Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Preliminary Geotechnical Investigation

Congo Precinct, Taronga Zoological Park
Bradleys Head Road, Mosman

Prepared for
Taronga Conservation Society Australia

Project 85538.00
August 2016

Douglas Partners
Geotechnics / Environment / Groundwater

Document History

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

	Signature	Date
Author		16/8/16
Reviewer		16 Aug 2016

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Report on Preliminary Geotechnical Investigation
Congo Precinct, Taronga Zoological Park
Bradleys Head Road, Mosman

1. Introduction

The report describes the results of a geotechnical investigation undertaken for the Congo precinct at Taronga Zoological Park at Bradley Head Road, Mosman. The work was undertaken for the Taronga Conservation Society Australia.

It is understood that new facilities and animal exhibits are being considered and that preliminary information is required for planning and design purposes. As such there are no details of the development layout including excavation depth and footing requirements.

Geotechnical investigation was undertaken to provide information on subsurface conditions on the site and included the drilling of twenty-five boreholes to the top of rock and site observations of rock outcrops. Details of the field work and comments relating to design and construction are provided in this report.

The geotechnical investigation was carried out concurrently with a contamination assessment which is reported separately.

2. Site Description and Geology

The area of the proposed Congo precinct is centrally located within Taronga Zoo and is boarded by the Koala Walkabout in the north, the cassowary enclosure in the east, lemur and gorilla enclosures in the south and the Giraffe enclosure and Taronga food market in the West. The site has been presented in Drawing 1, Appendix B.

The site is located on the southern side of a steep slope that dips towards Athol Bay. The site has been extensively terraced and numerous retaining walls provide level areas which house exhibits and walking paths/roadways. Many sandstone rock faces and cuttings are evident on the wider zoo site. The surface levels in the area of the proposed development vary from about RL 67 m relative to the Australian Height Datum (AHD) in the north portion to about RL 48 m AHD in the south.

The area experiences high pedestrian traffic and occasional use by service vehicles. Extensive underground services are present in this area, particularly within the footpath or along the pavement curb, with manholes, hatches observed at the time of field work.

The Sydney 1:100 000 Geological Series Sheet shows that the site underlain by Hawkesbury Sandstone which typically comprises medium to coarse-grained quartz sandstone with minor shale and laminite lenses.

3. Site Observations

A site walkover and mapping of rock outcrops was undertaken with the results shown graphically on Drawing 2 in Appendix B. Site specific observations together with site photographs are presented in Appendix C.

The site is located on a Hawkesbury Sandstone slope, typical of the Sydney region. Over geological time, the sandstone cuttings were exposed to the weather and the seawater environment. The results are erosion of the sandstone faces, often resulting in undercutting of sandstone beds, collapse of the overhangs onto the underlying ledges. Hawkesbury Sandstone tends to form a series of cliffs and ledges. Colluvial material washed down from upslope tends to accumulate on the ledges together with fallen sandstone blocks forming a wedge between the cliff and ledges. The wedge material is commonly called talus.

Development of the site, however, has seen most of the Congo precinct worked so as to produce relatively level or landscaped enclosures. This has involved, among other activities, levelling the ground, removal of some talus, some filling on other areas, landscaping, construction of retaining walls using sandstone boulders and blocks, shotcreting some weathered sandstone faces and localised excavation, etc.

The main observations on the site are:

- The site is considered typical of a Hawkesbury Sandstone topography with the bedrock forming a number of cliffs and ledges;
- In the developed areas, the site has been reworked. A typical profile appears to be with shallow depth of soil, expected to be mainly filling, overlying sandstone;
- Many retaining walls have been constructed on rock ledges or on top of cliffs to provide level benches;
- The sandstone exposed in the outcrop and cliffs tends to be medium to high strength. Areas covered by shotcrete probably consist of low strength sandstone;
- Water seepage over the top of rock and through bedding partings and joints below top of rock is common.

4. Field Work Methods

Twenty-five boreholes (C01 to C26 except C11) were drilled to depths ranging from 0.5 m to 1.8 m using a bobcat drilling rig or a hand auger. The bores were commenced using solid flight augers or a hand auger to drill through the overburden material. The borehole would then be terminated near the top of the rock strata or prior refusal. The materials observed in the boreholes were logged by a geotechnical engineer.

The locations of the boreholes are shown in Drawing 1 in Appendix B. The ground surface levels at the test locations were approximated from the survey plan, provided by the client.

5. Field Work Results

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

The boreholes encountered:

- **Filling** – asphalt and concrete surfacing, roadbase, buried paths and silty and sandy filling; over
- **Natural Soil** – sand and clayey sand to depths of 0.8 m to1.5 m in Bores C08, C10A, C19 and C20;
- **Bedrock** – sandstone bedrock generally initially of extremely low strength from depths 0.2 m to over 1.5 m increasing in strength with depth.

Rock and natural soil were not encountered in all bores.

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

Table 1: Summary of Material Strata Level in Boreholes

Bore	RL of Top of Stratum (m, AHD)			
	Ground Surface	Natural Soil	Sandstone	Base of Borehole
C01	59.3	NE	58.1	58.1
C02	58.9	NE	58.0	58.0
C03	58.5	NE	56.9	56.9
C04	58.0	NE	57.5	57.5
C05	63.8	NE	63.7	63.5
C06	65.6	NE	NE	NE
C07	57.1	NE	56.6	56.2
C08	51.1	49.6	49.4	49.4
C09	49.3	NE	NE	48.1
C10	51.0	NE	NE	NE
C10A	51.0	50.2	49.8	49.5
C12	64.8	NE	64.4	64.4
C13	64.9	NE	64.3	64.3
C14	62.3	NE	61.9	61.8
C15	64.9	NE	64.4	64.4
C16	62.3	NE	62.0	61.9

Bore	RL of Top of Stratum (m, AHD)			
	Ground Surface	Natural Soil	Sandstone	Base of Borehole
C17	59.2	NE	NE	58.1
C18	57.5	NE	56.9	56.5
C19	51.6	50.7	50.2	50.2
C20	51.6	50.9	50.5	50.5
C21	55.4	NE	NE	50.0
C22	48.3	NE	48.0	48.0
C23	48.3	NE	48.0	48.0
C24	48.3	NE	47.7	47.7
C25	48.3	NE	NE	48.1
C26	53.8	NE	53.1	53.1

Notes: ELS = extremely low strength; NE = not encountered

Seepage or ground water was not observed during auguring in the boreholes. A cross-section of the site is shown on Drawing 3 in Appendix B.

