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Project 216903.02
13 April 2023
R.001.Rev0
AT

Attention: Leigh Manser

Email: leigh@bennelong.com

Groundwater and Infiltration Testing
Proposed Residential Development
61 North Steyne, Manly

1. Introduction

This report presents the results of recent groundwater level and infiltration testing undertaken by Douglas Partners Pty Ltd (DP) for a proposed residential development at 61 North Steyne, Manly. The assessment was commissioned by Leigh Manser of Lindsay Bennelong Development acting on behalf of Manly Property Developments Pty Ltd in accordance with DP's email proposal dated 7 March 2023.

It is understood that the proposed development is in the early design and planning stages and an absorption pit is being considered as part of the stormwater management system. This report will be used to provide information for the design of the absorption pit and may be submitted as part of the development application (DA) to the local council.

The assessment included a site walkover by an experienced geotechnical engineer, one hand augered borehole to assess the groundwater level in the area and two boreholes to facilitate in situ permeability testing. Details of the field work are given in the report together with comments on likely geotechnical issues associated with construction of the storm water absorption pitas well as details on soil permeability for the design of the stormwater management system.

Reference should be made to our preliminary geotechnical assessment for comments on site description, geological conditions and comments on geotechnical issues associated with the proposed development.

2. Field Work Methods

The field work included:

- Two hand augered boreholes (BH1 and BH2) within the front yard of the property to a depth of 0.8 m. The boreholes targeted the location of the proposed stormwater absorption pit;

- One hand augered borehole (BH3) was also undertaken within the front yard of the property to a depth of 4.0 m to attempt to determine groundwater levels within the area;
- Logging of the soil profile within each borehole;
- One constant head test was undertaken at BH1 and BH2 to assess the hydraulic conductivity of the soil encountered.

The coordinates and ground surface levels were measured using a high precision GPS system accurate to 0.1 m in plan and elevation. On completion of the borehole drilling and testing, the locations were backfilled with the excavated spoil, nominally compacted and topped up with sand if required.

3. Field Work Results

3.1 Boreholes

Details of the field work results are attached together with notes explaining descriptive terms and classification methods used.

The boreholes indicated a subsurface profile including:

Fill	Silty sand fill to depths of 0.3 m with rootlets (topsoil and organics to 0.1 m) followed by find to medium sand fill with silt, sandstone gravels and some anthropogenic inclusions (ceramic fragments and possible charcoal were observed to 1.2 m depth.
Sand	Marine sand to a depth of 4.0 m (the limit of the investigation). The sand was generally yellow-brown, fine to medium grained and moist. The sand was observed to be moist to wet at 4.0 m depth with the hand auger being terminated as cuttings could not be recovered.

No free groundwater was encountered within the boreholes whilst auguring, however the moisture conditions of the sand at 4.0 m depth was noted to be moist to wet which could be close to the groundwater table. Further comments on groundwater levels has been provided within the groundwater section of this report.

3.2 Soil Permeability Tests

Constant head permeability tests were carried out at BH1 and BH2 within the sandy fill. Testing consisted of prefilling the augered boreholes for approximately 30 minutes and followed by two tests at each borehole. Representative tests results are attached and indicate the hydraulic conductivity (k) of the soil ranged between 1.5×10^{-3} m/s to 4.4×10^{-4} m/s.

Details of the constant head permeability testing can be found on the attached test summary sheets.

4. Comments

4.1 Stormwater Management

The results of the permeability tests indicate that the filling has a hydraulic conductivity (k) ranging between 1.5x10^{-3} m/s to 4.4x10^{-4} m/s. This is reasonably consistent with expected k values for the underlying marine sands which typically have k values in the range of 2 to 5x10^{-4} m/s.

By assuming a hydraulic gradient (i) of 5%, which is based on average surface slopes in the area (and therefore likely groundwater surface), the permeability tests indicate an absorption rate of approximately 400 to 1000 litres per day per square metre of the absorption pit.

It is noted that the hydraulic conductivity of the uncontrolled fill is likely to be highly variable and depends on the particles size distribution, compaction and void ratio within the filling.

The design of the absorption system will need to consider the proximity to adjacent high level footings and below ground structures (i.e. new or existing basements) as this has the potential to create an elevated groundwater level in the area.

4.2 Groundwater

As outlined in Section 7.2 of our desktop geotechnical report (216903.R.001.Rev0, dated September 2022) the groundwater level is anticipated to typically fluctuate between about 4 m to 5 m below existing surface levels (RL0 m to RL1 m AHD). It should be noted that groundwater levels will fluctuate with climatic conditions and to lesser extent due to tidal influences and are likely to increase following periods of extended wet weather. At this stage it is suggested that a groundwater level to at least RL2.5 m should be considered for design of the absorption system.

