Appendix 4

Geotechnical Investigations February and December 2012

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MACQUARIE GEOTECH

Geotechnical Engineers & Engineering Geologists
NATA Accredited Laboratories for Asphalt, Aggregate, Coal,
Concrete, Environmental, Soil & Rock
Geotechnical & Environmental Drilling

Geotechnical Investigation for Proposed Waste Management Facility, Nyngan

Bogan Shire Council

15th February 2012

Ref: 12/047

NATA

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APPENDICES

1 INTRODUCTION

At the request of Dean Woods from Bogan Shire Council, Macquarie Geotechnical has carried out a Geotechnical investigation for permeability assessment of material at the proposed waste management facility, Nyngan.

The objectives of this investigation were to determine the sub-surface conditions and provide permeability parameters.

2 METHOD OF INVESTIGATION

Fieldwork was undertaken on 6th February 2012 by an Engineering Geologist from our Bathurst office.

The fieldwork was undertaken in accordance with AS1726 - "Geotechnical Site Investigations" and our proposal dated 9th January 2012.

The fieldwork comprised six test pits up to 1.2m depth.

The test pits were excavated using a backhoe fitted with a 450mm toothed bucket. The test pits were identified as TP1 to TP6 inclusive. The test pit locations are shown in Appendix B and the test pit logs are located in Appendix C.

The soil samples were returned to Macquarie Geotechnical NATA accredited laboratory in Bathurst for further assessment and testing.

Laboratory testing was carried out on selected samples and included the following:

- Six (6) Falling Head Permeability tests for soil permeability characteristics

Subsequently, the results of the field investigation and laboratory testing were assessed and this report prepared.

2.1 Testing Methods

Falling Head Permeability Testing:
Falling Head Permeability testing was carried out as per AS1289 6.7.2.

Moisture Contents:
The moisture contents of the samples were determined in accordance with AS1289 2.1.1.

Maximum Dry Density:
The maximum dry density of the samples was determined in accordance with AS1289 5.1.1.

3 SITE DESCRIPTION

The site is located off the Nyngan – Mundaroo Road, behind the existing Nyngan Waste Facility, approximately 5km North of Nyngan.

At the time of the investigation the test pits were located in relatively flat lying scrubland with an elevation of 170m.

The site plan and test pit locations are attached within Appendix B.

3.1 Regional Geology

Reference to the Nyngan Geological map (1 250:000) sheet SH/55-15 and indicates that the geology underlying the site consists of the following:

"Unconsolidated dark yellow brown clay, slightly silty with rare carbonate nodules and quartz sand. Common desiccation cracks. Laminated and contains rootlets."

4 RESULTS OF INVESTIGATION

4.1 Sub-surface conditions

The existing ground conditions have been summarised as follows:

Table 1: Subsurface Conditions TP-1 to TP-5

Depth (m)	Log	Descriptions
0.0 – 0.60		Sandy CLAY with roots: red brown, medium to high plasticity clay, fine to coarse sand, firm, moist, moisture content ~ plastic limit (TOPSOIL) (ALLUVIAL)
0.60 – 1.20		Sandy CLAY trace gravel: red brown, medium to high plasticity clay, fine to coarse sand, fine subangular to subrounded gravel, stiff, dry, moisture content < plastic limit (ALLUVIAL).

Note: Please refer to logs for detailed descriptions.
Groundwater was not encountered in the test pits.

4.2 Laboratory Test Results

Laboratory testing in this area is summarised as follows;

Table 2: Results of Falling Head Permeability

Test Pit Number	Depth (m)	Permeability
TP-1	0.8 – 1.0	3.48×10^{-9}
TP-2	0.8 – 1.0	9.17×10^{-8}
TP-3	0.8 – 1.0	3.90×10^{-9}
TP-4	0.8 – 1.0	7.44×10^{-11}
TP-5	0.8 – 1.0	7.13×10^{-9}
TP-6	0.8 – 1.0	2.05×10^{-11}

5 CONCLUSION

The findings of our report were based on our fieldwork, in-situ testing, laboratory testing, technical assessment and local knowledge for this site. We trust the foregoing is sufficient for your present purposes, and if you have any questions please contact either of the undersigned.

Yours sincerely

Karl Addison
Engineering Geologist
BSc (Hons) Environmental Management

Reviewed by

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References: Australian Standard 1726 – 2007 Geotechnical Site Investigations

LIMITATIONS OF GEOTECHNICAL SITE INVESTIGATION

Scope of Services

This report has been prepared for the Client in accordance with the Services Engagement Form (SEF), between the Client and Macquarie Geotechnical.

Reliance on Data

Macquarie Geotechnical has relied upon data and other information provided by the Client and other individuals. Macquarie Geotechnical has not verified the accuracy or completeness of the data, except as otherwise stated in the report. Recommendations in the report are based on the data.

Macquarie Geotechnical will not be liable in relation to incorrect recommendations should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed.

Geotechnical Investigation

Findings of Geotechnical Investigations are based extensively on judgment and experience. Geotechnical reports are prepared to meet the specific needs of individual clients. This report was prepared expressly for the Client and expressly for the Clients purposes.

This report is based on a subsurface investigation, which was designed for project-specific factors. Unless further geotechnical advice is obtained this report cannot be applied to an adjacent site nor can it be used when the nature of any proposed development is changed.

Limitations of Site investigation

As a result of the limited number of sub-surface excavations or boreholes there is the possibility that variations may occur between test locations. The investigation undertaken is an estimate of the general profile of the subsurface conditions. The data derived from the investigation and laboratory testing are extrapolated across the site to form a geological model. This geological model infers the subsurface conditions and their likely behavior with regard to the proposed development.

The actual conditions at the site might differ from those inferred to exist.

No subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies.

Time Dependence

This report is based on conditions, which existed at the time of subsurface exploration. Construction operations at or adjacent to the site, and natural events such as floods, or groundwater fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report.

Macquarie Geotechnical should be kept appraised of any such events, and should be consulted for further geotechnical advice if any changes are noted.

Avoid Misinterpretation

A geotechnical engineer or engineering geologist should be retained to work with other design professionals explaining relevant geotechnical findings and in reviewing the adequacy of their plans and specifications relative to geotechnical issues.

No part of this report should be separated from the Final Report.

Sub-surface Logs

Sub-surface logs are developed by geoscientific professionals based upon their interpretation of field logs and laboratory evaluation of field samples. These logs should not under any circumstances be redrawn for inclusion in any drawings.

Geotechnical Involvement During Construction

During construction, excavation frequently exposes subsurface conditions. Geotechnical consultants should be retained through the construction stage, to identify variations if they are exposed.

Report for Benefit of Client

The report has been prepared for the benefit of the Client and no other party. Other parties should not rely upon the report or the accuracy or completeness of any recommendations and should make their own enquiries and obtain independent advice in relation to such matters

Macquarie Geotechnical assumes no responsibility and will not be liable to any other person or organisations for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisations arising from matters dealt with or conclusions expressed in the report.

Other limitations

Macquarie Geotechnical will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

Other Information

For further information reference should be made to "Guidelines for the Provision of Geotechnical Information in Construction Contracts" published by the Institution of Engineers Australia, 1987.

Appendix A – General Notes

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Explanatory Notes

Soil Description

In engineering terms soil includes every type of uncemented or partially cemented inorganic material found in the ground. In practice, if the material can be remoulded by hand in its field condition or in water it is described as a soil. The dominant soil constituent is given in capital letters, with secondary textures in lower case. The dominant feature is assessed from the Unified Soil Classification system and a soil symbol is used to define a soil layer as follows:

UNIFIED SOIL CLASSIFICATION

The appropriate symbols are selected on the result of visual examination, field tests and available laboratory tests, such as, sieve analysis, liquid limit and plasticity index.

USC Symbol	Description
GW	Well graded gravel
GP	Poorly graded gravel
GM	Silty gravel
GC	Clayey gravel
SW	Well graded sand
SP	Poorly graded sand
SM	Silty sand
SC	Clayey sand
ML	Silt of low plasticity
CL	Clay of low plasticity
OL	Organic soil of low plasticity
MH	Silt of high plasticity
CH	Clay of high plasticity
OH	Organic soil of high plasticity
Pt	Peaty Soil

MOISTURE CONDITION

Dry – Cohesive soils are friable or powdery
Cohesionless soil grains are free-running

Moist – Soil feels cool, darkened in colour
Cohesive soils can be moulded
Cohesionless soil grains tend to adhere

Wet – Cohesive soils usually weakened
Free water forms on hands when handling

For cohesive soils the following codes may also be used:

MC>PL Moisture Content greater than the Plastic Limit.
MC~PL Moisture Content near the Plastic Limit.
MC<PL Moisture Content less than the Plastic Limit.