6. Geotechnical Model

The boreholes, located in developed areas, indicate that the site is underlain by filling and natural clayey sand and sand over Hawkesbury Sandstone bedrock. The filling in the bores was generally less than 1 m thick, but this may vary over the site. There is also remnant talus left under the filling in some locations. The bedrock, which is exposed at the surface in some locations, and in the cliffs, steps down with the surface slope towards Athol Bay, so rock levels are likely to vary over short distances. Buried sandstone is likely to have a thin veneer of weathered material over medium to high strength sandstone.

The site observations confirm the presence of rock ledges and cliffs down the site.

7. Proposed Development

It is understood that the area is being considered for redevelopment and that preliminary information is required for planning and design purposes. Details of the proposed construction including excavation depths and footing requirements are yet to be finalised.

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

8. Comments

8.1 Excavation

Excavation for the proposed redevelopment, may be required within the filling, natural soils and sandstone bedrock. Excavation in filling, soils and extremely low strength sandstone should be readily achievable using an excavator with bucket attachment.

Excavation in sandstone, expected to be mainly in medium and high strength rock, will probably require ripping, hammering and / or sawing.

8.2 Excavation Support

Excavations in filling, soils and weathered rock 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(H):1(V) is recommended for excavations of up to about 2 m depth in these materials provided they are protected against erosion. Permanent batters should be flattened to no steeper than 2(H):1(V).

Medium and high strength rock should be able to stand vertically provided adverse jointing is not present.

Retaining walls (temporary and or permanent) may be required in some areas of the site and could be designed using the material and strength parameters outlined in Table 2.

Table 2: General Material and Strength Parameters for Retaining Structures

Material	Bulk Unit Weight (kN/m^3)	Coefficient of Active Earth Pressure (K_a)	Coefficient of Earth pressure at Rest (K_0)	Ultimate Passive Earth Pressure (kPa)
Filling	20	0.4	0.6	
Natural Soil	20	0.3	0.45	
ELS Sandstone	22	0.2[1]	0.3[1]	750[2]
LS/MS/HS Sandstone	22	0[1]	0[1]	3000[2]

Notes: [1] Unless unfavourable jointed;
[2] Only below ground level and where jointing is favourable;
ELS = extremely low strength; LS = low strength; MS = medium strength; HS = high strength.

A triangular lateral earth pressure distribution could be assumed for cantilevered walls, and a rectangular lateral earth pressure distribution for walls propped at their top and base. 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.

8.3 Slope Stability

The overall site is located on a slope which has generally been landscaped for its present use. It is generally underlain by a thin layer of filling (approximately 0.5 m to 1.5 m deep) overlying a stepping sandstone profile. The slope is considered to have a low risk of major slope instability. Excavations will need to be battered or retained in accordance to Section 8.2 to reduce the risk of localised slope instability.

8.4 Site Preparation

Areas of the site that require filling to raise site levels should be stripped of vegetation and existing filling materials prior to proof-rolling with a minimum 10 t steel smooth drum roller. 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 sandstone bedrock.

Approved filling should then be placed on the prepared subgrade in 250mm thick layers and 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 of at least 95% relative to Standard compaction in areas that are not required to support structures or pavements. The moisture content of the filling 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 non-structural and unpaved areas where filling and excavation are not required such as in animal enclosures, it would be prudent to proof roll the areas to detect any soft spots which require repairs. Some moisture conditioning and compaction of the surface may be required.

8.5 Groundwater

The regional groundwater table is expected to be well below the bedrock surface and flow in a southerly direction towards Athol Bay. However, seepage through and along strata boundaries and jointing in the rock should be expected and this should be considered in the design of the drainage systems on the site. There was a significant amount of seepage over rock faces observed on the site during the site visit.

8.6 Foundations

Due to relatively shallow depth of rock on the site it is recommended that all new structure be founded on the sandstone bedrock on spread footings (e.g. pad footings and strip footings) or on short bored piles. The footings and piles could be designed using the design bearing pressures and shaft adhesions provided in Table 3.

Table 3: Preliminary Design Parameters for Spread Footing and Bored Piles.

Material Description	Allowable End-Bearing Pressure (kPa)	Allowable Shaft Adhesion[1] (kPa)
ELS Sandstone	700	50
LS/MS/HS Sandstone	3000	300

Notes: [1] Only for piles where adequate socket-roughness has been achieved;
ELS = extremely low strength; MS = medium strength; HS = high strength

Higher bearing pressures for the sandstone bedrock are possible based on the strength of the rock outcrops, but would require further investigations and some rock strength testing to justify the higher parameters.

The settlement of a footing is dependent on the dimension of the footing, the load applied and the underlying foundation conditions. Spread footings and piles designed using the information contained in this report should experience settlement of less than 10 mm upon application of the design load.

All new footings should be inspected by an experienced geotechnical professional to check the suitability of foundation material. Additionally in the case of bored piles the socket roughness and the base cleanliness should be checked.

8.7 Pavements

Each pavement area should be individually assessed based on the subsurface profile and the loading. For lightly loaded pavements on the existing filling, it may be possible to found on the filling after a satisfactory proof roll. For heavy loaded pavements, some treatment of the underlying filling may be required before the pavement is constructed.

8.8 Further Investigation

The above comments are preliminary in nature as detailed proposal for the site is unknown. When the layouts are known further investigation may be required for detailed design purposes.

9. Limitations

Douglas Partners (DP) has prepared this report for this project at Bradleys Head Road, Mosman in accordance with DP's proposal dated 7 April 2016 and acceptance received from Mr Andrew Chippindall. The work was carried out under DP's Conditions of Engagement. The report is provided for the use of the Taronga Conservation Society Australia for this project only and for the purpose(s) described in the report. It should not be used for other projects or by a third party.

The results provided in the report are indicative of the sub-surface conditions only at the specific sampling or testing locations, and then only to the depths investigated and at the time the work was carried out. Subsurface conditions can change abruptly due to variable geological processes and also

as a result of anthropogenic influences. Such changes may occur after DPs field testing has been completed.

