Unit 1, 5 Bugden Avenue
Alstonville
NSW 2477 Australia
t: 02 6628 3224

coffey.com

11 July 2018

Our ref: 754-LSYGE-220175-A

Byron Shire Council
Station Street
Mullumbimby NSW 2482

Attention: Mr James Flockton

Dear Sir,

Infiltration Testing – Ironbark Avenue, Byron Bay

1. Introduction

Byron Shire Council (Council) requested Coffey to carry out infiltration testing at the south-western end of Ironbark Avenue, Byron Bay.

The infiltration testing was required to assess the permeability of the site soils, as Council proposes to construct a subsurface stormwater detention structure (stormwater pods) which will rely on subsurface infiltration to disperse collected stormwater into the subsoil.

The work was carried out in accordance with our proposal 754-LSYGE-P18034-B dated 27 June 2018.

2. Site Description

The proposed site for the stormwater infiltration pods are at the end of Ironbark Drive. At present, stormwater collects across the road within the road reserve, at a low point, as shown in Photograph 1 below.

A site sketch is enclosed.

The surface geology of the site comprises Pleistocene-age dune sand deposits. The Neranleigh-Fernvale beds are present to the west of the site as noted below Photograph 1.

Photograph 1: View of standing water across the roadway. The monitoring well was installed behind the camera. The geology of the low-lying area comprises a Pleistocene aged dune deposit (aeolian sand). Beyond the road, where the ground slope develops away from the camera, the underlying geology comprises the Neranleigh-Fernvale beds.

3. Monitoring Well Installation and Log

Coffey installed a monitoring well, comprising a standpipe with slotted screen, to a depth of 2.86m below ground level. A hand-auger was used to drill the borehole which received the standpipe casing. The well construction details and log of the encountered materials are enclosed.

Groundwater was not intersected within the 2.86m depth of the monitoring well.

The upper 250mm of the profile comprised gravelly clay fill, likely from nearby cuttings, and spread across the site for shaping of the ground surface or to provide a surface for car parking.

Aeolian sand was encountered to the investigation depth of 2.86m. The underlying Neranleigh-Fernvale beds were not intersected.

The well location is shown in Photograph 2 below.

Photograph 2: Well Location looking south.

4. Infiltration Testing

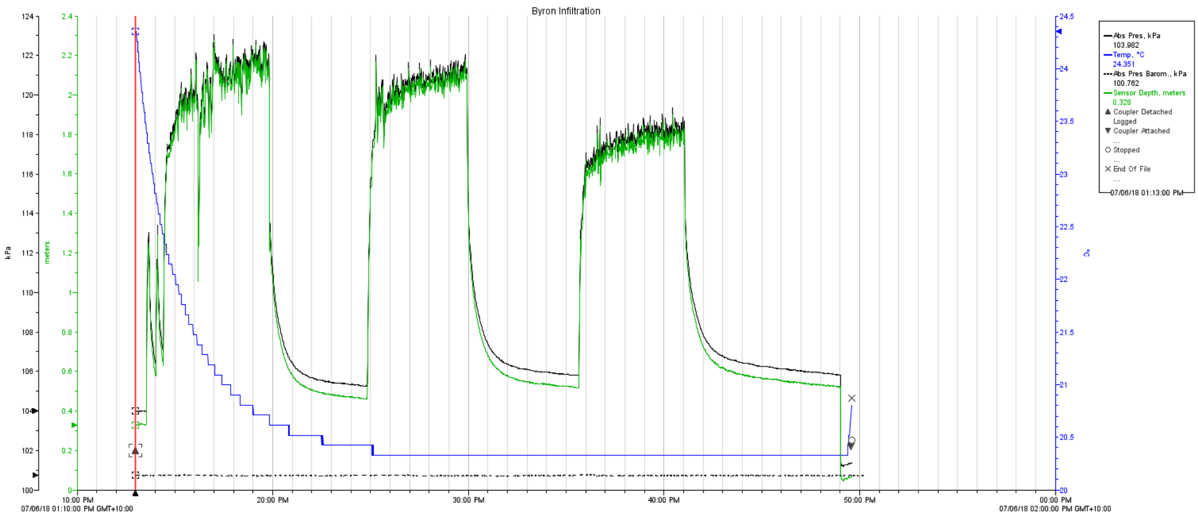
Infiltration testing was conducted using a constant head approach, and municipal supply water was pumped to the borehole to maintain a constant head as far as was practicable.

Estimates of the flow rate were made by timing the filling of known volume containers.