PLASTICITY

The potential for soil to undergo change in volume with moisture change is assessed from its degree of plasticity. The classification of the degree of plasticity in terms of the Liquid Limit (LL) is as follows:

Description of Plasticity	LL (%)
Low	<35
Medium	35 to 50
High	>50

COHESIVE SOILS – CONSISTENCY

The consistency of a cohesive soil is defined by descriptive terminology such as very soft, soft, firm, stiff, very stiff and hard. These terms are assessed by the shear strength of the soil as observed visually, by the pocket penetrometer values and by resistance to deformation to hand moulding.

A Pocket Penetrometer may be used in the field or the laboratory to provide approximate assessment of unconfined compressive strength of cohesive soils. The values are recorded in kPa, as follows:

Strength	Symbol	Pocket Penetrometer Reading (kPa)
Very Soft	VS	< 25
Soft	S	20 to 50
Firm	F	50 to 100
Stiff	St	100 to 200
Very Stiff	VSt	200 to 400

Hard	H	> 400

COHESIONLESS SOILS – RELATIVE DENSITY

Relative density terms such as very loose, loose, medium, dense and very dense are used to describe silty and sandy material, and these are usually based on resistance to drilling penetration or the Standard Penetration Test (SPT) 'N' values. Other condition terms, such as friable, powdery or crumbly may also be used.

The Standard Penetration Test (SPT) is carried out in accordance with AS 1289, 6.3.1. For completed tests the number of blows required to drive the split spoon sampler 300 mm are recorded as the N value. For incomplete tests the number of blows and the penetration beyond the seating depth of 150 mm are recorded. If the 150 mm seating penetration is not achieved the number of blows to achieve the measured penetration is recorded. SPT correlations may be subject to corrections for overburden pressure and equipment type.

Term	Symbol	Density Index	N Value (blows/0.3 m)
Very Loose	VL	0 to 15	0 to 4
Loose	L	15 to 35	4 to 10
Medium Dense	MD	35 to 65	10 to 30
Dense	D	65 to 85	30 to 50
Very Dense	VD	>85	>50

COHESIONLESS SOILS 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

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Rock Description

The rock is described with strength and weathering symbols as shown below. Other features such as bedding and dip angle are given.

ROCK QUALITY

The fracture spacing is shown where applicable and the Rock Quality Designation (RQD) or Total Core Recovery (TCR) is given where:

$$\text{RQD (\%)} = \frac{\text{Sum of Axial lengths of core} > 100\text{mm long}}{\text{total length considered}}$$

$$\text{TCR (\%)} = \frac{\text{length of core recovered}}{\text{length of core run}}$$

ROCK STRENGTH

Rock strength is described using AS1726 and ISRM – Commission on Standardisation of Laboratory and Field Tests, "Suggested method of determining the Uniaxial Compressive Strength of Rock materials and the Point Load Index", as follows:

Term	Symbol	Point Load Index $Is_{(50)}$ (MPa)
Extremely Low	EL	<0.03
Very Low	VL	0.03 to 0.1
Low	L	0.1 to 0.3
Medium	M	0.3 to 1
High	H	1 to 3
Very High	VH	3 to 10
Extremely High	EH	>10

ROCK MATERIAL WEATHERING

Rock weathering is described using the following abbreviation and definitions used in AS1726:

Abbreviation	Term
RS	Residual soil
XW	Extremely weathered
DW	Distinctly weathered
SW	Slightly weathered
FR	Fresh

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DEFECT SPACING/BEDDING THICKNESS

Measured at right angles to defects of same set or bedding.

Term	Defect Spacing	Bedding
Extremely closely spaced	<6 mm	Thinly Laminated
	6 to 20 mm	Laminated
Very closely spaced	20 to 60 mm	Very Thin
Closely spaced	0.06 to 0.2 m	Thin
Moderately widely spaced	0.2 to 0.6 m	Medium
Widely spaced	0.6 to 2 m	Thick
Very widely spaced	>2 m	Very Thick

DEFECT DESCRIPTION

Type:	Description
B	Bedding
F	Fault
C	Cleavage
J	Joint
S	Shear Zone
D	Drill break

Planarity/Roughness:

Class	Description
I	rough or irregular, stepped
II	smooth, stepped
III	slickensided, stepped
IV	rough or irregular, undulating
V	smooth, undulating
VI	slickensided, undulating
VII	rough or irregular, planar
VIII	smooth, planar
IX	slickensided, planar

The inclination if defects are measured from perpendicular to the core axis.

WATER

Water level at date shown Partial water loss

Water inflow Complete water loss

Groundwater not observed: The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.

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Graphic Symbols for Soils and Rocks

Typical symbols for soils and rocks are as follows. Combinations of these symbols may be used to indicated mixed materials such as clayey sand.

Soil Symbols

Main components


CLAY


SILT


SAND


GRAVEL


BOULDERS / COBBLES


TOPSOIL


PEAT

Minor Components


Clayey


Silty


Sandy


Gravelly

Other


FILL


BITUMEN


CONCRETE

Rock Symbols

Sedimentary Rocks


SANDSTONE


SILTSTONE


CLAYSTONE, MUDSTONE


SHALE


LAMINITE


COAL


LIMESTONE


CONGLOMERATE

Igneous Rocks


GRANITE


BASALT


UNDIFFERENTIATED IGNEOUS

Metamorphic Rocks


SLATE, PHYLLITE, SCHIST


GNEISS


QUARTZITE

Groundwater not encountered: The borehole/test pit was dry soon after excavation, however groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period.

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Engineering Classification of Shales and Sandstones in the Sydney Region – A Summary Guide

The Sydney Rock Class classification system is based on rock strength, defect spacing and allowable seams as set out below. All three factors must be satisfied.

CLASSIFICATION FOR SANDSTONE

Class	Uniaxial Compressive Strength (MPa)	Defect Spacing (mm)	Allowable Seams (%)
I	>24	>600	<1.5
II	>12	>600	<3
III	>7	>200	<5
IV	>2	>60	<10
V	>1	N.A.	N.A.

CLASSIFICATION FOR SHALE

Class	Uniaxial Compressive Strength (MPa)	Defect Spacing (mm)	Allowable Seams (%)
I	>16	>600	<2
II	>7	>200	<4
III	>2	>60	<8
IV	>1	>20	<25
V	>1	N.A.	N.A.

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UNIAXIAL COMPRESSIVE STRENGTH (UCS)

For expedience in field/construction situations the uniaxial (unconfined) compressive strength of the rock is often inferred, or assessed using the point load strength index (Is_{50}) test (AS 4133.4.1 – 1993). For Sydney Basin sedimentary rocks the uniaxial compressive strength is typically about 20 x (Is_{50}) but the multiplier may range from about 10 to 30 depending on the rock type and characteristics. In the absence of UCS tests, the assigned Sydney Rock Class classification may therefore include rock strengths outside the nominated UCS range.

DEFECT SPACING

The terms relate to spacing of natural fractures in NMLC, NQ and HQ diamond drill cores and have the following definitions:

Defect Spacing (mm)	Terms Used to Describe Defect Spacing[1]
>2000	Very widely spaced
600 – 2000	Widely spaced
200 – 600	Moderately spaced
60 – 200	Closely spaced
20 – 60	Very closely spaced
<20	Extremely closely spaced

[1]After ISO/CD14689 and ISRM.

ALLOWABLE SEAMS

Seams include clay, fragmented, highly weathered or similar zones, usually sub-parallel to the loaded surface. The limits suggested in the tables relate to a defined zone of influence. For pad footings, the zone of influence is defined as 1.5 times the least footing dimension. For socketed footings, the zone includes the length of the socket plus a further depth equal to the width of the footing. For tunnel or excavation assessment purposes the defects are assessed over a length of core of similar characteristics.

Source: Based on Pells et al (1978), as revised by Pells et al (1998).
Pells, P.J.N, Mostyn, G. and Walker, B.F. – Foundations on Sandstone and Shale in the Sydney Region. Australian Geomechanics Journal, No 33 Part 3, December 1998.

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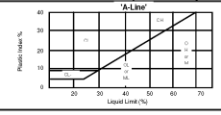
Summary of Soil Logging Procedures

Coarse Material: grain size - colour - particle shape - secondary components - minor constituents - moisture condition - relative density - origin - additional observations.
Fine Material: plasticity - colour - secondary components - minor constituents - moisture w.r.t. plasticity - consistency - origin - additional observations.