DPs advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be limited by undetected variations in ground conditions between sampling locations. The advice may also be limited by budget constraints imposed by others or by site accessibility. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

This report must be read in conjunction with all of the attached notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by a statement, interpretation, outcome or conclusion given 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.

Douglas Partners Pty Ltd

Appendix A

About this Report

About this Report

Douglas Partners

Introduction

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

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

Copyright

Borehole and Test Pit Logs

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

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

Groundwater

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

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

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

Reports

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

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

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

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

About this Report

Site Anomalies

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

Information for Contractual Purposes

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

Site Inspection

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

Appendix B

Drawings

0 10 20 30 40 50 75 100m

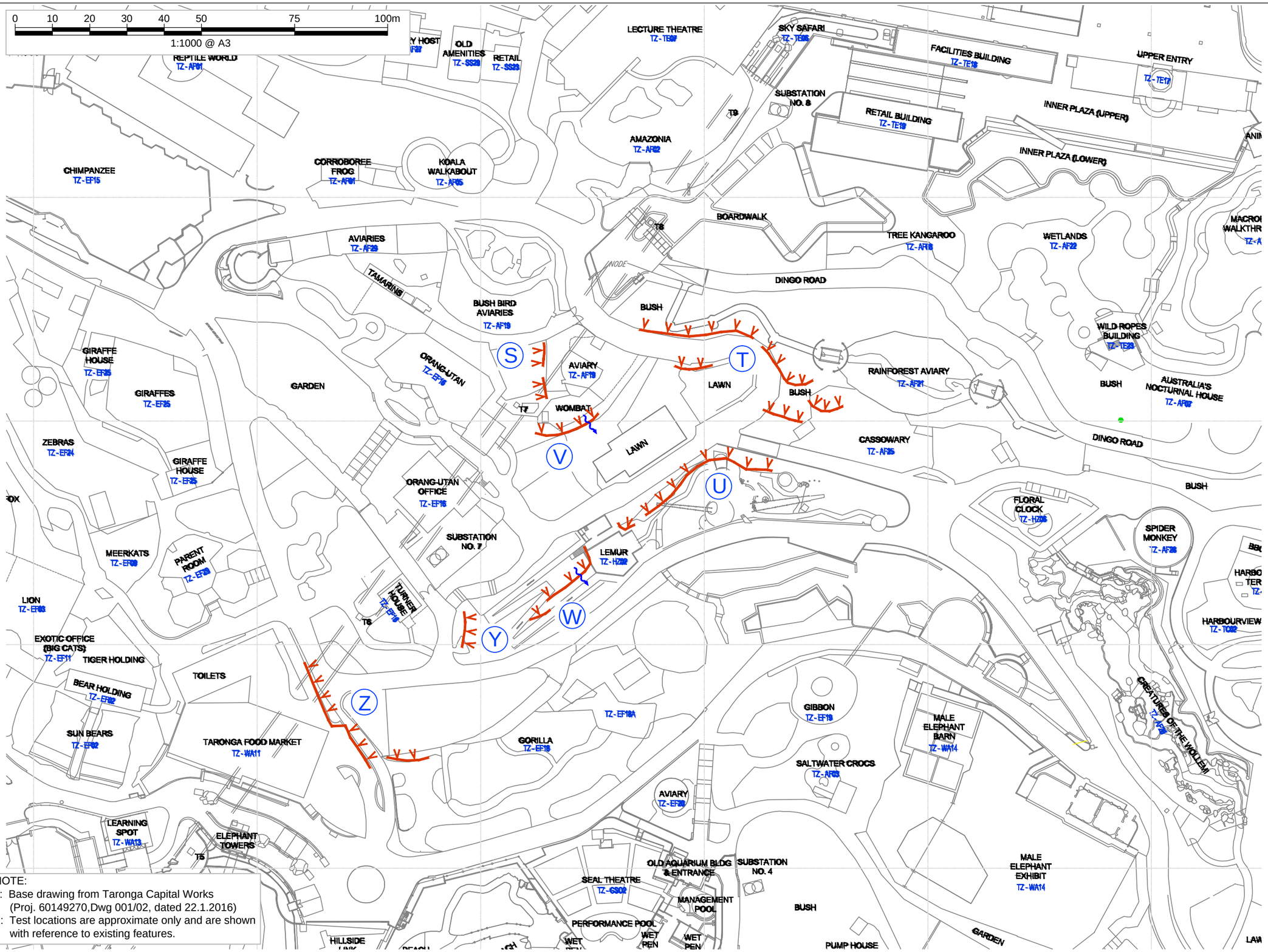
1:1000 @ A3

Locality Plan

NOTE:
1: Base drawing from Taronga Capital Works (Proj. 60149270,Dwg 001/02, dated 22.1.2016)
2: Test locations are approximate only and are shown with reference to existing features.

LEGEND
- Borehole location
- A A' Geotechnical Cross Section A-A'

Douglas Partners Geotechnics / Environment / Groundwater	CLIENT: Taronga Conservation Society Australia	TITLE: **Location of Tests** **Congo Precinct** **Bradleys Head Raod, MOSMAN**	PROJECT No: 85538.00
	OFFICE: Sydney DRAWN BY: PSCH		DRAWING No: 1
	SCALE: 1:1000 @ A3 DATE: 22.7.2016		REVISION: 0



NOTE:
1: Base drawing from Taronga Capital Works (Proj. 60149270,Dwg 001/02, dated 22.1.2016)
2: Test locations are approximate only and are shown with reference to existing features.

LEGEND

- (A) Mapping location
- Outcrop
- (F) Floater
- Seepage

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CLIENT: Taronga Conservation Society Australia		TITLE: **Rock Outcrops**
OFFICE: Sydney	DRAWN BY: PSCH	**Congo Precinct**
SCALE: 1:1000 @ A3	DATE: 12.7.2016	**Bradleys Head Road, MOSMAN**

N

PROJECT No:	85538.00
DRAWING No:	2
REVISION:	0

A

A'

ELEVATION (AHD)

62
60
58
56
54
52
50
48
46
44
42

C01
Offset 1.7m
Bottom Depth 1.15 m

C02
Offset - 3.0m
Bottom Depth 0.9 m

C03
Offset 1.8m
Bottom Depth 1.6 m

C04
Offset - 0.8m
Bottom Depth 0.5 m

C07
Offset - 5.7m
VL
Bottom Depth 0.9 m

C08
Offset 0.5m
Bottom Depth 1.7 m

FILLING

SURFACE LEVEL

FILLING

FILLING

SANDSTONE

SANDSTONE

SANDSTONE

0 20 40 60 80 100 120 140

DISTANCE ALONG PROFILE (m)

NOTE:
1. Subsurface conditions are accurate at the borehole locations only and variations may occur away from the borehole locations.
2. Strata layers and rock classification shown is generalised and each layer can include bands of lower or higher strength rock and also bands of less or more fractured rock.
3. Summary logs only. Should be read in conjunction with detailed logs.