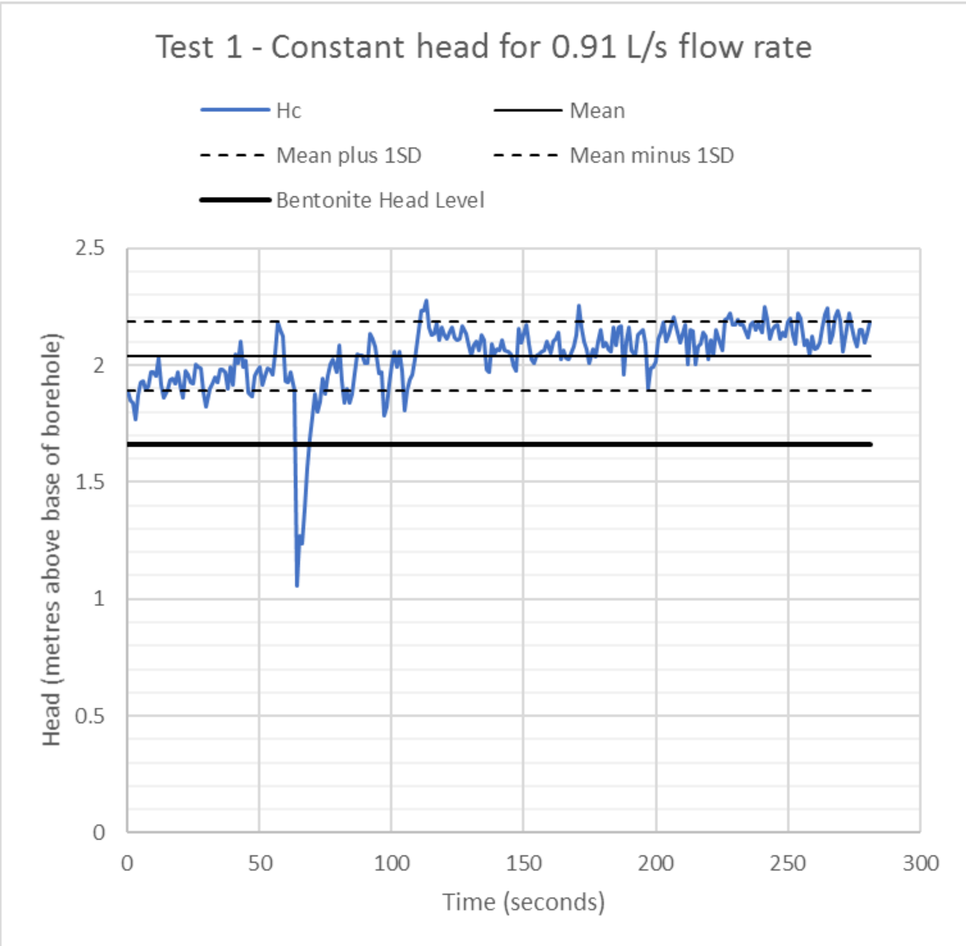
Water pressure data loggers were used to measure the water head above the base of the borehole at one second intervals.

Three tests were conducted, by progressively reducing the pump revolutions from high to idle. Each test comprised a five-minute duration of water flow down the borehole. The three tests are shown in Graph 1 below and are called Test 1, Test 2 and Test 3.

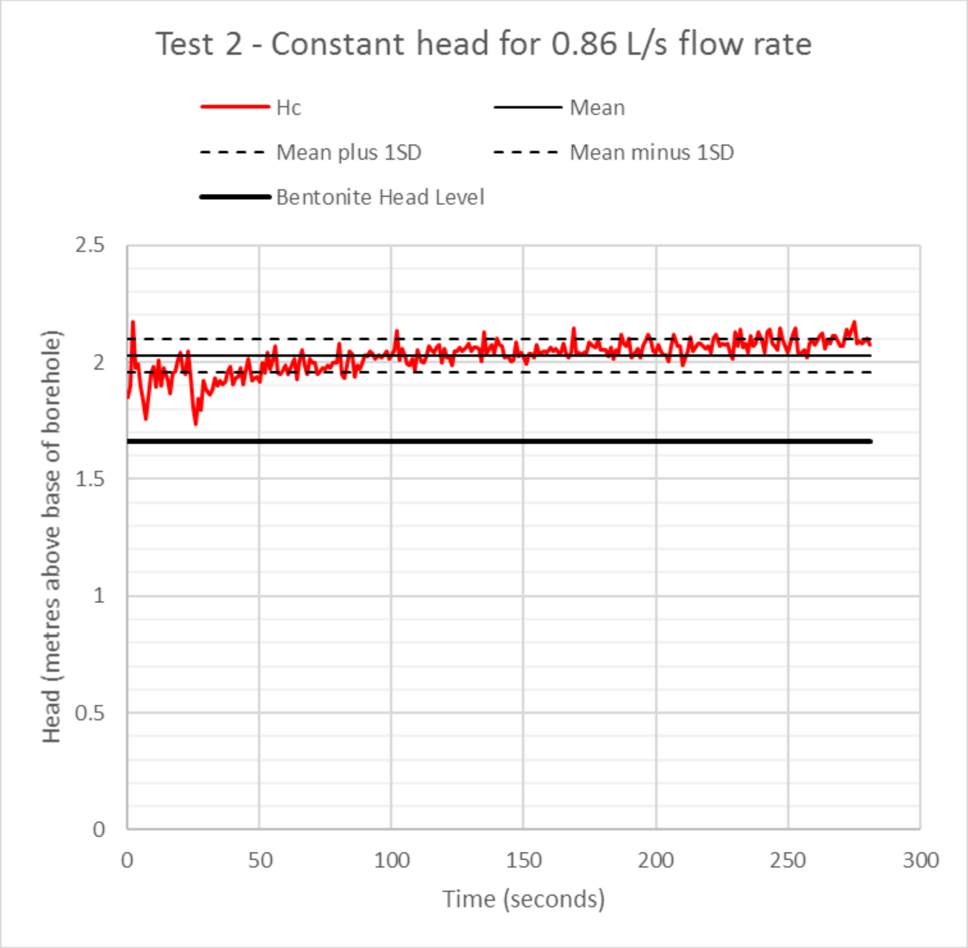
More detailed level measurements of each Test are shown in Graphs 2 to 4.