Guide to the Description, Identification and Classification of Soils

Major Divisions				SYMBOL	Typical Names
> 200mm		BOULDERS			
60 to 200mm		COBBLES			
COARSE GRAINED SOILS	More than 50% by dry mass less than 60mm is greater than 0.075mm	Gravelly Soils	GRAVEL More than 50% of coarse fraction > 2.36mm	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
				GP	Poorly graded gravels and gravel-sand mixtures, little or no fines, uniform gravels.
				GM	Silty gravels, gravel-sand-silt mixtures.
				GC	Clayey gravels, gravel-sand-clay mixtures
		Sandy Soils	SANDS More than 50% of coarse fraction < 2.36mm	SW	Well-graded sands, gravelly sands, little or no fines.
				SP	Poorly graded sands and gravelly sands; little or no fines, uniform sands.
				SM	Silty sands, sand-silt mixtures.
				SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	More than 50% by dry mass less than 60mm is less than 0.075mm		Liquid Limit < 50%	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts
				CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays.
				OL	Organic silts and organic silty clays of low plasticity.
			Liquid Limit > 50%	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
				CH	Inorganic clays of high plasticity, fat clays.
				OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS				Pt	Peat and other highly organic soils.



Grain sizes			
Gravel		Sand	
Coarse -	63 to 20mm	Coarse -	2.36 to 0.6mm
Medium -	20 to 6 mm	Medium -	0.6 to 0.2mm
Fine -	6 to 2.36mm	Fine -	0.2 to 0.075mm

GEOLOGICAL ORIGIN:-
Fill - artificial soils / deposits
Alluvial - soils deposited by the action of water
Aeolian - soils deposited by the action of wind
Topsoil - soils supporting plant life containing significant organic content
Residual - soils derived from insitu weathering of parent rock.
Colluvial - transported debris usually unsorted, loose and deposited

Field Identification of Fine Grained Soils - Silt or Clay?
Dry Strength - Allow the soil to dry completely and then test its strength by breaking and crumbling between the fingers.
High dry strength - Clays; Very slight dry strength - Silts.
Toughness Test - the soil is rolled by hand into a thread about 3mm in diameter. The thread is then folded and re-rolled repeatedly until it has dried sufficiently to break into lumps. In this condition inorganic clays are fairly stiff and tough while inorganic silts produce a weak and often soft thread which may be difficult to form and readily breaks and crumbles.
Dilatancy Test - Add sufficient water to the soil, held in the palm of the hand, to make it soft but not sticky. Shake horizontally, striking vigorously against the other hand several times. Dilatancy is indicated by the appearance of a shiny film on the surface of the soil. If the soil is then squeezed or pressed with the fingers, the surface becomes dull as the soil stiffens and eventually crumbles. These reactions are pronounced only for predominantly silt size material. Plastic clays give no reaction.

Descriptive Terms for Material Portions

COARSE GRAINED SOILS		FINE GRAINED SOILS	
% Fines	*Term/Modifier*	*% Coarse*	*Term/Modifier*
< 5	Omit, or use "trace"	< 15	Omit, or use "trace"
> 5, < 12	"with clay/silt" as applicable	> 15, < 30	"with sand/gravel" as applicable
> 12	Prefix soil as "silty/clayey"	> 30	Prefix as "sandy/gravelly"

Moisture Condition

for non-cohesive soils:
Dry - runs freely through fingers.
Moist - does not run freely but no free water visible on soil surface.
Wet - free water visible on soil surface.

for cohesive soils:
MC > PL Moisture content estimated to be greater than the plastic limit.
MC ~ PL Moisture content estimated to be approximately equal to the plastic limit. The soil can be moulded
MC < PL Moisture content estimated to be less than the plastic limit. The soil is hard and friable, or powdery.

The plastic limit (PL) is defined as the moisture content (percentage) at which the soil crumbles when rolled into threads of 3mm dia.

Consistency - For Clays & Silts

Description	*UCS(kPa)*	*Field guide to consistency*
Very soft	< 25	Exudes between the fingers when squeezed in hand
Soft	25 - 50	Can be moulded by light finger pressure
Firm	50 - 100	Can be moulded by strong finger pressure
Stiff	100 - 200	Cannot be moulded by fingers. Can be indented by thumb.
Very stiff	200 - 400	Can be indented by thumb nail
Hard	> 400	Can be indented with difficulty by thumb nail
Friable	-	Crumbles or powders when scraped by thumbnail

Relative Density for Gravels and Sands

Description	*SPT "N" Value*	*Density Index (ID) Range %*
Very loose	0 - 4	< 15
Loose	4 - 10	15 - 35
Medium dense	10 - 30	35 - 65
Dense	30 - 50	65 - 85
Very dense	> 50	> 85

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Summary of Rock Logging Procedures

Description order: constituents - rock name - grain size - colour - weathering - strength - minor constituents - additional observations.
- minor constituents - moisture w.r.t. plasticity - consistency - origin - additional observations.

Definition - Sedimentary Rock	
Conglomerate	more than 50% of the rock consists of gravel (> 2mm) sized fragments
Sandstone	more than 50% of the rock consists of sand (0.06 to 2mm) sized grains
Siltstone	more than 50% of the rock consists of silt sized granular particles and the rock is not laminated
Claystone	more than 50% of the rock consists of clay or mica material and the rock is not laminated
Shale	more than 50% of the rock consists of clay or silt sized particles and the rock is laminated

Weathering		
Residual Soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a change in volume but the soil has not significantly transported.
Extremely Weathered	EW	Rock is weathered to such an extent that it has 'soil' properties; ie. it either disintegrates or can be remoulded, in water
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 weathering products in pores.
Slightly Weathered	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh	FR	Rock shows no sign of decomposition or staining.

Stratification			
thinly laminated	< 6mm	medium bedded	0.2 - 0.6m
laminated	6 - 20mm	thickly bedded	0.6 - 2m
very thinly bedded	20 - 60mm	very thickly bedded	> 2m
thinly bedded	60mm - 0.2m		

Discontinuities

order of description: depth - type - orientation - spacing - roughness / planarity - thickness - coating

	Type	Class	Roughness/Planarity	Class	Roughness/Planarity
B	Bedding	I	rough or irregular, stepped	VI	slickensided, undulating
F	Fault	II	smooth, stepped	VII	rough or irregular, planar
C	Cleavage	III	slickensided, stepped	VIII	smooth, planar
J	Joint	IV	rough or irregular, undulating	IX	slickensided, planar
S	Shear Zone	V	smooth, undulating		
D	Drill break				

Rock Strength			
Term		Is (50)	Field Guide
Extremely Low	EL	0.03	Easily remoulded by hand to a material with soil properties.
Very low	VL	0.1	May be crumbled in the hand. Sandstone is "sugary" and friable
Low	L	0.3	A piece of core 150 mm long x 50 mm dia. may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.
Medium	M	1	A piece of core 150 mm long x 50 mm dia. can be broken by hand with considerable difficulty. Readily scored with knife.
High	H	3	A piece of core 150 mm long x 50 mm dia. core cannot be broken by unaided hands, can be slightly scratched or scored with knife.
Very High	VH	10	A piece of core 150 mm long x 50 mm dia. May be broken readily with hand held hammer. Cannot be scratched with pen knife.
Extremely High	EH		A piece of core 150 mm long x 50 mm dia. Is difficult to break with hand held hammer. Rings when struck with a hammer.

* - rock strength defined by point load strength (Is 50) in direction normal to bedding

Degree of fracturing	
fragmented	The core is comprised primarily of fragments of length less than 20mm, and mostly of width less than the core diameter
highly fractured	Core lengths are generally less than 20mm - 40mm with occasional fragments.
fractured	Core lengths are mainly 30mm - 100mm with occasional shorter and longer lengths
slightly fractured	Core lengths are generally 300mm - 1000mm with occasional longer sections and shorter sections of 100mm -- 300mm.
unbroken	The core does not contain any fracture.

- spacing of all types of natural fractures, but not artificial breaks, in cored bores.