LEGEND

- Filling
- Clayey Sand
- Asphaltic Concrete
- Roadbase
- Sandstone fine grained

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

SOIL CONSISTENCY
vs - very soft
s - soft
f - firm
st - stiff
vst - very stiff
h - hard
vl - very loose
l - loose
md - medium dense
d - dense
vd - very dense

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

0 8
Horizontal Scale (metres)

Vertical Exaggeration = 4.0

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CLIENT: Taronga Zoo Conservation Society Australia	TITLE: **Cross-section A-A'**	PROJECT No: 85538.00
OFFICE: Sydney / DRAWN BY: AT/LD	**Congo Precinct**	DRAWING No: 3
SCALE: 1:400 (H) 1:100 (V) @ A3 / DATE: 28.07.2016	**Bradleys Head Road, Mosman**	REVISION: 0

Appendix C

Site Observations

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NOTES FROM WALKOVER

S. Aviarys – Sandstone and retaining wall covered with fig tree roots. See Photo 1

T. Road down: Filling placed around an overhanging piece of sandstone on upside of path and rock outcriop exposed blow the path. See Photos 2 and 3.

U. Play area: - The top of the sandstone cliff is covered with shotcrete. See Photo 4.

V. Wombat Enclosure: Sandstone is exposed below the enclosure with the top of the face covered with shotcrete. There is plenty of water seepage over the rock face from under the shotcrete. See Photo 5.

W. Below stairs: The sandstone outcrop is rounded with water seepage over some of the rock. See Photo 6. There is a vertical cut in the rock on the side of the stairs.

Y. Near Turner House: A mortared sandstone block retaining wqall constructed on top of sandstone. See Photo 7.

Z. Food area: Sandstone exposed in side of cutting adjacent to escalator and at back of food court. Some cement render is on top of rock cutting. Water seeping from below the cement render. See Photos 8 and 9.

Photo 1 – Rock outcrop with fig tree roots near Aviary

Photo 2 – Overhanging rock on roadway

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs** **Congo Precinct, Taronga Zoological Park** **Bradleys Head Road, Mosman**	PROJECT:	85538.00
		PLATE No:	1
		REV:	0
	CLIENT: Taronga Conservation Society Australia	DATE:	11 Aug 2016

Photo 3 – Rock outcrop below road

Photo 4 – Shotcrete over rock near playground

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs** **Congo Precinct, Taronga Zoological Park** **Bradleys Head Road, Mosman**	PROJECT:	85538.00
		PLATE No:	2
		REV:	0
	CLIENT: Taronga Conservation Society Australia	DATE:	11 Aug 2016

Photo 5 – Rock outcrop below wombat enclosure

Photo 6 – Rounded rock outcrop near Lemur enclosure

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs** **Congo Precinct, Taronga Zoological Park** **Bradleys Head Road, Mosman**	PROJECT:	85538.00
		PLATE No:	3
		REV:	0
	CLIENT: Taronga Conservation Society Australia	DATE:	11 Aug 2016

Photo 7 – Retaining wall founded on rock

Photo 8 – Cutting in rock near food court

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs** **Congo Precinct, Taronga Zoological Park** **Bradleys Head Road, Mosman**	PROJECT:	85538.00
		PLATE No:	4
		REV:	0
	CLIENT: Taronga Conservation Society Australia	DATE:	11 Aug 2016

Photo 9 – Rock outcrop near food court

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs** **Congo Precinct, Taronga Zoological Park** **Bradleys Head Road, Mosman**	PROJECT:	85538.00
		PLATE No:	5
		REV:	0
	CLIENT: Taronga Conservation Society Australia	DATE:	11 Aug 2016

Appendix D

Results of Field Work

Sampling

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

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

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

Test Pits

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

Large Diameter Augers

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

Continuous Spiral Flight Augers

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

Non-core Rotary Drilling

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

Continuous Core Drilling

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

Standard Penetration Tests

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

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

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

  15, 30/40 mm

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

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

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

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

Description and Classification Methods

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

Soil Types

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

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

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

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

The proportions of secondary constituents of soils are described as:

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

Definitions of grading terms used are:

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

Cohesive Soils

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

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

Cohesionless Soils

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

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

Soil Descriptions

Soil Origin

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

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

Transported soils may be further subdivided into:

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

Rock Strength

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

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

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

Degree of Weathering

The degree of weathering of rock is classified as follows:

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

Degree of Fracturing

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

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

Rock Descriptions

Rock Quality Designation

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

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

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

Stratification Spacing

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

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

Symbols & Abbreviations

Douglas Partners

Introduction

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

Drilling or Excavation Methods

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

Water

▷	Water seep
▽	Water level

Sampling and Testing

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

Description of Defects in Rock

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

Defect Type

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

Orientation

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

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

Coating or Infilling Term

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

Coating Descriptor

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

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

Graphic Symbols for Soil and Rock

General


Asphalt


Road base


Concrete


Filling

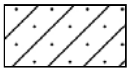
Soils


Topsoil

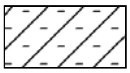

Peat


Clay

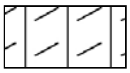

Silty clay

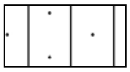

Sandy clay

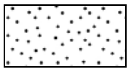

Gravelly clay

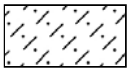

Shaly clay

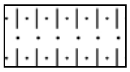

Silt


Clayey silt


Sandy silt


Sand

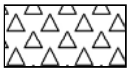

Clayey sand


Silty sand


Gravel


Sandy gravel


Cobbles, boulders

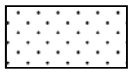

Talus

Sedimentary Rocks

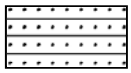

Boulder conglomerate

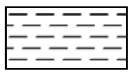

Conglomerate


Conglomeratic sandstone

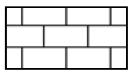

Sandstone


Siltstone


Laminite

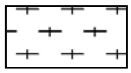

Mudstone, claystone, shale

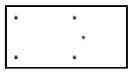

Coal


Limestone

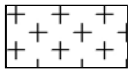
Metamorphic Rocks

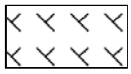

Slate, phyllite, schist

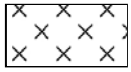

Gneiss

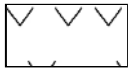

Quartzite

Igneous Rocks


Granite


Dolerite, basalt, andesite


Dacite, epidote


Tuff, breccia


Porphyry

BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 59.3 AHD
EASTING: 337349
NORTHING: 6253836
DIP/AZIMUTH: 90°/--