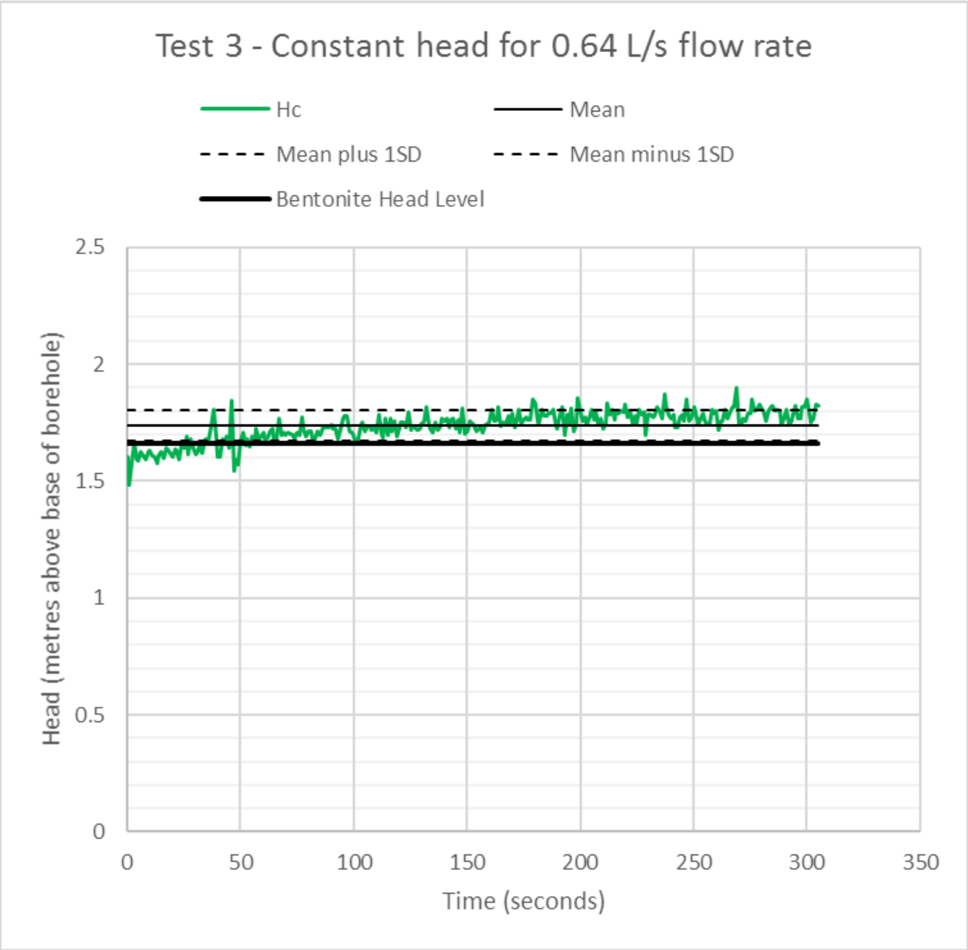
Graph 1: Constant Head Infiltration Tests – showing the three tests (Test 1, Test 2 and Test 3), each of about 5 minutes duration. Each vertical gridline represents one minute, and the head achieved (above the base of the borehole) in Test 1 and Test 2 was about 2 m (to indicate the vertical scale). Note the rapid decay of the water head in about two minutes following cessation of water delivery to the borehole.



Graph 2: Detailed water level measurements for Test 1. Average head is 2.04m.



Graph 3: Detailed water level measurements for Test 2. Average head is 2.03m.



Graph 4: Detailed water level measurements for Test 3. Average head is 1.74m.

5. Findings

We consider that the reason for the standing water at the location is the combination of the road being a sag/low point, and the presence of low permeability fill in the upper 250mm of the profile. The fill is preventing drainage of the runoff into the sand subgrade.

The permeability of the sand was estimated using a method guided by the US Department of Interior Groundwater Manual (US Department of the Interior, 1977). The calculation sheets are enclosed. The estimated permeability of the sand between 2.86m and 1.2m depth is shown in Table 5-1.

Table 5-1: Estimated Permeability of Sand from 1.2 – 2.86m depth based on Constant Head Tests

Test Number	Flow Rate	Maintained Head	Estimated Permeability
Test 1	Approximately 0.91 L/s	2.04m ± 0.15m	1.43 x 10^{-4} m/s
Test 2	Approximately 0.86 L/s	2.03m ± 0.07m	1.36 x 10^{-4} m/s
Test 3	Approximately 0.64 L/s	1.74m ± 0.07m	1.20 x 10^{-4} m/s

Note: Tolerance on the maintained head is shown to one standard deviation of the measurements over 5 minutes (Approximately 280 - 300 measurements depending on the test considered).

6. Recommendations

We recommend that:

- The design includes a sensitivity analysis to consider some natural variance in the permeability of the site soils, and the precision of head and flow measurements. A range of 10^{-3} m/s to 10^{-5} m/s is recommended.
- The subsurface soakage outlets within the stormwater pods should be serviceable, and/or clogging should be prevented (for example through pre-discharge clarifying/settlement chambers that are serviceable). Over time, the infiltration surface may become clogged by sediment suspended in stormwater. This sediment would then control (and likely substantially reduce) the rate of discharge from the stormwater pods, rather than the in-situ sands tested in our assessment. Removal of this sedimentation would be important in the long-term successful operation of the stormwater pods.
- Consideration be given to the further exploration of the site geology to observe the actual groundwater level, the response of this level to rainfall, and the level to the underlying residual soil. For instance, the infiltration test cannot predict whether groundwater rises would occur, for example, during sustained rainfall events. With shallow residual soil, it is possible that the groundwater level may increase significantly as the residual soil would impede downwards infiltration. If the groundwater level rises above the infiltration level of the stormwater pods, then infiltration from the pod will be limited until the groundwater level recedes again. Further to this, Council may monitor the existing borehole and standpipe over time, including a wet season, to assess this potential effect. We would be pleased to assist in this regard.