Based on the increased moisture conditions at 4.0 m depth in BH3, it is likely that the borehole terminated about 0.5-1 m above the groundwater level at the time of the investigation. Further groundwater monitoring will be required for detailed design and planning of the development to confirm groundwater level and fluctuations.

5. Limitations

Douglas Partners (DP) has prepared this report for this project at 61 North Steyne, Manly in accordance with DP's email proposal dated 7 March 2023 and acceptance received from Leigh Manser, on 8 March 2023, of Lindsay Bennelong Developments Pty Ltd acting on behalf of Manly Property Developments Pty Ltd. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Manly Property Developments Pty Ltd 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 their agents.

The assessment of atypical safety hazards arising from this advice is restricted to the geotechnical 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.

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.

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

Yours faithfully
Douglas Partners Pty Ltd

Adam Teoh
Geotechnical Engineer

Reviewed by

Scott Easton
Principal

Attachments:
- About this Report
- Test Location Plan
- Soil Descriptions
- Symbols and Abbreviations
- Borehole Logs
- Constant Head Permeameter Test Reports

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

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

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

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

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

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

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

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

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

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

About this Report

Site Anomalies

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

Information for Contractual Purposes

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

Site Inspection

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

LOCALITY MAP

Legend

- Borehole Location
- Site Boundary

0 5 10 15 m

CLIENT: Manly Property Developments Pty Ltd		TITLE: **Test Location Plan**	PROJECT No: 216903.02
OFFICE: Sydney	DRAWN BY: AT	**Proposed Infiltration Tank**	DRAWING No: 1
SCALE: 1:200 @ A3	DATE: 30.03.2023	**61 North Steyne, Manly**	REVISION: 0

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Geotechnics / Environment / Groundwater

Sampling

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

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

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

Test Pits

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

Large Diameter Augers

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

Continuous Spiral Flight Augers

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

Non-core Rotary Drilling

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

Continuous Core Drilling

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

Standard Penetration Tests

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

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

The test results are reported in the following form.

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

  4,6,7
  N=13

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

  15, 30/40 mm

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

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

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

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

Soil Descriptions

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Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are generally based on Australian Standard AS1726:2017, Geotechnical Site Investigations. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

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

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

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

Type	Particle size (mm)
Coarse gravel	19 - 63
Medium gravel	6.7 - 19
Fine gravel	2.36 – 6.7
Coarse sand	0.6 - 2.36
Medium sand	0.21 - 0.6
Fine sand	0.075 - 0.21

Definitions of grading terms used are:

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

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

In fine grained soils (>35% fines)

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

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

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

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

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

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

Soil Descriptions

Cohesive Soils

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

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	VS	<12
Soft	S	12 - 25
Firm	F	25 - 50
Stiff	St	50 - 100
Very stiff	VSt	100 - 200
Hard	H	>200
Friable	Fr	-

Cohesionless Soils

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

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

Soil Origin

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

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

Moisture Condition – Coarse Grained Soils

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

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

  Soil tends to stick together.

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

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

Moisture Condition – Fine Grained Soils

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

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

Rock Descriptions

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Rock Strength

Rock strength is defined by the Unconfined Compressive Strength and it refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects.

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

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

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

Degree of Weathering

The degree of weathering of rock is classified as follows:

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

Rock Descriptions

Degree of Fracturing

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

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	Core lengths of 20-40 mm with occasional fragments
Fractured	Core lengths of 30-100 mm with occasional shorter and longer sections
Slightly Fractured	Core lengths of 300 mm or longer with occasional sections of 100-300 mm
Unbroken	Core contains very few fractures

Rock Quality Designation

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

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

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

Stratification Spacing

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

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

Symbols & Abbreviations

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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

