		SANDSTONE: medium to coarse grained, yellow-brown, medium to high strength, moderately weathered, fractured, Hawkesbury Sandstone										
49	3											PL(A) = 0.8
	3.52	2.23-2.27m: low strength band						3.29m: B0°, pl, ro, cly co 10mm				
		SANDSTONE: medium grained, pale grey, high strength, fresh, slightly fractured to unbroken, Hawkesbury Sandstone						3.37m: Cs, 30mm				
	4								C	100	96	PL(A) = 1.4
48								4.13m: B0°, pl, ro, cly co 2mm				
								4.14m: B0°, pl, ro, cly co 2mm				
								4.7m: B0°, pl, ro, fe stn				
	5											
47												PL(A) = 1
	6											
46												
	7								C	100	99	PL(A) = 1.1
												PL(A) = 1.5
45								7.76m: Ds, 40mm				
	8											PL(A) = 1.3
44												
	9								C	100	98	
								9.31m: B0°, pl, ro, cly co 5mm				PL(A) = 1.7
43								9.35m: B0°, pl, ro, cly co 10mm				

RIG: Hanjin D8 **DRILLER:** Hagstrom **LOGGED:** KR **CASING:** HQ to 2.1m

TYPE OF BORING: Solid flight auger (TC-bit) to 2.12m, NMLC drilling to 11.55m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: *Blind duplicate taken at 0.8-1.0m (BD7/20210119).

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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BOREHOLE LOG

CLIENT: Taronga Conservation Society Australia
PROJECT: Reptile and Amphibian Project
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 52.6 AHD
EASTING: 337375
NORTHING: 6253801
DIP/AZIMUTH: 90°/--

BORE No: RA2
PROJECT No: 99931.00
DATE: 19/1/2021
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)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
42	11	SANDSTONE: medium grained, pale grey, high strength, fresh, slightly fractured to unbroken, Hawkesbury Sandstone *(continued)*							C	100	98	PL(A) = 1.7 PL(A) = 1.5
41	11.55	Bore discontinued at 11.55m - Target depth reached										
41	12											
40	13											
39	14											
38	15											
37	16											
36	17											
35	18											
34	19											
33												

RIG: Hanjin D8 **DRILLER:** Hagstrom **LOGGED:** KR **CASING:** HQ to 2.1m

TYPE OF BORING: Solid flight auger (TC-bit) to 2.12m, NMLC drilling to 11.55m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: *Blind duplicate taken at 0.8-1.0m (BD7/20210119).

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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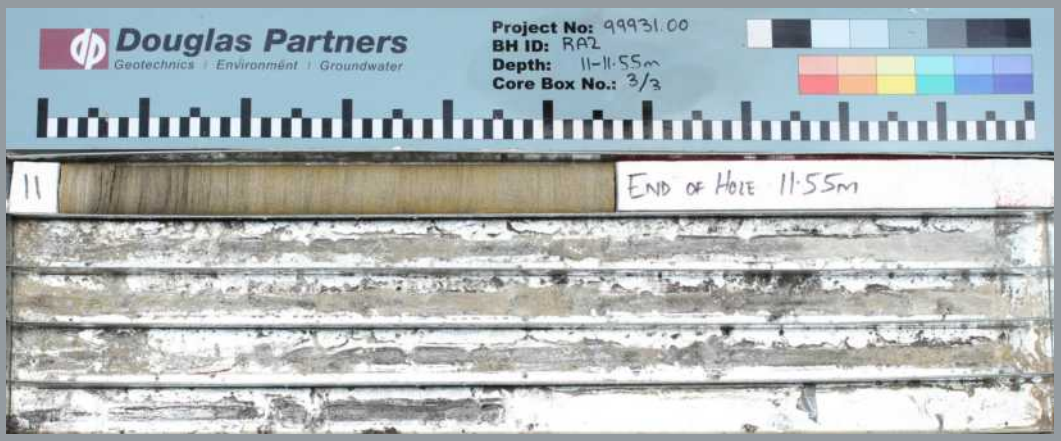
BORE: RA2 PROJECT: TARONGA JANUARY 2021

2.12 – 6. 00m

BORE: RA2 PROJECT: TARONGA JANUARY 2021

6.00 – 11.00m

BORE: RA2 PROJECT: TARONGA JANUARY 2021



11.00-11.55m

BOREHOLE LOG

CLIENT: Taronga Conservation Society Australia
PROJECT: Reptile and Amphibian Project
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 45.6 AHD
EASTING: 337359
NORTHING: 6253777
DIP/AZIMUTH: 90°/--