We draw your attention to the enclosed information sheets about your Coffey report.

I trust that this letter meets your current requirements. If you require further information please contact the undersigned on 02 6628 8350 (direct) or 042 339 3531.

For and on behalf of Coffey

Digitally signed by: Rian Vleggaar
Date: 2018.07.11 10:26:15 +10'00'

Rian Vleggaar
Senior Geotechnical Engineer

Attachments: References

Important Information about your Coffey Report

Site Sketch

Log with Explanation Sheets

Permeability Calculations

7. References

US Department of the Interior. (1977). Ground Water Manual. Washington DC: Water Resources Technical Publication.

Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Data should not be separated from the report

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way. Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

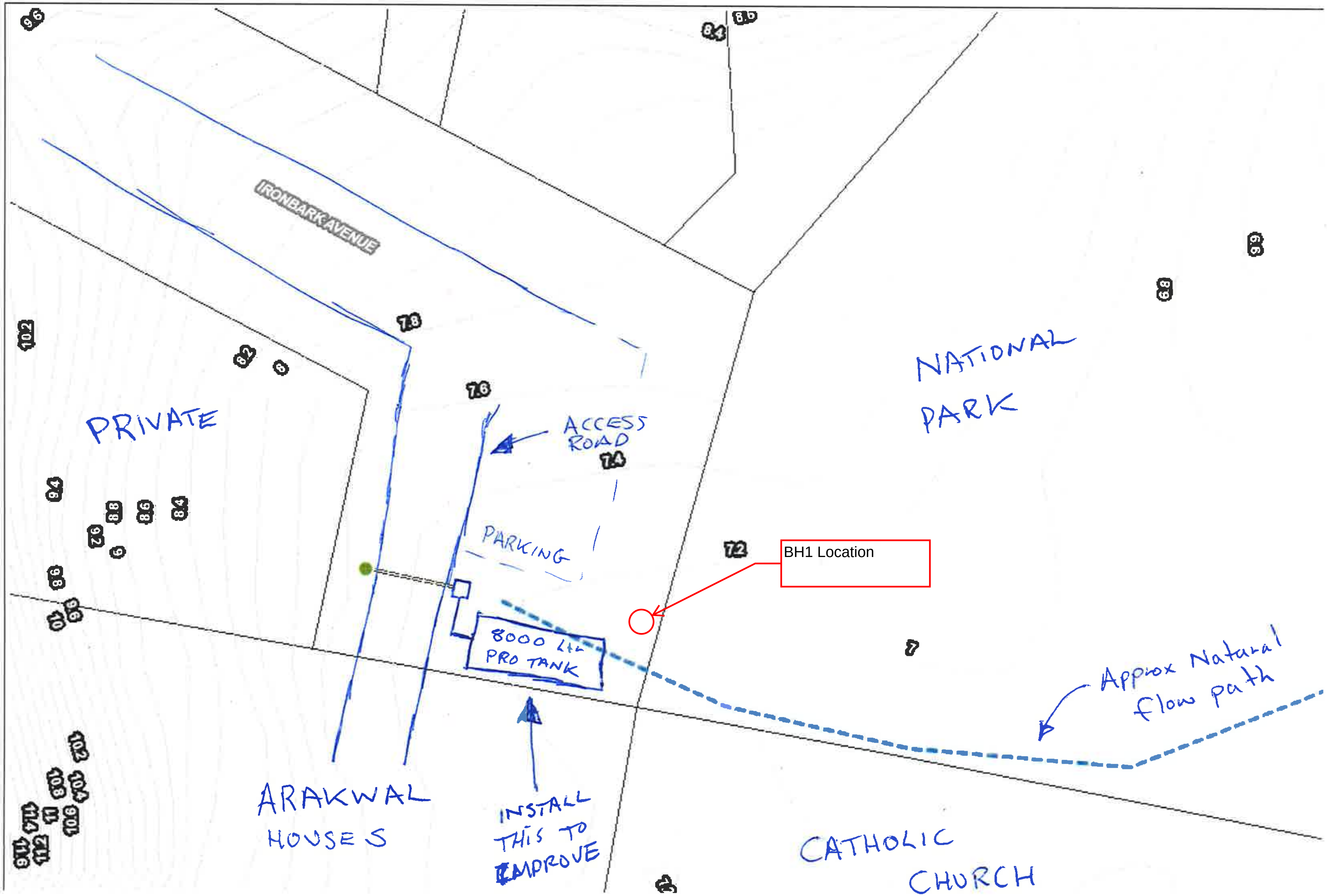
Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