The fracture spacing is shown where applicable and the Rock Quality Designation is given by:

$$RQD\ (\%) = \frac{\text{sum of unbroken core pieces 100 mm or longer}}{\text{total length considered}}$$

M:\2011\11-009-GHD-Intersection of the Orange distributor & Telopea Way in north orange-PI&D\Appendix A.doc 1 February, 2011
10

Appendix B

Site Plan & Test Pit Location

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Soils, Coal, Aggregates and Concrete
Geotechnical & Environmental Drilling

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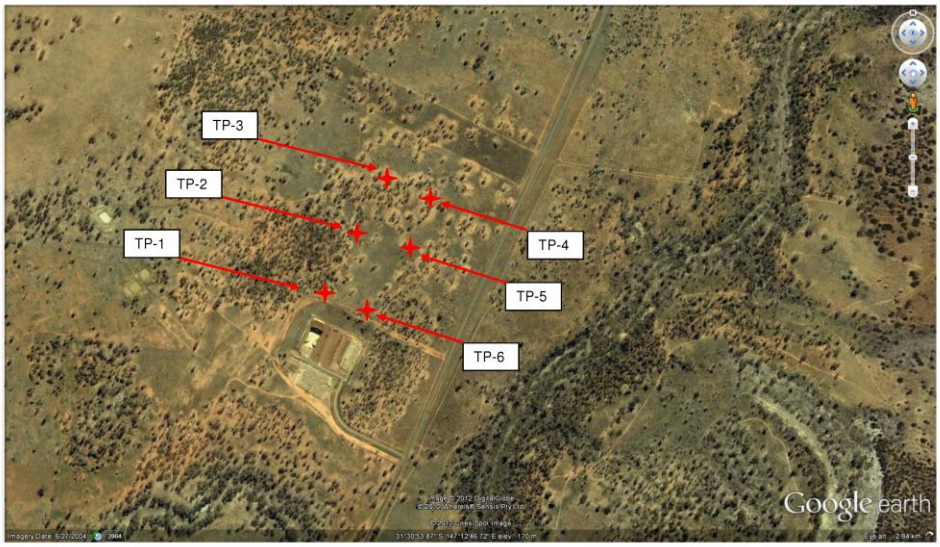
Test Pit Locations



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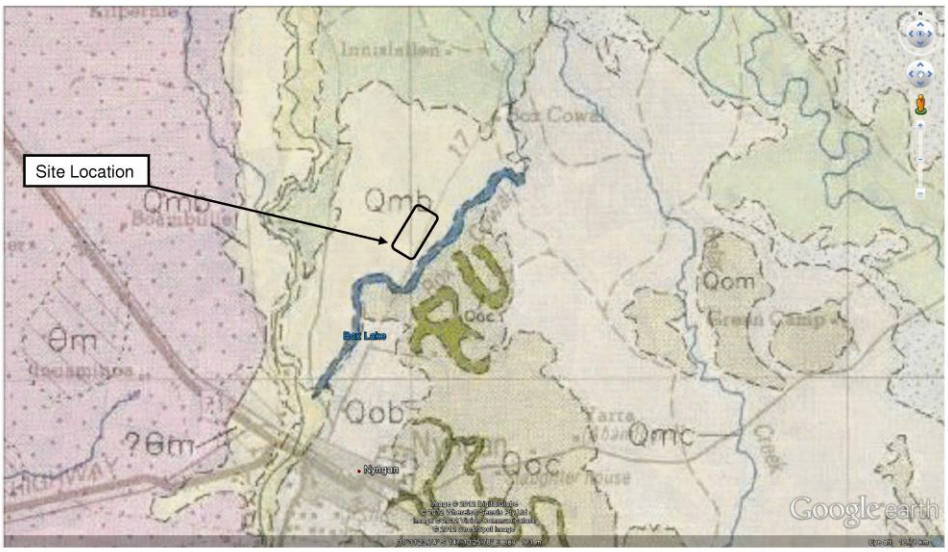
Geotechnical & Environmental Drilling

NATA

Site Location with Geological Map Overlay



KEY:
Qmb: "Unconsolidated dark yellow brown clay, slightly silty with rare carbonate nodules and quartz sand. Common desiccation cracks. Laminated and contains rootlets"
Qob: "Unconsolidated pale grey to grey brown silt, clay and sand with rare carbonate nodules. Very poorly sorted. Commonly cracking."

Appendix C – Test Pit Logs

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9 Bant Street
Bathurst NSW 2795
Telephone: 63322011
Fax: 63344213

TEST PIT NUMBER TP-01

PAGE 1 OF 1

CLIENT Bogan Shire Council **PROJECT NAME** Proposed Waste Management Facility

PROJECT NUMBER 12-047 **PROJECT LOCATION** Nyngan

DATE STARTED 6/2/12 **COMPLETED** 6/2/12 **R.L. SURFACE** --- **DATUM** ---

EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---

EQUIPMENT Backhoe **TEST PIT LOCATION** ---

TEST PIT SIZE 450mm **LOGGED BY** KA **CHECKED BY** JB

NOTES ---

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	DCP (blows/100mm) 0 5 10 15 20 25	Additional Observations
					CL	Sandy CLAY with roots: red brown, medium to high plasticity clay, fine to coarse sand, firm, moist, moisture content ~ plastic limit (TOPSOIL) (ALLUVIAL).			
			0.5		CH	Sandy CLAY trace gravel: red brown, medium to high plasticity clay, fine to coarse sand, fine subangular to subrounded gravel, stiff, dry, moisture content < plastic limit (ALLUVIAL).			
			1.0			Borehole TP-01 terminated at 1.1m			
			1.5						
			2.0						
			2.5						
			3.0						

BOREHOLE / TEST PIT TP LOGS.GPJ GINT STD AUSTRALIA.GDT 15/2/12

MACQUARIE GEOTECH

Macquarie Geotech
9 Bant Street
Bathurst NSW 2795
Telephone: 63322011
Fax: 63344213

TEST PIT NUMBER TP-02

PAGE 1 OF 1

CLIENT Bogan Shire Council **PROJECT NAME** Proposed Waste Management Facility

PROJECT NUMBER 12-047 **PROJECT LOCATION** Nyngan

DATE STARTED 6/2/12 **COMPLETED** 6/2/12 **R.L. SURFACE** _____ **DATUM** _____

EXCAVATION CONTRACTOR _____ **SLOPE** --- **BEARING** ---

EQUIPMENT Backhoe **TEST PIT LOCATION** _____

TEST PIT SIZE 450mm **LOGGED BY** KA **CHECKED BY** JB

NOTES _____

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	DCP (blows/100mm) 0 5 10 15 20 25	Additional Observations
					CL	CLAY with silt, sand and roots: brown, medium to high plasticity clay, fine to coarse sand, very soft to soft, moist to wet, moisture content > plastic limit (ALLUVIAL).			
			0.5		CH	Sandy CLAY with silt trace gravel: red brown, medium to high plasticity clay, fine to coarse sand, fine to medium subangular to subrounded gravel, stiff to very stiff, dry, moisture content < plastic limit (ALLUVIAL).			
			1.0			Borehole TP-02 terminated at 1.1m			
			1.5						
			2.0						
			2.5						
			3.0						

BOREHOLE / TEST PIT TP LOGS.GPJ GINT STD AUSTRALIA.GDT 15/2/12

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Telephone: 63322011
Fax: 63344213

TEST PIT NUMBER TP-03

PAGE 1 OF 1

CLIENT Bogan Shire Council **PROJECT NAME** Proposed Waste Management Facility

PROJECT NUMBER 12-047 **PROJECT LOCATION** Nyngan

DATE STARTED 6/2/12 **COMPLETED** 6/2/12 **R.L. SURFACE** --- **DATUM** ---

EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---

EQUIPMENT Backhoe **TEST PIT LOCATION** ---

TEST PIT SIZE 450mm **LOGGED BY** KA **CHECKED BY** JB

NOTES ---

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	DCP (blows/100mm) 0 5 10 15 20 25	Additional Observations
			0.0		CL	Sandy CLAY trace silt and roots: red brown, medium to high plasticity, fine to coarse sand, firm, moist, moisture content ~ plastic limit (TOPSOIL) (ALLUVIAL).			
			0.5		CH	CLAY with sand and silt: red brown, medium to high plasticity, fine to coarse sand, stiff, dry to slightly moist, moisture content < plastic limit (ALLUVIAL).			
			1.0			Borehole TP-03 terminated at 1.1m			
			1.5						
			2.0						
			2.5						
			3.0						

BOREHOLE / TEST PIT TP LOGS.GPJ GINT STD AUSTRALIA.GDT 15/2/12

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Bathurst NSW 2795
Telephone: 63322011
Fax: 63344213

TEST PIT NUMBER TP-04

PAGE 1 OF 1

CLIENT Bogan Shire Council **PROJECT NAME** Proposed Waste Management Facility
PROJECT NUMBER 12-047 **PROJECT LOCATION** Nyngan