BORE No: RA3
PROJECT No: 99931.00
DATE: 20/1/2021
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Degree of Weathering	Graphic Log	Rock Strength	Water	Fracture Spacing (m)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
45	0.05	SYNTHETIC GRASS AND FOAM							A/E*			PID<1 ppm
	0.2	FILL/Gravelly SAND: fine to medium, yellow-brown, fine igneous gravel, moist							A/E			PID<1 ppm
	0.5	FILL/Clayey SAND: fine to medium, dark brown, with silt, moist, apparently medium dense							A/E*			PID<1 ppm
1	1.1	FILL/Silty CLAY: low to medium plasticity, pale grey mottled pale yellow, with fine sand, w~PL, apparently stiff Below 1.0m: w>PL							A/E S			PID<1 ppm 1/100,B refusal
44								1.21m: B0°, pl, ro, cly co 5mm				PID<1 ppm
2	2.11	SANDSTONE: medium to coarse grained, red-brown, medium to high strength, moderately weathered, unbroken, Hawkesbury Sandstone							C	100	100	PL(A) = 1 PL(A) = 1.2
43		SANDSTONE: medium to coarse grained, pale grey, high strength, fresh, slightly fractured, Hawkesbury Sandstone						2.83m: Cs, 30mm 3.03m: B0° pl, ro, cly co 5mm				PL(A) = 1.5
3												
42		3.86-3.96m: siltstone clasts						3.99m: B0°, pl, ro, cly co 2mm	C	100	100	
4												PL(A) = 1.7
41												PL(A) = 2.2
5												
40	5.54	Bore discontinued at 5.54m - Target depth reached										
6												
39												
7												
38												
8												
37												
9												
36												

RIG: Hanjin D8 **DRILLER:** Hagstrom **LOGGED:** KR **CASING:** HQ to 1.1m

TYPE OF BORING: Solid flight auger (TC-bit) to 1.10m, NMLC drilling to 5.54m

WATER OBSERVATIONS: Clayey fill moisture content greater than plastic limit below 1.0m depth

REMARKS: *Blind duplicates taken at 0.1-0.2m (BD8/20210120) and 0.5-0.6m (BD9/20210120)

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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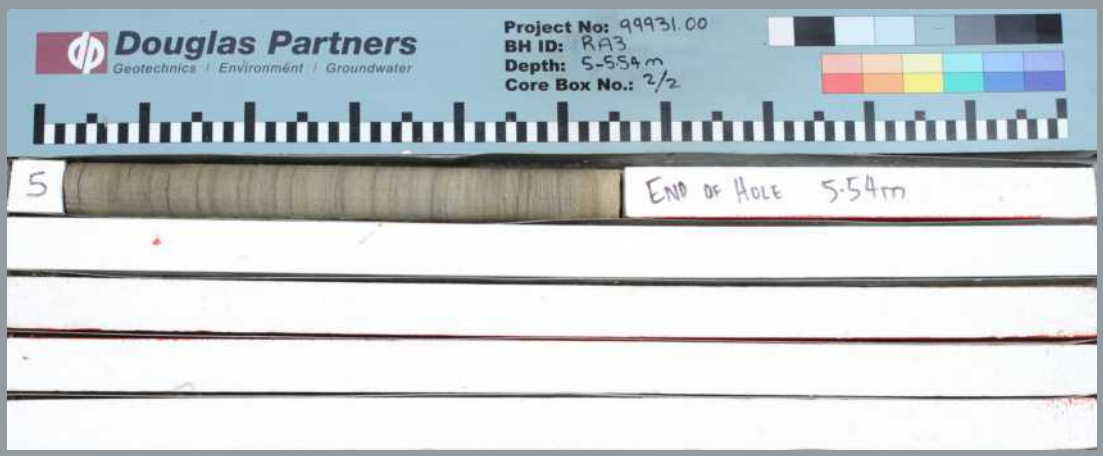
BORE: RA3 PROJECT: TARONGA JANUARY 2021

1.10 – 5. 00m

BORE: RA3 PROJECT: TARONGA JANUARY 2021



5.00 – 5.54m

BOREHOLE LOG

CLIENT: Taronga Conservation Society Australia
PROJECT: Reptile and Amphibian Project
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 45.8 AHD
EASTING: 337375
NORTHING: 6253780
DIP/AZIMUTH: 90°/--