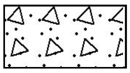
Symbols & Abbreviations

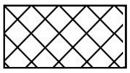
Graphic Symbols for Soil and Rock

General

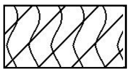
 Asphalt

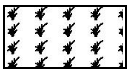
 Road base

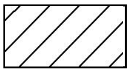
 Concrete

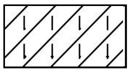
 Filling

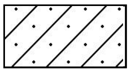
Soils

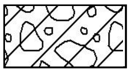
 Topsoil

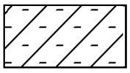
 Peat

 Clay

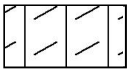
 Silty clay

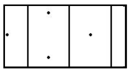
 Sandy clay

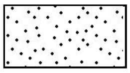
 Gravelly clay

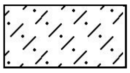
 Shaly clay

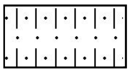
 Silt

 Clayey silt

 Sandy silt

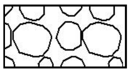
 Sand

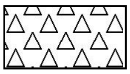
 Clayey sand

 Silty sand

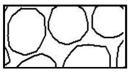
 Gravel

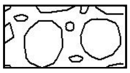
 Sandy gravel

 Cobbles, boulders

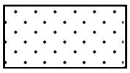
 Talus

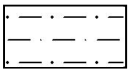
Sedimentary Rocks

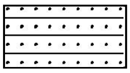
 Boulder conglomerate

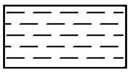
 Conglomerate

 Conglomeratic sandstone

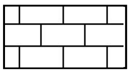
 Sandstone

 Siltstone

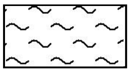
 Laminite

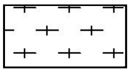
 Mudstone, claystone, shale

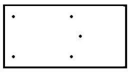
 Coal

 Limestone

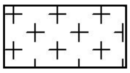
Metamorphic Rocks

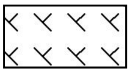
 Slate, phyllite, schist

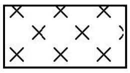
 Gneiss

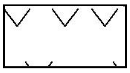
 Quartzite

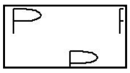
Igneous Rocks

 Granite

 Dolerite, basalt, andesite

 Dacite, epidote

 Tuff, breccia

 Porphyry

BOREHOLE LOG

CLIENT: Manly Property Developments Pty Ltd
PROJECT: Proposed Infiltration Tank
LOCATION: 61 North Steyne, Manly

SURFACE LEVEL: 5.1 AHD
EASTING: 341420.6
NORTHING: 6259289.5
DIP/AZIMUTH: 90°/--

BORE No: 1
PROJECT No: 216903.02
DATE: 20-3-2023
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
5	0.1	FILL/TOPSOIL: Silty SAND, fine to medium, dark grey, with rootlets, moist							
	0.4	FILL/Silty SAND: fine to medium, dark grey, trace rootlets, moist							
	0.8	FILL/Silty SAND: fine to medium, dark brown, trace medium sandstone gravel, moist At 0.7m: trace charcoal							
4	1	Bore discontinued at 0.8m Target depth reached							
3	2								
2	3								
1	4								

RIG: Hand Tools **DRILLER:** TM/RT **LOGGED:** TM **CASING:** Uncased
TYPE OF BORING: Hand auger to 0.8m
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: Manly Property Developments Pty Ltd
PROJECT: Proposed Infiltration Tank
LOCATION: 61 North Steyne, Manly

SURFACE LEVEL: 5.1 AHD
EASTING: 341426.7
NORTHING: 6259289.1
DIP/AZIMUTH: 90°/--

BORE No: 2
PROJECT No: 216903.02
DATE: 20-3-2023
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
5	0.1	FILL/TOPSOIL: Silty SAND, fine to medium, dark grey, with rootlets, moist							
	0.3	FILL/Silty SAND: fine to medium, dark grey, trace rootlets, moist							
	0.8	FILL/Silty SAND: fine to medium, dark brown, trace medium sandstone gravel, moist At 0.6m: trace ceramic fragments							
		Bore discontinued at 0.8m Target depth reached							
4	1								1
3	2								2
2	3								3
1	4								4

RIG: Hand Tools **DRILLER:** TM/RT **LOGGED:** TM **CASING:** Uncased
TYPE OF BORING: Hand auger to 0.8m
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: Manly Property Developments Pty Ltd
PROJECT: Proposed Infiltration Tank
LOCATION: 61 North Steyne, Manly

SURFACE LEVEL: 5.3 AHD
EASTING: 341422
NORTHING: 6259285.9
DIP/AZIMUTH: 90°/--

BORE No: 3
PROJECT No: 216903.02
DATE: 20-3-2023
SHEET 1 OF 1

Depth (m)	Description of Strata	Graphic Log	Sampling: Type	Sampling: Depth	Sample	Results & Comments	Water	Well Construction Details
0.1	FILL/TOPSOIL: Silty SAND, fine to medium, brown, with rootlets, moist		A	0.1–0.2				
0.3	FILL/Silty SAND: fine to medium, dark grey, trace rootlets, moist							
1.2	FILL/Silty SAND: fine to medium, dark brown, trace medium sandstone gravel, moist		A	0.4–0.5				
	SAND SP: fine to medium, pale brown, moist, marine		A	1.2–1.3				
	Below 2.0m: pale yellow		A	2.0–2.1				
			A	3.0–3.1				
4.0	Below 3.9m becoming wet		A	3.9–4.0				
	Bore discontinued at 4.0m Target depth reached							