BORE No: C01
PROJECT No: 85538.00
DATE: 17/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
59	0.0	FILLING - moderately compacted, dark grey silty sand filling, traces of rootlets, organic odour (topsoil)		A/E	0.1 0.2	Dup1			
	0.3	FILLING - variably compacted, dark grey filling with crushed shell and sand filling, organic odour		A/E	0.5 0.6				
58	1.0	FILLING - variably compacted, light brown-grey medium sand filling with traces of silt and rootlets		A/E	1.0 1.1				
	1.15	Bore discontinued at 1.15m - refusal on sandstone							
57									
56									
55									

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3, 4

RIG: Bobcat **DRILLER:** GM **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger to 1.15m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ 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

BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 58.9 AHD
EASTING: 337344
NORTHING: 6253838
DIP/AZIMUTH: 90°/--

BORE No: C02
PROJECT No: 85538.00
DATE: 17/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
58	0	FILLING - apparently poorly to moderately compacted, dark grey sandy silt filling with traces of rootlets, crushed sandstone gravel, organic odour (topsoil)		A/E	0.1				
		0.2m: becoming silty sand							
	0.55	FILLING - apparently poorly to moderately compacted, brown-pale grey silty clay filling with traces of fine sand and rootlets		A/E	0.5				
	0.9	Bore discontinued at 0.9m - refusal on sandstone		A/E	0.9				
57	1								
56	2								
55	3								
54	4								

RIG: Bobcat **DRILLER:** GM **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger to 0.9m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ 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

BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 58.5 AHD
EASTING: 337333
NORTHING: 6253823
DIP/AZIMUTH: 90°/--

BORE No: C03
PROJECT No: 85538.00
DATE: 17/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
58	0.25	FILLING - apparently moderately compacted, dark brown silty sand filling with traces of fine sand and rootlets (topsoil)		A/E	0.1				
		FILLING - apparently moderately compacted, dark brown-grey sandy igneous gravel filling (possible coal?) with traces of brown clay		A/E	0.5				
	0.75	FILLING - variably compacted, pale grey medium sand filling with some concrete cobbles, some brown sand, moist		A/E	1.0	Dup2			
57	1.6			A/E	1.5				
		Bore discontinued at 1.6m - refusal on sandstone							
56									
55									
54									

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3, 4; >>

RIG: Bobcat **DRILLER:** GM **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger to 1.6m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ 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

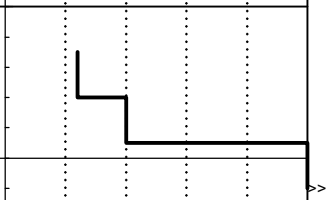
BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 58.0 AHD
EASTING: 337325
NORTHING: 6253820
DIP/AZIMUTH: 90°/--

BORE No: C04
PROJECT No: 85538.00
DATE: 17/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
58	0.2	FILLING - variably compacted, brown sandy silt filling with traces of rootlets and sandstone gravel (topsoil)		A/E	0.1				
		FILLING - moderately compacted, brown-grey silty sand filling with some crushed sandstone gravel, fine shale gravel		A/E	0.45				
	0.5	Bore discontinued at 0.5m - refusal on sandstone							
57	1								
56	2								
55	3								
54	4								



RIG: Bobcat **DRILLER:** GM **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger to 0.5m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ 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

BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 63.8 AHD
EASTING: 337312
NORTHING: 6253853
DIP/AZIMUTH: 90°/--

BORE No: C05
PROJECT No: 85538.00
DATE: 17/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
63	0.06	ASPHALTIC CONCRETE							
	0.1	ROADBASE GRAVEL - igneous fine to medium gravel with some brown fine sand		A/E	0.1				
	0.25	SANDSTONE - very low strength, moderately weathered, brown sandstone		A/E	0.25				
		Bore discontinued at 0.25m - refusal on sandstone							
62	1								1
	2								2
61	3								3
60	4								4
59									

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Bobcat **DRILLER:** GM **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger to 0.25m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ 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

BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 65.6 AHD
EASTING: 337305
NORTHING: 6253873
DIP/AZIMUTH: 90°/--

BORE No: C06
PROJECT No: 85538.00
DATE: 17/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.05	ASPHALTIC CONCRETE		A/E	0.1				
		Bore discontinued at 0.05m - refusal on concrete							
65	1								1
64	2								2
63	3								3
62	4								4
61									

RIG: Bobcat **DRILLER:** GM **LOGGED:** AT **CASING:** Uncased
TYPE OF BORING: 100mm diameter solid flight auger to 0.05m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 57.1 AHD
EASTING: 337291
NORTHING: 6253799
DIP/AZIMUTH: 90°/--

BORE No: C07
PROJECT No: 85538.00
DATE: 17/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
57	0.35	FILLING - apparently loosely compacted, dark brown-grey sandy silt filling, organic odour, traces of rootlets (topsoil)		A/E	0.1				
	0.4	ASPHALTIC CONCRETE							
	0.45	ROADBASE GRAVEL - igneous gravel and some grey sand		A/E	0.5				
		SANDSTONE - very low strength, moderately weathered, orange-brown medium grained sandstone		A/E	0.8				
	0.9	Bore discontinued at 0.9m - refusal on sandstone							
56	1								
55	2								
54	3								
53	4								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Bobcat **DRILLER:** GM **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger to 0.9m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ 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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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 51.1 AHD
EASTING: 337251
NORTHING: 6253759
DIP/AZIMUTH: 90°/--