DATE STARTED 6/2/12 **COMPLETED** 6/2/12 **R.L. SURFACE** **DATUM**
EXCAVATION CONTRACTOR **SLOPE** --- **BEARING** ---
EQUIPMENT Backhoe **TEST PIT LOCATION**
TEST PIT SIZE 450mm **LOGGED BY** KA **CHECKED BY** JB
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	DCP (blows/100mm) 0 5 10 15 20 25	Additional Observations
					CL	Sandy CLAY with silt: brown, medium to high plasticity clay, fine to coarse sand, firm, slightly moist, moisture content < plastic limit (TOPSOIL) (ALLUVIAL).			
			0.5		CH	Silty CLAY with sand trace gravel: red brown, medium to high plasticity clay, fine to coarse sand, fine to medium subangular gravel, stiff, dry, moisture content < plastic limit (ALLUVIAL).			
			1.0						
						Borehole TP-04 terminated at 1.2m			
			1.5						
			2.0						
			2.5						
			3.0						

BOREHOLE / TEST PIT TP LOGS.GPJ GINT STD AUSTRALIA.GDT 15/2/12

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Fax: 63344213

TEST PIT NUMBER TP-05

PAGE 1 OF 1

CLIENT Bogan Shire Council **PROJECT NAME** Proposed Waste Management Facility

PROJECT NUMBER 12-047 **PROJECT LOCATION** Nyngan

DATE STARTED 6/2/12 **COMPLETED** 6/2/12 **R.L. SURFACE** --- **DATUM** ---

EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---

EQUIPMENT Backhoe **TEST PIT LOCATION** ---

TEST PIT SIZE 450mm **LOGGED BY** KA **CHECKED BY** JB

NOTES ---

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	DCP (blows/100mm) 0 5 10 15 20 25	Additional Observations
					CL	Sandy CLAY with silt and roots: red brown, medium to high plasticity clay, fine to coarse sand, firm, slightly moist, moisture content < plastic limit (TOPSOIL) (ALLUVIAL).			
			0.5		CH	CLAY with sand and silt: red brown, medium to high plasticity clay, fine to coarse sand, stiff, dry, moisture content < plastic limit (ALLUVIAL).			
			1.0			Borehole TP-05 terminated at 1.1m			
			1.5						
			2.0						
			2.5						
			3.0						

BOREHOLE / TEST PIT TP LOGS.GPJ GINT STD AUSTRALIA.GDT 15/2/12

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Bathurst NSW 2795
Telephone: 63322011
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TEST PIT NUMBER TP-06

PAGE 1 OF 1

CLIENT Bogan Shire Council **PROJECT NAME** Proposed Waste Management Facility
PROJECT NUMBER 12-047 **PROJECT LOCATION** Nyngan

DATE STARTED 6/2/12 **COMPLETED** 6/2/12 **R.L. SURFACE** **DATUM**
EXCAVATION CONTRACTOR **SLOPE** --- **BEARING** ---
EQUIPMENT Backhoe **TEST PIT LOCATION**
TEST PIT SIZE 450mm **LOGGED BY** KA **CHECKED BY** JB
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	DCP (blows/100mm) 0 5 10 15 20 25	Additional Observations
					CL	Sandy CLAY with silt and roots: red brown, medium to high plasticity clay, fine to coarse sand, firm, slightly moist, moisture content ~ plastic limit (TOPSOIL) (ALLUVIAL).			
			0.5		CH	Sandy CLAY with silt trace gravel: red brown, medium to high plasticity clay, fine to coarse sand, fine subangular to subrounded gravel, stiff, dry to slightly moist, moisture content < plastic limit (ALLUVIAL).			
			1.0			Borehole TP-06 terminated at 1.1m			
			1.5						
			2.0						
			2.5						
			3.0						

BOREHOLE / TEST PIT TP LOGS.GPJ GINT STD AUSTRALIA.GDT 15/2/12

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Appendix D – Laboratory Test Results

FALLING HEAD PERMEABILITY TEST REPORT

Test Method AS 1289 6.7.2, 5.1.1

Client:	Bogan Shire Council	**Job No:**	12-047
Client Address:	PO Box 221, Nyngan, NSW, 2825	**Sample No:**	8010
		Report No:	01-FHP
Project Location:	Proposed Waste Management Facility, Nyngan	**Date Tested:**	08/02/2012
		Source:	TP1 0.80-1.00m

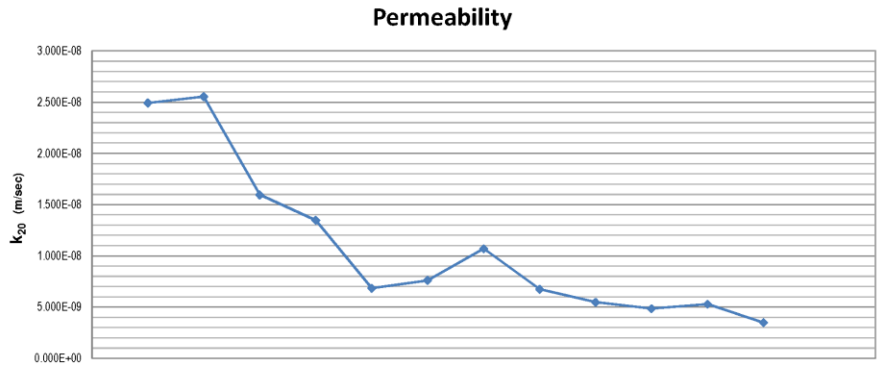
SAMPLE DETAILS

Sample Number:	8010	Sampling Method:	Sampled in accordance with AS1289.6.7.2
Date Sampled:	06/02/2012	Material Type:	Soil
Date Tested:	08/02/2012	Sample Location	TP1 0.80-1.00m
Sampled By:	Macquarie Geotechnical staff	Sample Description	Silty/Sandy CLAY
Remarks:			

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.73**	Hydraulic Gradient	**0.0**
Optimum Moisture Content (%)	**18.2**	Surcharge (kPa)	**0.0**
Placement Moisture Content (%)	**18.1**	Head Pressure Applied (kPa)	**0.0**
Moisture Ratio (%)	**99.6**	Water Type	**Tap**
Placement Dry Density (t/m^3)	**1.70**	Percentage Material Retained/Sieve Size (mm)	**0 % on 9.5 mm**
Density Ratio (%)	**98.1**	Sample Height and Diameter (mm)	**103.81 by 100.33 mm**

PERMEABILITY $k_{(20)}$ = **3.48E-09** **(m/sec)**



Remarks/Comments

Authorised Signatory:

Jason Lewis

Date: 15/02/2012 Page 1

NATA Accredited Laboratory Number: 14874

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BATHURST NSW 2795

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FALLING HEAD PERMEABILITY TEST REPORT

Test Method AS 1289 6.7.2, 5.1.1

Client:	Bogan Shire Council	**Job No:**	12-047
Client Address:	PO Box 221, Nyngan, NSW, 2825	**Sample No:**	8011
		Report No:	02-FHP
Project Location:	Proposed Waste Management Facility, Nyngan	**Date Tested:**	08/02/2012
		Source:	TP2 0.80-1.00m

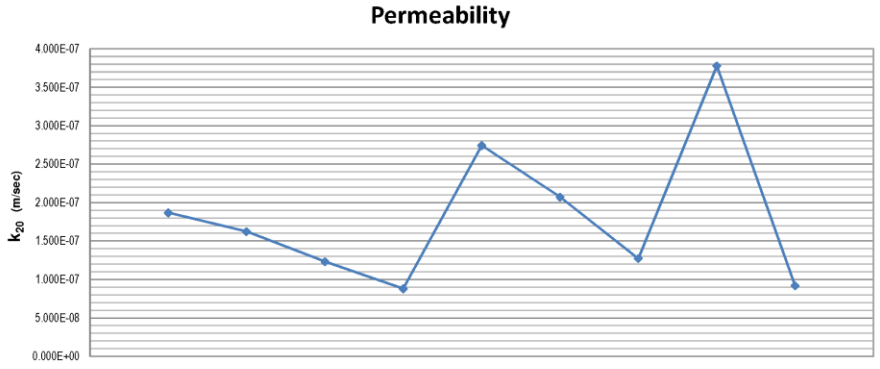
SAMPLE DETAILS

Sample Number:	8011	Sampling Method:	Sampled in accordance with AS1289.6.7.2
Date Sampled:	06/02/2012	Material Type:	Soil
Date Tested:	08/02/2012	Sample Location	TP2 0.80-1.00m
Sampled By:	Macquarie Geotechnical staff	Sample Description	Silty/Sandy CLAY
Remarks:			