RIG: Hand Tools **DRILLER:** TM/RT **LOGGED:** TM **CASING:** Uncased
TYPE OF BORING: Hand auger to 4.0m
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

Constant Head Permeameter Test Report [AS1547-2012 App G]

Client:	Manly Property Developments Pty Ltd	Project No:	206903.02
Project:	Proposed Infiltration Tank	Date:	20-Mar-23
Location:	61 North Steyne, Manly	Tested by:	TM/RT
		Checked by:	AT

Test Location

Description: Grass Garden
Material type: Fill/ SAND
Condition of ground surface before test: Moist
Weather during test: Overcast

Test No. BH1
Easting: 341420.6
Northing 6259289.5
Surface Level: 5.1 m AHD

Details of Test

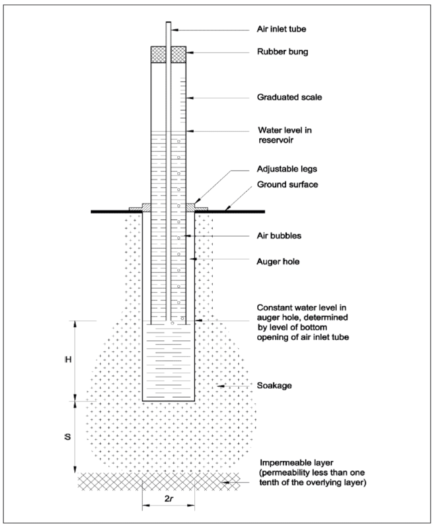
Depth of augered hole	800 mm	Depth to impermeable layer (S)	>2H	m
Depth of constant water below permeameter (H)	550 mm	Time from filling to start	5	minute
Diameter of hole (2r)	100 mm	Diameter of permeameter	70	mm

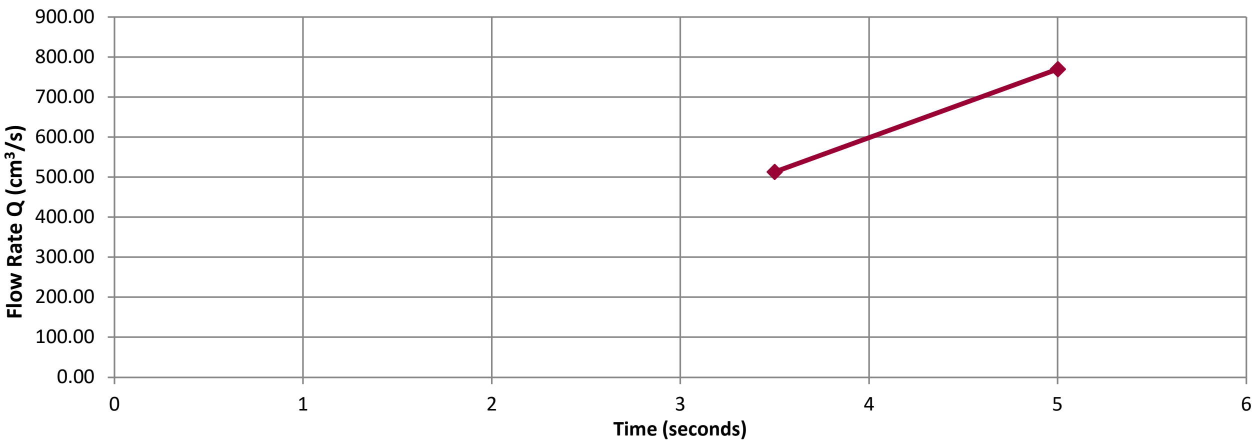
General Comments: Hole presoaked for 30 mins prior to testing

Test Results

Time (seconds)	Drop of Level (mm)	Flow Volume (cm^3)	Rate of Loss [Q] (cm^3/s)
2	100	0	-
3.5	200	770	513.127
5	300	1155	769.690

Rate of Loss Taken (cm^3/s) 769.690





Saturated Hydraulic Conductivity

k = **1.4E-01** cm/s
= **1.4E-03** m/s
= **120.964** m/day

where:

$$K_{sat} = \frac{4.4Q\left[0.5\sinh^{-1}\left(\frac{H}{2r}\right) - \sqrt{\left(\frac{r}{H}\right)^2 + 0.25} + \frac{r}{H}\right]}{2\pi H^2}$$