Map Title

200mm Contours



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Engineering Log - Borehole

client:	***BYRON SHIRE COUNCIL***	Hole ID.	***BH1***
principal:		sheet:	1 of 1
project:	***INFILTRATION TESTING***	project no.	***754-LSYGE220175***
location:	***SEE FIGURE 1***	date started:	***06 Jul 2018***
		date completed:	***06 Jul 2018***
		logged by:	***RV***
		checked by:	

position: E: 560,191; N: 6,829,048 (Datum Not Specified) surface elevation: 0.00 m (Datum Not Specified) angle from horizontal: 90°
equipment type: Hand Auger drilling fluid: hole diameter : 75 mm

drilling information | **well details** | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	well 1	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	structure and additional observations
HA / N (0.0–2.86 m)		Not Encountered		Bentonite	0	0.0		CH	**FILL: Gravelly CLAY**: high plasticity, pale brown mottled white.	M		**FILL**
								SP	**SAND**: medium grained, grey-brown.	D		**AEOLIAN**
						0.5						
					-1	1.0			Becoming white and fine to medium grained. Poor recovery on auger down to 2m due to dryness.			
			D (1.5–2.0 m)	Sand / screen		1.5						
					-2	2.0				M		
						2.5						
									Borehole BH1 terminated at 2.86 m Target depth			**backfill details:** 0.0-1.2m: Bentonite 1.2-2.86m: Sand **standpipe 1 details:** stickup: 1.01m 1.31-2.86m: screen
					-3	3.0						
						3.5						

method
AD auger drilling*
AS auger screwing*
HA hand auger
W washbore
HA hand auger

* bit shown by suffix
e.g. AD/T
B blank bit
T TC bit
V V bit

support
M mud N nil
C casing

penetration
1 2 3 no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
B bulk disturbed sample
D disturbed sample
E environmental sample
SS split spoon sample
U## undisturbed sample ##mm diameter
HP hand penetrometer (kPa)
N standard penetration test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
VS vane shear; peak/remouded (kPa)
R refusal
HB hammer bouncing

classification symbol & soil description
based on Unified Classification System

moisture
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

consistency / relative density
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

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Soil Description Explanation Sheet (1 of 2)

DEFINITION:

In engineering terms soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

CLASSIFICATION SYMBOL & SOIL NAME

Soils are described in accordance with the Unified Soil Classification (UCS) as shown in the table on Sheet 2.

PARTICLE SIZE DESCRIPTIVE TERMS

NAME	SUBDIVISION	SIZE
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 µm to 2.36 mm
	medium	200 µm to 600 µm
	fine	75 µm to 200 µm

MOISTURE CONDITION

Dry Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.

Moist Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.

Wet As for moist but with free water forming on hands when handled.

CONSISTENCY OF COHESIVE SOILS

TERM	UNDRAINED STRENGTH s_u (kPa)	FIELD GUIDE
Very Soft	<12	A finger can be pushed well into the soil with little effort.
Soft	12 - 25	A finger can be pushed into the soil to about 25mm depth.
Firm	25 - 50	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 - 100	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 - 200	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	>200	The surface of the soil can be marked only with the thumbnail.
Friable	–	Crumbles or powders when scraped by thumbnail.

DENSITY OF GRANULAR SOILS

TERM	DENSITY INDEX (%)
Very loose	Less than 15
Loose	15 - 35
Medium Dense	35 - 65
Dense	65 - 85
Very Dense	Greater than 85

MINOR COMPONENTS

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: <5% Fine grained soils: <15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%

SOIL STRUCTURE

ZONING		CEMENTING	
Layers	Continuous across exposure or sample.	Weakly cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous layers of lenticular shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water.
Pockets	Irregular inclusions of different material.		

GEOLOGICAL ORIGIN

WEATHERED IN PLACE SOILS

Extremely weathered material	Structure and fabric of parent rock visible.
Residual soil	Structure and fabric of parent rock not visible.

TRANSPORTED SOILS

Aeolian soil	Deposited by wind.
Alluvial soil	Deposited by streams and rivers.
Colluvial soil	Deposited on slopes (transported downslope by gravity).
Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.
Lacustrine soil	Deposited by lakes.
Marine soil	Deposited in ocean basins, bays, beaches and estuaries.

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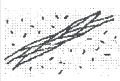
Soil Description Explanation Sheet (2 of 2)

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)						USC	PRIMARY NAME
COARSE GRAINED SOILS More than 50% of materials less than 63 mm is larger than 0.075 mm (A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.0 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.			GW	GRAVEL
			Predominantly one size or a range of sizes with more intermediate sizes missing.			GP	GRAVEL
		GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)			GM	SILTY GRAVEL
			Plastic fines (for identification procedures see CL below)			GC	CLAYEY GRAVEL
	SANDS More than half of coarse fraction is smaller than 2.0 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes			SW	SAND
			Predominantly one size or a range of sizes with some intermediate sizes missing.			SP	SAND
		SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).			SM	SILTY SAND
			Plastic fines (for identification procedures see CL below).			SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm			IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm.				
			DRY STRENGTH	**DILATANCY**	**TOUGHNESS**		
	SILTS & CLAYS Liquid limit less than 50		None to Low	Quick to slow	None	ML	SILT
			Medium to High	None	Medium	CL	CLAY
			Low to medium	Slow to very slow	Low	OL	ORGANIC SILT
	SILTS & CLAYS Liquid limit greater than 50		Low to medium	Slow to very slow	Low to medium	MH	SILT
			High	None	High	CH	CLAY
			Medium to High	None	Low to medium	OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS			Readily identified by colour, odour, spongy feel and frequently by fibrous texture.			Pt	PEAT

• Low plasticity – Liquid Limit W_L less than 35%. • Medium plasticity – W_L between 35% and 50%.

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM
PARTING	A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.	
JOINT	A surface or crack across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. The term 'fissure' may be used for irregular joints <0.2 m in length.	
SHEARED ZONE	Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.	
SHEARED SURFACE	A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.	

TERM	DEFINITION	DIAGRAM
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	
TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter	
TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	
INFILLED SEAM	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open joints.	

Rock Description Explanation Sheet (1 of 2)

The descriptive terms used by Coffey are given below. They are broadly consistent with Australian Standard AS1726-1993.