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.72**	Hydraulic Gradient	**0.0**
Optimum Moisture Content (%)	**18.8**	Surcharge (kPa)	**0.0**
Placement Moisture Content (%)	**18.8**	Head Pressure Applied (kPa)	**0.0**
Moisture Ratio (%)	**99.8**	Water Type	**Tap**
Placement Dry Density (t/m^3)	**1.68**	Percentage Material Retained/Sieve Size (mm)	**0 % on 9.5 mm**
Density Ratio (%)	**98.0**	Sample Height and Diameter (mm)	**103.98 by 99.66 mm**

PERMEABILITY $k_{(20)}$ = **9.17E-08** (m/sec)



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FALLING HEAD PERMEABILITY TEST REPORT

Test Method AS 1289 6.7.2, 5.1.1

Client:	Bogan Shire Council	**Job No:**	12-047
Client Address:	PO Box 221, Nyngan, NSW, 2825	**Sample No:**	8012
		Report No:	03-FHP
Project Location:	Proposed Waste Management Facility, Nyngan	**Date Tested:**	08/02/2012
		Source:	TP3 0.80-1.00m

SAMPLE DETAILS

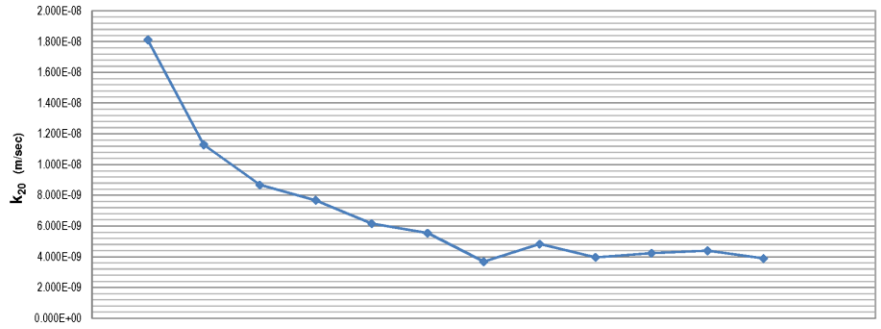
Sample Number:	8012	Sampling Method:	Sampled in accordance with AS1289.6.7.2
Date Sampled:	06/02/2012	Material Type:	Soil
Date Tested:	08/02/2012	Sample Location	TP3 0.80-1.00m
Sampled By:	Macquarie Geotechnical staff	Sample Description	Silty/Sandy CLAY
Remarks:			

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.74**	Hydraulic Gradient	**0.0**
Optimum Moisture Content (%)	**18.1**	Surcharge (kPa)	**0.0**
Placement Moisture Content (%)	**17.9**	Head Pressure Applied (kPa)	**0.0**
Moisture Ratio (%)	**99.1**	Water Type	**Tap**
Placement Dry Density (t/m^3)	**1.71**	Percentage Material Retained/Sieve Size (mm)	**0 % on 9.5 mm**
Density Ratio (%)	**98.1**	Sample Height and Diameter (mm)	**103.7 by 98.87 mm**

PERMEABILITY $k_{(20)}$ = **3.90E-09** (m/sec)

Permeability



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FALLING HEAD PERMEABILITY TEST REPORT

Test Method AS 1289 6.7.2, 5.1.1

Client:	Bogan Shire Council	**Job No:**	12-047
Client Address:	PO Box 221, Nyngan, NSW, 2825	**Sample No:**	8013
		Report No:	04-FHP
Project Location:	Proposed Waste Management Facility, Nyngan	**Date Tested:**	08/02/2012
		Source:	TP4 0.80-1.00m

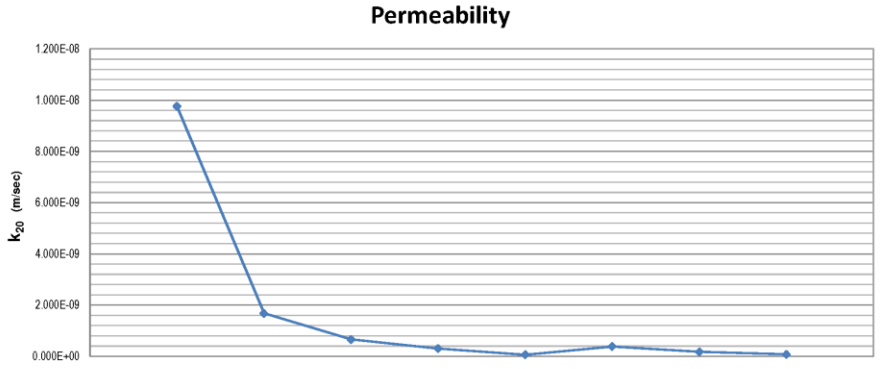
SAMPLE DETAILS

Sample Number:	8013	Sampling Method:	Sampled in accordance with AS1289.6.7.2
Date Sampled:	06/02/2012	Material Type:	Soil
Date Tested:	08/02/2012	Sample Location	TP4 0.80-1.00m
Sampled By:	Macquarie Geotechnical staff	Sample Description	Silty/Sandy CLAY
Remarks:			

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.71**	Hydraulic Gradient	**0.0**
Optimum Moisture Content (%)	**18.6**	Surcharge (kPa)	**0.0**
Placement Moisture Content (%)	**18.5**	Head Pressure Applied (kPa)	**0.0**
Moisture Ratio (%)	**99.5**	Water Type	**Tap**
Placement Dry Density (t/m^3)	**1.68**	Percentage Material Retained/Sieve Size (mm)	**0 % on 9.5 mm**
Density Ratio (%)	**98.1**	Sample Height and Diameter (mm)	**103.5 by 99.39 mm**

PERMEABILITY $k_{(20)}$ = **7.44E-11** (m/sec)



Remarks/Comments

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Date: 15/02/2012

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FALLING HEAD PERMEABILITY TEST REPORT

Test Method AS 1289 6.7.2, 5.1.1

Client:	Bogan Shire Council	**Job No:**	12-047
Client Address:	PO Box 221, Nyngan, NSW, 2825	**Sample No:**	8014
		Report No:	05-FHP
Project Location:	Proposed Waste Management Facility, Nyngan	**Date Tested:**	08/02/2012
		Source:	TP5 0.80-1.00m

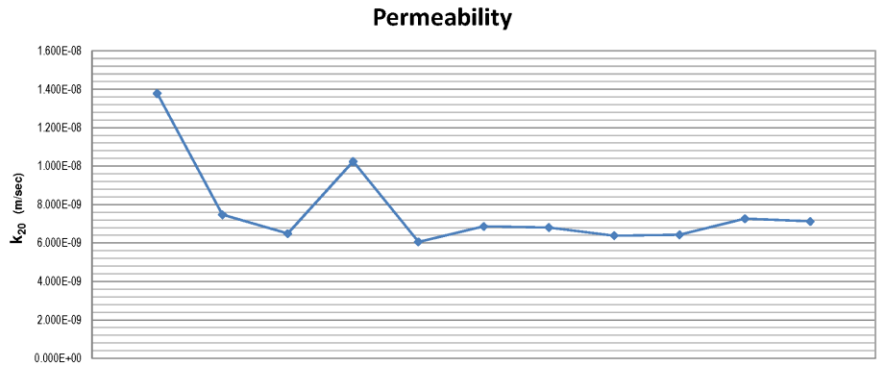
SAMPLE DETAILS

Sample Number:	8014	Sampling Method:	Sampled in accordance with AS1289.6.7.2
Date Sampled:	06/02/2012	Material Type:	Soil
Date Tested:	08/02/2012	Sample Location	TP5 0.80-1.00m
Sampled By:	Macquarie Geotechnical staff	Sample Description	Silty/Sandy CLAY
Remarks:			

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.76**	Hydraulic Gradient	**0.0**
Optimum Moisture Content (%)	**15.2**	Surcharge (kPa)	**0.0**
Placement Moisture Content (%)	**15.2**	Head Pressure Applied (kPa)	**0.0**
Moisture Ratio (%)	**100.0**	Water Type	**Tap**
Placement Dry Density (t/m^3)	**1.72**	Percentage Material Retained/Sieve Size (mm)	**0 % on 9.5 mm**
Density Ratio (%)	**98.0**	Sample Height and Diameter (mm)	**103.4 by 100.12 mm**

PERMEABILITY $k_{(20)}$ = **7.13E-09** **(m/sec)**



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FALLING HEAD PERMEABILITY TEST REPORT