BORE No: RA4
PROJECT No: 99931.00
DATE: 19/1/2021
SHEET 1 OF 1

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)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
45	0.05	PAVERS										
	0.1	FILL/SAND: fine to medium, orange, moist							A/E*			PID<1 ppm
	0.2								A/E			PID<1 ppm
	0.3	CONCRETE										
	0.6	FILL/SAND: fine to medium, grey, with fine igneous gravel, moist										
1	1.05	FILL/Clayey SAND: fine to medium, dark brown, with silt, moist							A/E			PID<1 ppm
									S			3/5,B refusal
		FILL/Silty CLAY: low to medium plasticity, pale grey mottled pale yellow, with fine sand, w~PL, apparently stiff										PID<1 ppm
44												PL(A) = 0.9
												PL(A) = 0.9
									C	100	100	
2	1.91	SANDSTONE: medium to coarse grained, red-brown, medium to high strength, moderately weathered, unbroken, Hawkesbury Sandstone										PL(A) = 1.4
												PL(A) = 1
43		SANDSTONE: medium to coarse grained, pale grey, high strength, fresh, slightly fractured, Hawkesbury Sandstone						2.62m: B0°, pl, ro, cly co 5mm				
3												
42												PL(A) = 1.4
4									C	100	100	
								4.22m: B0°, pl, ro, cly co 1mm				
41												PL(A) = 1.6
5												
												PL(A) = 0.9
	5.52	5.39-5.52m: massive sandstone, very high strength										PL(A) = 5.9
40		Bore discontinued at 5.52m - Target depth reached										
6												
39												
7												
38												
8												
37												
9												
36												

RIG: Hanjin D8 **DRILLER:** Hagstrom **LOGGED:** KR **CASING:** HQ to 1.0m

TYPE OF BORING: Solid flight auger (TC-bit) to 1.05m, NMLC drilling to 5.52m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: *No sample taken for asbestos testing at 0.2-0.3m.

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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BORE: RA4 PROJECT: TARONGA JANUARY 2021

1.05 – 5.00m

BORE: RA4 PROJECT: TARONGA JANUARY 2021

5.00 – 5.52m

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
96 Hermitage Road
West Ryde NSW 2114
PO Box 472
West Ryde NSW 1685
Phone (02) 9809 0666
Fax (02) 9809 4095

Results of Dynamic Penetrometer Tests

Client Taronga Conservation Society Australia
Project MOSMAN Taronga Zoo – Reptile and Amphibian
Location Bradleys Head Road, MOSMAN

Project No. 99931.00
Date 20-21/01/2021
Page No. 1 of 1

Test Locations	RA5	RA6	RA7	RA8	RA9				
RL of Test (AHD)	50.1*	51.3*	51.8*	47.5	48.0				
Depth (m)	**Penetration Resistance** Blows/150 mm								
0.00 – 0.15	4	1	3	3	1				
0.15 – 0.30	6	10	12	8	10				
0.30 – 0.45	B	11	14	11	19				
0.45 – 0.60		5	18	8	17/120				
0.60 – 0.75		7	14	10	B				
0.75 – 0.90		7	9	11					
0.90 – 1.05		9	14	43					
1.05 – 1.20		10	20	11					
1.20 – 1.35		11	23	8					
1.35 – 1.50		18	26	43					
1.50 – 1.65		9/50	17	18					
1.65 – 1.80		B	33	8					
1.80 – 1.95			23	12					
1.95 – 2.10			40	32					
2.10 – 2.25			R	27					
2.25 – 2.40				24					
2.40 – 2.55				B					
2.55 – 2.70									
2.70 – 2.85									
2.85 – 3.00									
3.00 – 3.15									
3.15 – 3.30									
3.30 – 3.45									

Test Method AS 12829.6.3.2, Cone Penetrometer ☑ **Tested By** KR
Remarks B = Bouncing, D = Discontinued, R = Refusal **Checked By** SB

50 / 100 indicates 50 blows for 100 mm penetration, * Level approximate only - interference from nearby structures prevented accurate dGPD reading.

Appendix D

Laboratory Test Results

Misc Inorg - Soil					
Our Reference		260040-3	260040-8	260040-9	260040-12
Your Reference	UNITS	RA1	RA3	RA3	RA4
Depth		1.4-1.5	0.5-0.6	0.9-1.0	0.9-1.0
Date Sampled		18/01/2021	20/01/2021	20/01/2021	19/01/2021
Type of sample		SOIL	SOIL	SOIL	SOIL
Date prepared	-	25/01/2021	25/01/2021	25/01/2021	25/01/2021
Date analysed	-	25/01/2021	25/01/2021	25/01/2021	25/01/2021
pH 1:5 soil:water	pH Units	7.9	9.0	9.6	8.2
Total Organic Carbon (Walkley Black)	mg/kg	3,800	1,300	[NA]	[NA]
Electrical Conductivity 1:5 soil:water	µS/cm	[NA]	[NA]	410	600
Chloride, Cl 1:5 soil:water	mg/kg	[NA]	[NA]	290	710
Sulphate, SO4 1:5 soil:water	mg/kg	[NA]	[NA]	120	33