DEFINITIONS: Rock substance, defect and mass are defined as follows:

Rock Substance	In engineering terms roch substance is any naturally occurring aggregate of minerals and organic material which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Effectively homogenous material, may be isotropic or anisotropic.
Defect	Discontinuity or break in the continuity of a substance or substances.
Mass	Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

SUBSTANCE DESCRIPTIVE TERMS:

ROCK NAME — Simple rock names are used rather than precise geological classification.

PARTICLE SIZE — Grain size terms for sandstone are:

Coarse grained	Mainly 0.6mm to 2mm
Medium grained	Mainly 0.2mm to 0.6mm
Fine grained	Mainly 0.06mm (just visible) to 0.2mm

FABRIC — Terms for layering of penetrative fabric (eg. bedding, cleavage etc.) are:

Massive	No layering or penetrative fabric.
Indistinct	Layering or fabric just visible. Little effect on properties.
Distinct	Layering or fabric is easily visible. Rock breaks more easily parallel to layering of fabric.

CLASSIFICATION OF WEATHERING PRODUCTS

Term	Abbreviation	Definition
Residual Soil	**RS**	Soil derived from the weathering of rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely Weathered Material	**XW**	Material is weathered to such an extent that it has soil properties, ie, it either disintegrates or can be remoulded in water. Original rock fabric still visible.
Highly Weathered Rock	**HW**	Rock strength is changed by weathering. The whole of the rock substance is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Some minerals are decomposed to clay minerals. Porosity may be increased by leaching or may be decreased due to the deposition of minerals in pores.
Moderately Weathered Rock	**MW**	The whole of the rock substance is discoloured, usually by iron staining or bleaching , to the extent that the colour of the fresh rock is no longer recognisable.
Slightly Weathered Rock	**SW**	Rock substance affected by weathering to the extent that partial staining or partial discolouration of the rock substance (usually by limonite) has taken place. The colour and texture of the fresh rock is recognisable; strength properties are essentially those of the fresh rock substance.
Fresh Rock	**FR**	Rock substance unaffected by weathering.

Notes on Weathering:

1. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between XW and SW. For projects where it is not practical to delineate between HW and MW or it is judged that there is no advantage in making such a distinction. DW may be used with the definition given in AS1726.
2. Where physical and chemical changes were caused by hot gasses and liquids associated with igneous rocks, the term "altered" may be substituted for "weathering" to give the abbreviations XA, HA, MA, SA and DA.

ROCK SUBSTANCE STRENGTH TERMS

Term	Abbreviation	Point Load Index, I_S50 (MPa)	Field Guide
Very Low	**VL**	Less than 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; pieces up to 30mm thick can be broken by finger pressure.
Low	**L**	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show with firm bows of a pick point; has a dull sound under hammer. Pieces of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	**M**	0.3 to 1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	**H**	1 to 3	A piece of core 150mm long by 50mm can not be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	**VH**	3 to 10	Hand specimen breaks after more than one blow of a pick; rock rings under hammer.
Extremely High	**EH**	More than 10	Specimen requires many blows with geological pick to break; rock rings under hammer.

Notes on Rock Substance Strength:

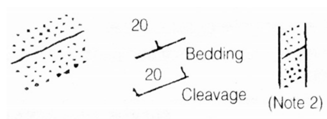
1. In anisotropic rocks the field guide to strength applies to the strength perpendicular to the anisotropy. High strength anisotropic rocks may break readily parallel to the planar anisotropy.
2. The term "extremely low" is not used as a rock substance strength term. While the term is used in AS1726-1993, the field guide therein makes it clear that materials in that strength range are soils in engineering terms.
3. The unconfined compressive strength for isotropic rocks (and anisotropic rocks which fall across the planar anisotropy) is typically 10 to 25 times the point load index (Is50). The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.

Rock Description Explanation Sheet (2 of 2)

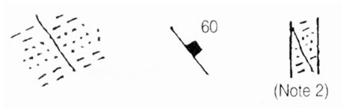
COMMON DEFECTS IN ROCK MASSES

Term | Definition | Diagram | Map Symbol | Graphic Log (Note 1)

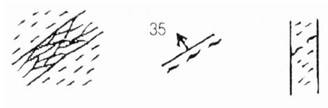
Parting
A surface or crack across which the rock has little or no tensile strength. Parallel or sub parallel to layering (eg bedding) or a planar anisotropy in the rock substance (eg, cleavage). May be open or closed.



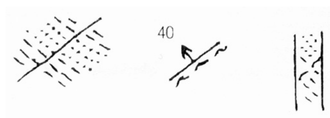
Joint
A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.



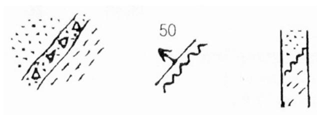
Sheared Zone (Note 3)
Zone of rock substance with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge shaped blocks.



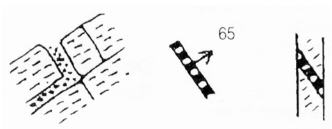
Sheared Surface (Note 3)
A near planar, curved or undulating surface which is usually smooth, polished or slickensided.



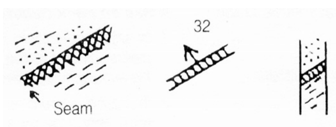
Crushed Seam (Note 3)
Seam with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock substance which may be more weathered than the host rock. The seam has soil properties.



Infilled Seam
Seam of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface.



Extremely Weathered Seam
Seam of soil substance, often with gradational boundaries. Formad by weathering of the rock substance in place.