Test Method AS 1289 6.7.2, 5.1.1

Client:	Bogan Shire Council	**Job No:**	12-047
Client Address:	PO Box 221, Nyngan, NSW, 2825	**Sample No:**	8015
		Report No:	06-FHP
Project Location:	Proposed Waste Management Facility, Nyngan	**Date Tested:**	08/02/2012
		Source:	TP6 0.80-1.00m

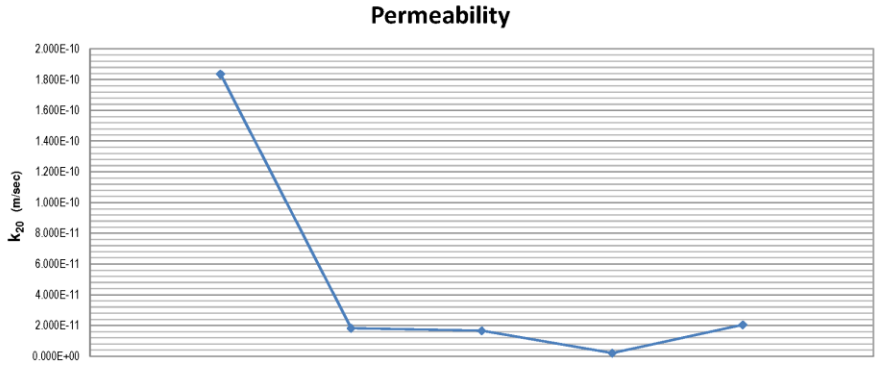
SAMPLE DETAILS

Sample Number:	8015	Sampling Method:	Sampled in accordance with AS1289.6.7.2
Date Sampled:	06/02/2012	Material Type:	Soil
Date Tested:	08/02/2012	Sample Location	TP6 0.80-1.00m
Sampled By:	Macquarie Geotechnical staff	Sample Description	Silty/Sandy CLAY
Remarks:			

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.72**	Hydraulic Gradient	**0.0**
Optimum Moisture Content (%)	**18.3**	Surcharge (kPa)	**0.0**
Placement Moisture Content (%)	**18.1**	Head Pressure Applied (kPa)	**0.0**
Moisture Ratio (%)	**98.9**	Water Type	**Tap**
Placement Dry Density (t/m^3)	**1.69**	Percentage Material Retained/Sieve Size (mm)	**0 % on 9.5 mm**
Density Ratio (%)	**98.3**	Sample Height and Diameter (mm)	**103.8 by 99.69 mm**

PERMEABILITY $k_{(20)}$ = **2.05E-11** (m/sec)



Remarks/Comments

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BATHURST NSW 2795

Appendix E – Test Pit Photographs

Test Pit TP-1 : GL to 1.10m

Test Pit TP-2 : GL to 1.10m

Test Pit TP-3 : GL to 1.10m

Test Pit TP-4 : GL to 1.20m

Test Pit TP-5 : GL to 1.10m

Test Pit TP-6: GL to 1.10m

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Concrete, Environmental, Soil & Rock
Geotechnical & Environmental Drilling

Geotechnical Investigation for Proposed Waste Management Facility, Nyngan

Bogan Shire Council

10th December 2012

Ref: 12/047

NATA

Bathurst	3 Watt Drive	Bathurst NSW 2795	(T) 6332 2011	(F) 6334 4213
Dubbo	6/57 Douglas Mawson Drive	Dubbo NSW 2830	(T) 6885 4033	(F) 6885 5533
Lithgow	1/5 Castlereagh Hwy	Lidsdale NSW 2790	(T) 6355 7991	(F) 6355 7994
Gulgong	1/9 Industrial Avenue	Gulgong NSW 2852	(T) 63741858	(F) 6374 1752

www.macgeo.com.au macgeo@macgeo.com.au

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APPENDICES

1 INTRODUCTION

At the request of Christy Hill from R.W. Corkery on behalf of Bogan Shire Council, Macquarie Geotechnical has carried out a Geotechnical investigation for permeability assessment of stabilised material at the proposed waste management facility, Nyngan.

The objectives of this investigation were to determine the sub-surface conditions and provide stabilization options to achieve the targeted permeability.

2 METHOD OF INVESTIGATION

Fieldwork was undertaken on 23rd November 2012 by an Engineering Geologist from our Bathurst office.

The fieldwork was undertaken in accordance with AS1726 - "Geotechnical Site Investigations" and our proposal dated 14th November 2012.

The fieldwork comprised six test pits up to 1.2m depth located as close as possible to the original test pits undertaken on 6th February 2012. For exact offsets of the test pits, refer to test pit logs in Appendix B.

The test pits were excavated using a backhoe fitted with a 450mm toothed bucket. The test pits were identified as TP7 to TP12 inclusive. The test pit locations are shown in Appendix B and the test pit logs are located in Appendix C.

The soil samples were returned to Macquarie Geotechnical NATA accredited laboratory in Bathurst for further assessment and testing.

Laboratory testing was carried out on selected samples and included the following:

- Three (3) Falling Head Permeability tests stabilized with 2% Hydrated Lime for soil permeability characteristics.
- Three (3) Falling Head Permeability tests stabilized with 4% Hydrated Lime for soil permeability characteristics.
- Three (3) Falling Head Permeability tests stabilized with 1% Bentonite for soil permeability characteristics.
- Three (3) Falling Head Permeability tests stabilized with 2% Bentonite for soil permeability characteristics.

Subsequently, the results of the field investigation and laboratory testing were assessed and this report prepared.

2.1 Testing Methods

Falling Head Permeability Testing:
Falling Head Permeability testing was carried out as per AS1289 6.7.2.

Moisture Contents:
The moisture contents of the samples were determined in accordance with AS1289 2.1.1.

Maximum Dry Density:
The maximum dry density of the samples was determined in accordance with AS1289 5.1.1.

3 SITE DESCRIPTION

The site is located off the Nyngan – Mundaroo Road, behind the existing Nyngan Waste Facility, approximately 5km North of Nyngan.

At the time of the investigation the test pits were located in relatively flat lying scrubland with an elevation of 170m.

The site plan and test pit locations are attached within Appendix B.

3.1 Regional Geology

Reference to the Nyngan Geological map (1 250:000) sheet SH/55-15 and indicates that the geology underlying the site consists of the following:

"Unconsolidated dark yellow brown clay, slightly silty with rare carbonate nodules and quartz sand. Common desiccation cracks. Laminated and contains rootlets."

4 RESULTS OF INVESTIGATION

4.1 Sub-surface conditions

The existing ground conditions have been summarised as follows:

Table 1: Subsurface Conditions TP-7 to TP-12

Depth (m)	Log	Descriptions
0.0 – 0.60		Sandy CLAY with roots: red brown, medium to high plasticity clay, fine to coarse sand, firm, moist, moisture content ~ plastic limit (TOPSOIL) (ALLUVIAL)
0.60 – 1.20		Sandy CLAY trace gravel: red brown, medium to high plasticity clay, fine to coarse sand, fine subangular to subrounded gravel, stiff, dry, moisture content < plastic limit (ALLUVIAL).

Note: Please refer to logs for detailed descriptions.

Groundwater was not encountered in the test pits.

4.2 Site Soils

The investigation indicates that the site comprised of alluvial clay to a depth of 1.20m, the investigation undertaken on the 6th February indicated site soils with a permeability between 9×10^{-8} to 2×10^{-11}.

Groundwater was not encountered in any of the test pits.

Based on our investigation, the previous laboratory test results and our experience with similar soils, the samples were stabilised with 2 & 4% Hydrated Lime and 1 & 2% Bentonite.

4.3 Laboratory Test Results

Laboratory testing in this area is summarised as follows;

Table 2: Results of Falling Head Permeability

Test Pit Number	Depth (m)	Permeability from previous investigation	Permeability (m/sec) (2% Hydrated Lime)	Permeability (m/sec) (4% Hydrated Lime)	Permeability (m/sec) (1% Bentonite)	Permeability (m/sec) (2% Bentonite)
TP-7	0.8 – 1.0	(TP-1) 3.48×10^{-9}	-	1.08×10^{-9}	-	2.34×10^{-10}
TP-8	0.8 – 1.0	(TP-2) 9.17×10^{-8}	2.32×10^{-8}	-	8.17×10^{-11}	-
TP-9	0.8 – 1.0	(TP-3) 3.90×10^{-9}	-	7.31×10^{-10}	-	4.87×10^{-10}
TP-10	0.8 – 1.0	(TP-4) 7.44×10^{-11}	-	4.28×10^{-9}	-	4.42×10^{-10}
TP-11	0.8 – 1.0	(TP-5) 7.13×10^{-9}	5.46×10^{-10}	-	1.99×10^{-10}	-
TP-12	0.8 – 1.0	(TP-6) 2.05×10^{-11}	9.26×10^{-10}	-	8.07×10^{-11}	-

5 RECOMMENDATIONS

5.1 Stabilisation Results

The laboratory results indicated that the majority of the soil samples showed a decrease in permeability as part of the stabilisation with Hydrated Lime and Bentonite.