(ref. AS1547-2012 App G)

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Constant Head Permeameter Test Report [AS1547-2012 App G]

Client:	Manly Property Developments Pty Ltd	Project No:	206903.02
Project:	Proposed Infiltration Tank	Date:	20-Mar-23
Location:	61 North Steyne, Manly	Tested by:	TM/RT
		Checked by:	AT

Test Location

Description:	Grass Garden	**Test No.**	BH2
Material type:	Fill/ SAND	Easting:	341426.7
Condition of ground surface before test:	Moist	Northing	6259289.1
Weather during test:	Overcast	Surface Level:	5.1 m AHD

Details of Test

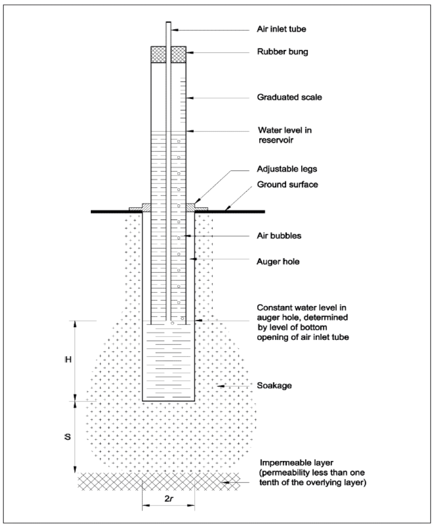
Depth of augered hole	820	mm	Depth to impermeable layer (S)	>2H	m
Depth of constant water below permeameter (H)	570	mm	Time from filling to start	5	minute
Diameter of hole (2r)	100	mm	Diameter of permeameter	70	mm

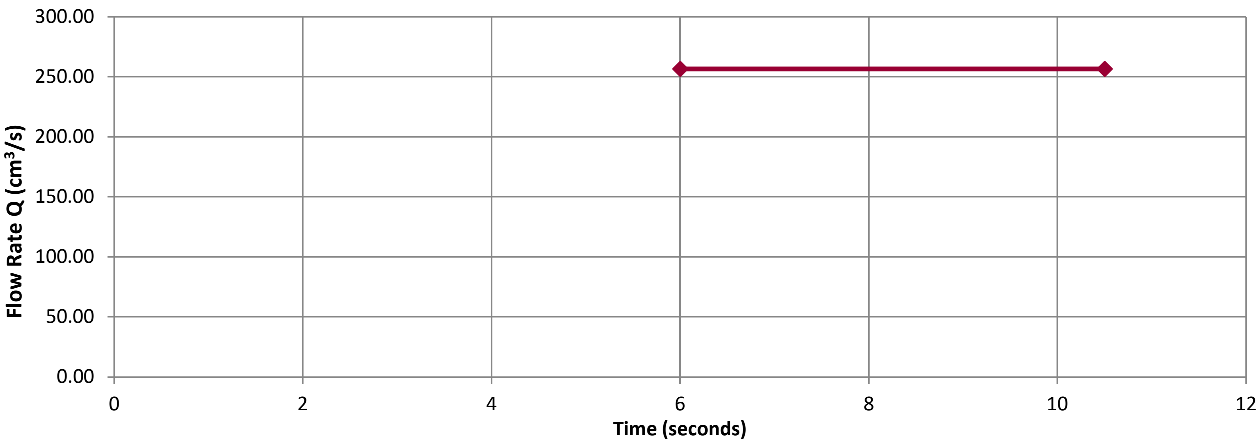
General Comments: Hole presoaked for 30 mins prior to testing

Test Results

Time (seconds)	Drop of Level (mm)	Flow Volume (cm^3)	Rate of Loss [Q] (cm^3/s)
3	100	0	-
6	200	770	256.563
10.5	300	1155	256.563

Rate of Loss Taken (cm^3/s): 256.563





Saturated Hydraulic Conductivity

k =	4.4E-02	cm/s
=	4.4E-04	m/s
=	38.256	m/day

where:

$$K_{sat} = \frac{4.4Q\left[0.5\sinh^{-1}\left(\frac{H}{2r}\right) - \sqrt{\left(\frac{r}{H}\right)^2 + 0.25} + \frac{r}{H}\right]}{2\pi H^2}$$

(ref. AS1547-2012 App G)

CONSTANT HEAD PERMEAMETER TEST v2.11

Approved Spreadsheet