Notes on Defects:

1. Usually borehole logs show the true dip of defects and face sketches and sections the apparent dip.
2. Partings and joints are not usually shown on the graphic log unless considered significant.
3. Sheared zones, sheared surfaces and crushed seams are faults in geological terms.

DEFECT SHAPE TERMS

Planar	The defect does not vary in orientation
Curved	The defect has a gradual change in orientation
Undulating	The defect has a wavy surface
Stepped	The defect has one or more well defined steps
Irregular	The defect has many sharp changes of orientation

Note: The assessment of defect shape is partly influenced by the scale of the observation.

ROUGHNESS TERMS

Slickensided	Grooved or striated surface, usually polished
Polished	Shiny smooth surface
Smooth	Smooth to touch. Few or no surface irregularities
Rough	Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.
Very Rough	Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.

COATING TERMS

Clean	No visible coating
Stained	No visible coating but surfaces are discoloured
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	A visible coating up to 1mm thick. Thicker soil material is usually described using appropriate defect terms (eg, infilled seam). Thicker rock strength material is usually described as a vein.

BLOCK SHAPE TERMS

Blocky	Approximately equidimensional
Tabular	Thickness much less than length or width
Columnar	Height much greate than cross section

HYDRAULIC CONDUCTIVITY -
ABOVE WATER TABLE - CASED - OPEN
Constant Head

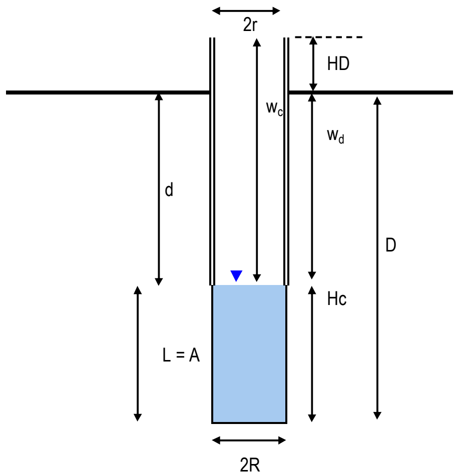
Borehole Number: **BH1**

office: Alstonville

Client :	Byron Shire Council	**Job Number :**	754-LSYGE220175
Principal :		**Test Date :**	6/07/2018
Project :	Ironbark Drive Infiltration pods	**Tested By :**	RV
Test Location :	End of Ironbark Drive	**Checked By :**	

Test Method : Jarvis 1949, after page 270 in USGWM, 1977

Sketch of site conditions (not to scale)



Test Fluid :	Town Supply Water	
Height of Datum, HD :	0	m
Hole Radius, R :	0.038	m
Hole Depth, D :	2.86	m
Casing Radius, r :	0.25	m
Depth of Casing, d :	1.20	m
Test Length, L :	1.66	m
Depth to Water, w_c :	0.82	m
Constant Head, Hc :	2.04	m
Depth to Water Table, w :	4?	m
- date & time :	Estimate	

Constants :

L / Hc :	0.81	
Hc / R :	54	
Cu :	82.9	From Fig 10-7 in USGWM, 1977

Reading No.	Elapsed Time t (mins)	Time Interval Δt (mins)	Water Added per Δt (litres)	Discharge Rate (litres/min)
0	1	1	54.6	54.6
1	2	1	54.6	54.6
2	3	1	54.6	54.6
3	4	1	54.6	54.6
4	5	1	54.6	54.6
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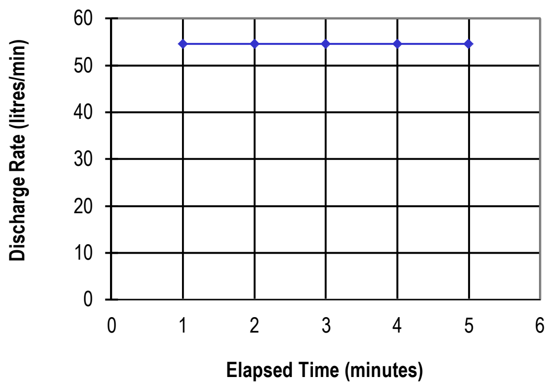
Discharge Rate versus Time



Discharge Rate, Q = 54.6 litres/min

Hydraulic Conductivity, K = $\frac{Q}{Cu\ R\ Hc}$

= **1.43E-04 m/sec**

= **12.4 m/day**

Notes: The flow rate in the test is adjusted such that the measured water level is below the casing, but not more than 3 times the diameter below the casing.

HYDRAULIC CONDUCTIVITY -
ABOVE WATER TABLE - CASED - OPEN
Constant Head

Borehole Number
BH1

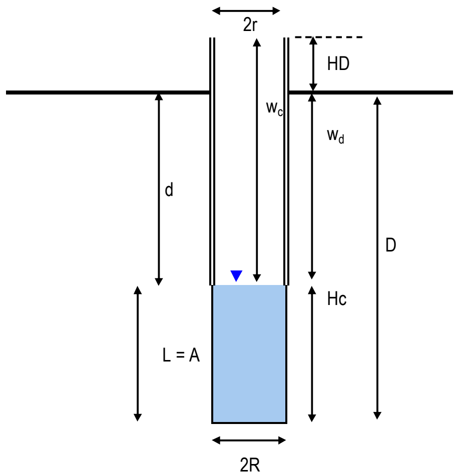
office: Alstonville

Client :	Byron Shire Council	**Job Number :**	754-LSYGE220175
Principal :		**Test Date :**	6/07/2018
Project :	Ironbark Drive Infiltration pods	**Tested By :**	RV
Test Location :	End of Ironbark Drive	**Checked By :**	