BORE No: C08
PROJECT No: 85538.00
DATE: 17/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
51	0.0	FILLING - apparently loosely compacted, dark grey-brown sandy silt filling with traces of sandstone gravel and some rootlets, organic odour (topsoil)		A/E	0.1				
	0.4	FILLING - apparently loosely compacted, dark grey-brown silty sand filling with some medium sand, tree bark		A/E	0.5				
50	1	0.8m: traces of broken glass		A/E	1.0				1
	1.2	FILLING - dark grey sand filling and some rootlets and tree bark			1.4				
	1.5	CLAYEY SAND - brown clayey sand, possible weathered sandstone		A/E*	1.6				
	1.7	Bore discontinued at 1.7m - refusal on sandstone		A/E	1.7				
49	2								2
48	3								3
47	4								4

RIG: Bobcat **DRILLER:** GM **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger to 1.7m

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *BD3-170616 and BD4-170616 collected at 1.4m to 1.6m

☐ 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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BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 49.3 AHD
EASTING: 337274
NORTHING: 6253758
DIP/AZIMUTH: 90°/--

BORE No: C09
PROJECT No: 85538.00
DATE: 17/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
49	0.8	FILLING - variably compacted, dark grey sandy silt filling with traces of medium sand and ceramics (topsoil)		A/E	0.1				
				A/E	0.5				
	1	FILLING - brown sand and silt filling (possible moderately weathered shale)		E	1.0				
	1.2				1.1				
48		Bore discontinued at 1.2m - refusal on sandstone							
	2								
47									
	3								
46									
	4								
45									

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Bobcat **DRILLER:** GM **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger to 1.2m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ 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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BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 51.0 AHD
EASTING: 337236
NORTHING: 6253775
DIP/AZIMUTH: 90°/--

BORE No: C10
PROJECT No: 85538.00
DATE: 17/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
51	0.2	FILLING - dark grey silty sand filling (topsoil)		A/E	0.1				
		Bore discontinued at 0.2m - refusal on concrete							
50	1								1
49	2								2
48	3								3
47	4								4

RIG: Bobcat **DRILLER:** GM **LOGGED:** AT **CASING:** Uncased
TYPE OF BORING: 100mm diameter solid flight auger to 0.2m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 51.0 AHD
EASTING: 337236
NORTHING: 6253775
DIP/AZIMUTH: 90°/--

BORE No: C10A
PROJECT No: 85538.00
DATE: 22/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
51	0.06	CONCRETE PAVING							
	0.1	FILLING - yellow sand and cement bed		E	0.1				
	0.3	FILLING - grey sandy gravel filling (roadbase) with a trace of clay							
		FILLING - yellow-brown, medium grained sand filling with a trace of gravel, moist		E	0.5				
		- becoming wet at 0.7m							
	0.8	SAND - yellow-brown, medium grained silty sand							
50	1			E	1.0				1
	1.2	SANDSTONE - extremely low to low strength, extremely to highly weathered, yellow-brown and red-brown sandstone							
	1.5	Bore discontinued at 1.5m - auger refusal on sandstone							
49	2								2
48	3								3
47	4								4

RIG: Bobcat **DRILLER:** GM **LOGGED:** AT **CASING:** Uncased
TYPE OF BORING: 100mm diameter solid flight auger to 1.5m
WATER OBSERVATIONS: No free groundwater observed
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

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

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 64.8 AHD
EASTING: 337284
NORTHING: 6253883
DIP/AZIMUTH: 90°/--

BORE No: C12
PROJECT No: 85538.00
DATE: 20/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
64	0.25	FILLING - apparently loosely compacted, dark grey silt filling with traces of fine sand, clay and rootlets, organic odour (topsoil)		A/E	0.1 0.15				
	0.35	FILLING - apparently moderately compacted, orange-brown medium sand filling with some traces of clay and gravel		A/E	0.25 0.3				
		Bore discontinued at 0.35m - auger refusal on sandstone							

RIG: Hand tools **DRILLER:** AT **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: Hand auger to 0.35m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ 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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BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 64.9 AHD
EASTING: 337292
NORTHING: 6253879
DIP/AZIMUTH: 90°/--

BORE No: C13
PROJECT No: 85538.00
DATE: 20/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
64	0.25	FILLING - apparently loosely compacted, dark brown-grey sandy silt filling with traces of plastic, rootlets, organic odour (topsoil)		A/E	0.1				
	0.45	FILLING - silty sand filling with traces of coarse quartz sand		A/E	0.3				
	0.55	FILLING - variably compacted, dark brown-grey medium sand filling with some coarse sand and crushed sandstone gravel, trace of rootlets		A/E	0.45				
63		Bore discontinued at 0.55m - refusal on sandstone							
62									
61									
60									

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3, 4

RIG: Hand tools **DRILLER:** AT **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: Hand auger to 0.55m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ 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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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 62.3 AHD
EASTING: 337316
NORTHING: 6253845
DIP/AZIMUTH: 90°/--

BORE No: C14
PROJECT No: 85538.00
DATE: 20/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
62	0.25	FILLING - apparently loosely compacted, dark grey silt filling with some rootlets, igneous gravel and medium sand (topsoil)		E	0.1				
	0.35	FILLING - variably compacted, brown-grey silty sand filling with traces of rootlets		E	0.2				
	0.5	SANDSTONE - extremely low strength, highly weathered, medium grained sandstone with some orange ironstone layers		E	0.3				
		Bore discontinued at 0.5m - refusal on sandstone			0.35				
					0.4				
					0.45				
61	1								1
60	2								2
59	3								3
58	4								4

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Hand tools **DRILLER:** AT **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: Hand auger to 0.5m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ 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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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 64.9 AHD
EASTING: 337304
NORTHING: 6253854
DIP/AZIMUTH: 90°/--

BORE No: C15
PROJECT No: 85538.00
DATE: 20/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
64	0.5	FILLING - apparently loosely compacted, dark grey silt filling with some sand, trace rootlets, trace of plastic (topsoil) 0.45m: becoming sandy		A/E*	0.1 0.15				
				A/E	0.25 0.3				
63	1	Bore discontinued at 0.5m - refusal on sandstone							
62	2								
61	3								
60	4								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Hand tools **DRILLER:** AT **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: Hand auger to 0.5m