Test Method : Jarvis 1949, after page 270 in USGWM, 1977

Test Fluid :	Town Supply Water	
Height of Datum, HD :	0	m
Hole Radius, R :	0.038	m
Hole Depth, D :	2.86	m
Casing Radius, r :	0.25	m
Depth of Casing, d :	1.20	m
Test Length, L :	1.66	m
Depth to Water, w_c :	0.8347	m
Constant Head, Hc :	2.03	m
Depth to Water Table, w :	4?	m
- date & time :	Estimate	

Sketch of site conditions (not to scale)



Constants :

L / Hc :	0.82	
Hc / R :	54	
Cu :	83.5	From Fig 10-7 in USGWM, 1977

Reading No.	Elapsed Time t (mins)	Time Interval Δt (mins)	Water Added per Δt (litres)	Discharge Rate (litres/min)
0	1	1	51.6	51.6
1	2	1	51.6	51.6
2	3	1	51.6	51.6
3	4	1	51.6	51.6
4	5	1	51.6	51.6
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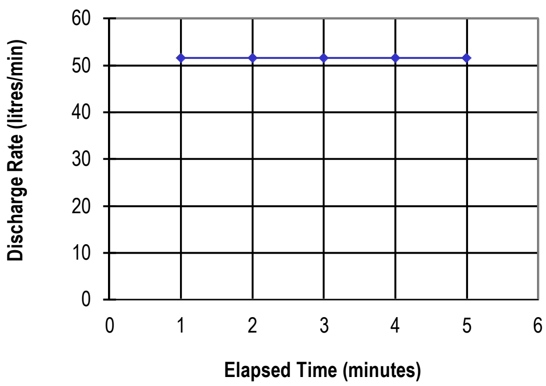
Discharge Rate versus Time



Discharge Rate, Q = 51.6 litres/min

Hydraulic Conductivity, K = $\frac{Q}{Cu\ R\ Hc}$

= **1.36E-04 m/sec**

= **11.7 m/day**

Notes: The flow rate in the test is adjusted such that the measured water level is below the casing, but not more than 3 times the diameter below the casing.

HYDRAULIC CONDUCTIVITY -
ABOVE WATER TABLE - CASED - OPEN
Constant Head

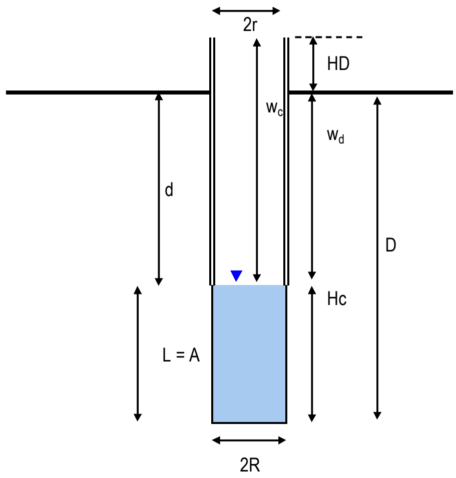
Borehole Number: **BH1**

office: Alstonville

Client :	Byron Shire Council	**Job Number :**	754-LSYGE220175
Principal :		**Test Date :**	6/07/2018
Project :	Ironbark Drive Infiltration pods	**Tested By :**	RV
Test Location :	End of Ironbark Drive	**Checked By :**	

Test Method : Jarvis 1949, after page 270 in USGWM, 1977

Sketch of site conditions (not to scale)



Test Fluid :	Town Supply Water	
Height of Datum, HD :	0	m
Hole Radius, R :	0.038	m
Hole Depth, D :	2.86	m
Casing Radius, r :	0.25	m
Depth of Casing, d :	1.20	m
Test Length, L :	1.66	m
Depth to Water, w_c :	1.12	m
Constant Head, Hc :	1.74	m
Depth to Water Table, w :	4?	m
- date & time :	Estimate	

Constants :

L / Hc :	0.95	
Hc / R :	46	
Cu :	81.8	From Fig 10-7 in USGWM, 1977

Reading No.	Elapsed Time t (mins)	Time Interval Δt (mins)	Water Added per Δt (litres)	Discharge Rate (litres/min)
0	1	1	38.4	38.4
1	2	1	38.4	38.4
2	3	1	38.4	38.4
3	4	1	38.4	38.4
4	5	1	38.4	38.4
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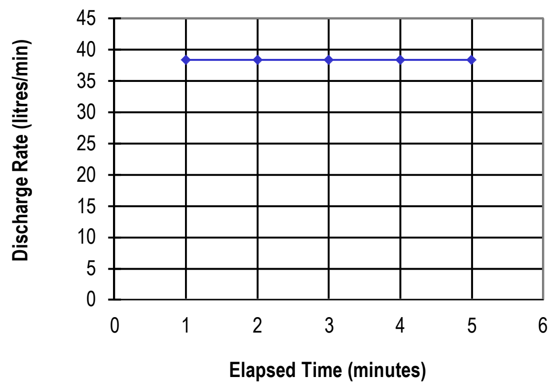
Discharge Rate versus Time



Discharge Rate, Q = 38.4 litres/min

Hydraulic Conductivity, K = $\frac{Q}{Cu\ R\ Hc}$

= **1.20E-04 m/sec**

= **10.4 m/day**

Notes: The flow rate in the test is adjusted such that the measured water level is below the casing, but not more than 3 times the diameter below the casing.