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *BD5-200616 collected at 0.1m to 0.15m

☐ 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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BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 62.3 AHD
EASTING: 337301
NORTHING: 6253843
DIP/AZIMUTH: 90°/--

BORE No: C16
PROJECT No: 85538.00
DATE: 20/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
62	0.3	FILLING - apparently loosely compacted, dark grey sandy silt filling with traces of rootlets and fine sandstone gravel (topsoil)		A/E	0.15 0.25				
	0.4	SANDSTONE - extremely low strength, highly weathered, pale grey medium grained sandstone		A/E	0.35 0.4				
		Bore discontinued at 0.4m - refusal on sandstone							
61	1								
60	2								
59	3								
58	4								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Hand tools **DRILLER:** AT **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: Hand auger to 0.4m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ 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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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 59.2 AHD
EASTING: 337286
NORTHING: 6255820
DIP/AZIMUTH: 90°/--

BORE No: C17
PROJECT No: 85538.00
DATE: 20/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
59	0.75	FILLING - apparently loosely compacted, dark grey silt filling with some rootlets and organic matter (mulch/leaves), slightly sandy (topsoil) - apparently becoming sandy, slightly fine igneous gravel, moderately compacted							
	1.1	FILLING - apparently loose, brown medium sand filling with traces of silt and some large grey-brown sandstone gravel							
58		Bore discontinued at 1.1m - auger refusal on large tree root							
57									
56									
55									

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3, 4

RIG: Hand tools **DRILLER:** AT **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: Hand auger to 1.1m

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Refusal of auger on roots at 0.7m, then relocated

☐ 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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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 57.5 AHD
EASTING: 337292
NORTHING: 6253773
DIP/AZIMUTH: 90°/--

BORE No: C18
PROJECT No: 85538.00
DATE: 20/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
57	0.6	FILLING - apparently loosely compacted, dark grey silt filling with some rootlets, traces of fine sand (topsoil) 0.3m: becoming sandy, apparently moderately compacted		A/E	0.1 0.2				
		SANDSTONE - extremely low strength, highly to moderately weathered, brown medium grained sandstone		A/E A/E	0.5 0.6 0.7 0.8				
	0.95	Bore discontinued at 0.95m - refusal on low strength sandstone							

RIG: Hand tools **DRILLER:** AT **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: Hand auger to 0.95m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ 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

BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 51.6 AHD
EASTING: 337246
NORTHING: 6253789
DIP/AZIMUTH: 90°/--

BORE No: C19
PROJECT No: 85538.00
DATE: 20/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
51	0.0	FILLING - apparently loosely compacted, dark grey silt filling with some rootlets, slightly sandy, organic odour (topsoil)		E/A	0.1				
					0.2				
		0.3m: becoming sandy and variably compacted							
				E/A	0.5				
					0.6				
	0.9								
	1	SAND - loose, brown medium grained sand with traces of silt		E/A	0.9				
					1.0				
	1.35	Bore discontinued at 1.35m - refusal on sandstone							
50	2								
49	3								
48	4								
47									

5 10 15 20

RIG: Hand tools **DRILLER:** AT **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: Hand auger to 1.35m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ 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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BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 51.6 AHD
EASTING: 337252
NORTHING: 6253784
DIP/AZIMUTH: 90°/--

BORE No: C20
PROJECT No: 85538.00
DATE: 20/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
51	0.1	FILLING - apparently loosely compacted, dark grey silt filling with slightly sandy, some rootlets, traces of plastic (topsoil)		E/A	0.1				
	0.2	0.2m: becoming sandy and variably compacted			0.2				
	0.4			E/A	0.4				
	0.5				0.5				
	0.7	SAND - loose, brown sand, traces of silt							
	0.8	0.9m: becoming sandstone		E/A	0.8				
	1.0				1.0				
	1.05	Bore discontinued at 1.05m - refusal on sandstone							

RIG: Hand tools **DRILLER:** AT **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: Hand auger to 1.05m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ 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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BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 55.4 AHD
EASTING: 337258
NORTHING: 6253818
DIP/AZIMUTH: 90°/--

BORE No: C21
PROJECT No: 85538.00
DATE: 20/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
55	0.4	FILLING - apparently loosely compacted, dark grey silt filling with some rootlets, slightly fine sand (topsoil)		A/E	0.2 0.3				
		Bore discontinued at 0.4m - refusal on possibly concrete, sandstone or root)							

RIG: Hand tools **DRILLER:** AT **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: Hand auger to 0.4m

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Refusal at 0.4m - hole moved by 0.5m away from tree

☐ 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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BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 48.3 AHD
EASTING: 337286
NORTHING: 6253737
DIP/AZIMUTH: 90°/--

BORE No: C22
PROJECT No: 85538.00
DATE: 22/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
48	0.25	FILLING - apparently moderately compacted, grey-brown silty sand filling with traces of organic matter (topsoil)		E	0.1 0.2				
		Bore discontinued at 0.25m - DCP layer refusal (possible sandstone boulder)							
47	1								
46	2								
45	3								
44	4								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Hand tools **DRILLER:** AT **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: Hand auger to 0.25m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ 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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BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 48.3 AHD
EASTING: 337299
NORTHING: 6253743
DIP/AZIMUTH: 90°/--

BORE No: C23
PROJECT No: 85538.00
DATE: 22/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
48	0.25	FILLING - apparently moderately compacted, brown medium sand filling with trace of igneous gravel and organic matter (topsoil)		E	0.1 0.2				
		Bore discontinued at 0.25m - DCP and auger refusal on sandstone (possible floater)							
47	1								1
46	2								2
45	3								3
44	4								4

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Hand tools **DRILLER:** AT **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: Hand auger to 0.25m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ 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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BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 48.3 AHD
EASTING: 337310
NORTHING: 6253749
DIP/AZIMUTH: 90°/--

BORE No: C24
PROJECT No: 85538.00
DATE: 22/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
48	0.2	FILLING - apparently moderately compacted, dark grey coarse igneous sand filling with some fine gravel, traces of rootlets and silt (topsoil)		E	0.1				
		FILLING - apparently moderately compacted, grey coarse igneous and crushed sandstone sand filling with traces of silt			0.2				
	0.55			E	0.5				
		Bore discontinued at 0.55m - auger refusal on sandstone (possible floater)			0.55				
47	1								1
46	2								2
45	3								3
44	4								4

Dynamic Penetrometer Test (blows per 150mm) scale: 5, 10, 15, 20

RIG: Hand tools **DRILLER:** AT **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: Hand auger to 0.55m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ 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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BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 48.3 AHD
EASTING: 337300
NORTHING: 6253736
DIP/AZIMUTH: 90°/--

BORE No: C25
PROJECT No: 85538.00
DATE: 22/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
48	0.13	FILLING - variably compacted, dark grey, silty medium sand filling with traces of organics (topsoil)		E	0.1				
		Bore discontinued at 0.13m - refusal on sandstone			0.13				
47	1								
46	2								
45	3								
44	4								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Hand tools **DRILLER:** AT **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: Hand auger to 0.13m

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ 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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BOREHOLE LOG

CLIENT: Taronga Zoo Conservation Society Australia
PROJECT: Congo Site, Taronga Zoo
LOCATION: Bradleys Head Road, Mosman

SURFACE LEVEL: 53.8 AHD
EASTING: 337245
NORTHING: 6253809
DIP/AZIMUTH: 90°/--

BORE No: C26
PROJECT No: 85538.00
DATE: 22/6/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
53	0.25	FILLING - variably compacted, dark grey silty sand filling with traces of sandstone gravel (topsoil)		E	0.1 0.2				
		FILLING - variably compacted, brown sand filling with some crushed sandstone gravel and cobbles		E	0.5 0.6				
52	0.65	Bore discontinued at 0.65m - possible root or sandstone cobble							
51									
50									
49									

RIG: Hand tools **DRILLER:** AT **LOGGED:** AT **CASING:** Uncased

TYPE OF BORING: Hand auger to 0.65m

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Moved due to early refusal at 0.2m

☐ 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

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Results of Dynamic Penetrometer Tests

Client	Taronga Zoo Conservation Society Australia	**Project No.**	85538.00
Project	Congo Precinct	**Date**	17/06/2016
Location	Bradleys Head Road, Mosman	**Page No.**	1 of 3

Test Locations	C01	C02	C03	C04	C05	C07	C08	C09	C12	C13
RL of Test (AHD)	59.3	58.9	58.5	58.0	63.8	57.1	51.1	49.3	64.8	64.9
Depth (m)										
0.00 – 0.15	5	3	6	-		1	1	1	0	0
0.15 – 0.30	20	3	6	6	25/50	1	2	2	1	1
0.30 – 0.45	2	2	3	10		25/50	3	7	25/100	0
0.45 – 0.60	1	3	6	25/50		3	3	10	B	25/100
0.60 – 0.75	1	25/140	5	R		3	4	23		
0.75 – 0.90	4		5			25/50	1	22		
0.90 – 1.05	25/150		1			R	3	6		
1.05 – 1.20			3				5	6		
1.20 – 1.35			5				4	2		
1.35 – 1.50			25/130				25/70	5		
1.50 – 1.65							R	10		
1.65 – 1.80								12		
1.80 – 1.95								25/50		
1.95 – 2.10										
2.10 – 2.25										
2.25 – 2.40										
2.40 – 2.55										
2.55 – 2.70										
2.70 – 2.85										
2.85 – 3.00										

Test Method AS 1289.6.3.2, Cone Penetrometer ☑ **Tested By** **AT**
AS 1289.6.3.3, Sand Penetrometer ☐ **Checked By** **KDP**

Remarks R = REFUSAL
25/150 = 25 BLOW COUNTS FOR 150mm PENETRATION

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Results of Dynamic Penetrometer Tests

Client	Taronga Zoo Conservation Society Australia	**Project No.**	85538.00
Project	Congo Precinct	**Date**	17-22/06/16
Location	Bradleys Head Road, Mosman	**Page No.**	2 of 3

Test Locations	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
RL of Test (AHD)	62.3	64.1	62.3	59.2	57.5	51.6	51.6	55.4	48.3	48.3
Depth (m)										
0.00 – 0.15	1	1	1	1	1	1	1	1	10	7
0.15 – 0.30	1	1	2	0	0	1	0	0	25/140	25/100
0.30 – 0.45	12	1	25/50	1	1	13	3	25/100		
0.45 – 0.60	25/100	25/50		5	6	5	6			
0.60 – 0.75		B		5	12	2	3			
0.75 – 0.90				2	20	3	5			
0.90 – 1.05				3	25/100	5	3			
1.05 – 1.20				1		2	25/50			
1.20 – 1.35				4		6	R			
1.35 – 1.50				6		25/140				
1.50 – 1.65				6						
1.65 – 1.80				10						
1.80 – 1.95				5						
1.95 – 2.10				6						
2.10 – 2.25				3						
2.25 – 2.40				3						
2.40 – 2.55										
2.55 – 2.70										
2.70 – 2.85										
2.85 – 3.00										

Test Method AS 1289.6.3.2, Cone Penetrometer ☑ **Tested By** **AT**
AS 1289.6.3.3, Sand Penetrometer ☐ **Checked By** **KDP**

Remarks B = BOUNCING
R = REFUSAL
25/100 = 25 BLOW COUNTS FOR 100mm PENETRATION

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Results of Dynamic Penetrometer Tests

Client	Taronga Zoo Conservation Society Australia	**Project No.**	85538.00
Project	Congo Precinct	**Date**	17-22/06/16
Location	Bradleys Head Road, Mosman	**Page No.**	3 of 3

Test Locations	C24	C25	C26							
RL of Test (AHD)	48.3	48.3	53.8							
Depth (m)										
0.00 – 0.15	6	25/120	3							
0.15 – 0.30	7		2							
0.30 – 0.45	6		3							
0.45 – 0.60	B		7							
0.60 – 0.75			25/20							
0.75 – 0.90										
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										
1.95 – 2.10										
2.10 – 2.25										
2.25 – 2.40										
2.40 – 2.55										
2.55 – 2.70										
2.70 – 2.85										
2.85 – 3.00										

Test Method AS 1289.6.3.2, Cone Penetrometer ☑ **Tested By** **AT**
AS 1289.6.3.3, Sand Penetrometer ☐ **Checked By** **KDP**

Remarks B = BOUNCING
25/120 = 25 BLOW COUNTS FOR 120mm PENETRATION