Variations in the permeability between the original investigation and the present investigation are down to the samples being taken from slightly different locations (Which were as close as practicable to the previous locations) and due to variation in the sand content of the material.

Based on the stabilisation results hydrated lime did not achieve the target permeability on all the samples, there could be the option to stabilise the material at a higher blend than the trials, however this wouldn't be recommended due to variations in the clay mineralogy which may not respond as well to the hydrated lime and also the potential of making the soil brittle and prone to cracking.

The bentonite trials for both 1% & 2% all met the target permeability and based on the trial blends undertaken we would recommend that the insitu and stockpiled material is stabilised with 2% bentonite.

5.2 Construction

It is understood that the proposed lining thickness for the cells is to be approximately 900mm, the insitu material that is proposed to be used for the liner should be stockpiled within a relatively clean area of hardstanding.

It is recommended that a suitably qualified Geotechnical Engineer/Engineering Geologist is on site to verify the material on removal or if any significant difference in the material is noted.

The subgrade should be stripped of all soft, organic or moisture affected materials and the material at the base of the cell walls should be ripped to a depth of 300mm and have a blend of 2% Bentonite mixed with the material prior to compaction, the compacted subgrade is to have a minimum dry density ratio of 98% relative to standard compaction at a moisture ratio of 80-110% of the optimum moisture content.

It is recommended that the bentonite is blended with the stockpiled material prior to placement in 200mm compacted thick layers, however if this is not possible then the material can be stabilised once placed in 300mm layers.

The filled material is to be rolled and compacted to a minimum dry density ratio of 98% relative to standard compaction at a moisture ratio of 80-110% of the optimum moisture content.

For compaction testing and proof rolling it is recommended that Level 1 Inspection and Testing is undertaken as specified in AS3798-2007, testing frequencies will be based on Table 8.1.

6 CONCLUSION

The findings of our report were based on our fieldwork, in-situ testing, laboratory testing, technical assessment and local knowledge for this site. We trust the foregoing is sufficient for your present purposes, and if you have any questions please contact either of the undersigned.

Yours sincerely

John Boyle
Senior Engineering Geologist
BSc (Hons) Affil MIE Aust

Reviewed by

Jason P Lewis
Principal Geotechnical Engineer
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References: Australian Standard 1726 – 2007 Geotechnical Site Investigations

LIMITATIONS OF GEOTECHNICAL SITE INVESTIGATION

Scope of Services

This report has been prepared for the Client in accordance with the Services Engagement Form (SEF), between the Client and Macquarie Geotechnical.

Reliance on Data

Macquarie Geotechnical has relied upon data and other information provided by the Client and other individuals. Macquarie Geotechnical has not verified the accuracy or completeness of the data, except as otherwise stated in the report. Recommendations in the report are based on the data.

Macquarie Geotechnical will not be liable in relation to incorrect recommendations should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed.

Geotechnical Investigation

Findings of Geotechnical Investigations are based extensively on judgment and experience. Geotechnical reports are prepared to meet the specific needs of individual clients. This report was prepared expressly for the Client and expressly for the Clients purposes.

This report is based on a subsurface investigation, which was designed for project-specific factors. Unless further geotechnical advice is obtained this report cannot be applied to an adjacent site nor can it be used when the nature of any proposed development is changed.

Limitations of Site investigation

As a result of the limited number of sub-surface excavations or boreholes there is the possibility that variations may occur between test locations. The investigation undertaken is an estimate of the general profile of the subsurface conditions. The data derived from the investigation and laboratory testing are extrapolated across the site to form a geological model. This geological model infers the subsurface conditions and their likely behavior with regard to the proposed development.

The actual conditions at the site might differ from those inferred to exist.

No subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies.

Time Dependence

This report is based on conditions, which existed at the time of subsurface exploration. Construction operations at or adjacent to the site, and natural events such as floods, or groundwater fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report.

Macquarie Geotechnical should be kept appraised of any such events, and should be consulted for further geotechnical advice if any changes are noted.

Avoid Misinterpretation

A geotechnical engineer or engineering geologist should be retained to work with other design professionals explaining relevant geotechnical findings and in reviewing the adequacy of their plans and specifications relative to geotechnical issues.

No part of this report should be separated from the Final Report.

Sub-surface Logs

Sub-surface logs are developed by geoscientific professionals based upon their interpretation of field logs and laboratory evaluation of field samples. These logs should not under any circumstances be redrawn for inclusion in any drawings.

Geotechnical Involvement During Construction

During construction, excavation frequently exposes subsurface conditions. Geotechnical consultants should be retained through the construction stage, to identify variations if they are exposed.

Report for Benefit of Client

The report has been prepared for the benefit of the Client and no other party. Other parties should not rely upon the report or the accuracy or completeness of any recommendations and should make their own enquiries and obtain independent advice in relation to such matters

Macquarie Geotechnical assumes no responsibility and will not be liable to any other person or organisations for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisations arising from matters dealt with or conclusions expressed in the report.

Other limitations

Macquarie Geotechnical will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

Other Information

For further information reference should be made to "Guidelines for the Provision of Geotechnical Information in Construction Contracts" published by the Institution of Engineers Australia, 1987.

Appendix A – General Notes

MACQUARIE GEOTECH

Explanatory Notes

Soil Description

In engineering terms soil includes every type of uncemented or partially cemented inorganic material found in the ground. In practice, if the material can be remoulded by hand in its field condition or in water it is described as a soil. The dominant soil constituent is given in capital letters, with secondary textures in lower case. The dominant feature is assessed from the Unified Soil Classification system and a soil symbol is used to define a soil layer as follows:

UNIFIED SOIL CLASSIFICATION

The appropriate symbols are selected on the result of visual examination, field tests and available laboratory tests, such as, sieve analysis, liquid limit and plasticity index.

USC Symbol	Description
GW	Well graded gravel
GP	Poorly graded gravel
GM	Silty gravel
GC	Clayey gravel
SW	Well graded sand
SP	Poorly graded sand
SM	Silty sand
SC	Clayey sand
ML	Silt of low plasticity
CL	Clay of low plasticity
OL	Organic soil of low plasticity
MH	Silt of high plasticity
CH	Clay of high plasticity
OH	Organic soil of high plasticity
Pt	Peaty Soil

MOISTURE CONDITION

Dry – Cohesive soils are friable or powdery
Cohesionless soil grains are free-running

Moist – Soil feels cool, darkened in colour
Cohesive soils can be moulded
Cohesionless soil grains tend to adhere

Wet – Cohesive soils usually weakened
Free water forms on hands when handling

For cohesive soils the following codes may also be used:

MC>PL Moisture Content greater than the Plastic Limit.
MC~PL Moisture Content near the Plastic Limit.
MC<PL Moisture Content less than the Plastic Limit.

PLASTICITY

The potential for soil to undergo change in volume with moisture change is assessed from its degree of plasticity. The classification of the degree of plasticity in terms of the Liquid Limit (LL) is as follows:

Description of Plasticity	LL (%)
Low	<35
Medium	35 to 50
High	>50

COHESIVE SOILS – CONSISTENCY

The consistency of a cohesive soil is defined by descriptive terminology such as very soft, soft, firm, stiff, very stiff and hard. These terms are assessed by the shear strength of the soil as observed visually, by the pocket penetrometer values and by resistance to deformation to hand moulding.

A Pocket Penetrometer may be used in the field or the laboratory to provide approximate assessment of unconfined compressive strength of cohesive soils. The values are recorded in kPa, as follows:

Strength	Symbol	Pocket Penetrometer Reading (kPa)
Very Soft	VS	< 25
Soft	S	20 to 50
Firm	F	50 to 100
Stiff	St	100 to 200
Very Stiff	VSt	200 to 400

Hard	H	> 400

COHESIONLESS SOILS – RELATIVE DENSITY

Relative density terms such as very loose, loose, medium, dense and very dense are used to describe silty and sandy material, and these are usually based on resistance to drilling penetration or the Standard Penetration Test (SPT) 'N' values. Other condition terms, such as friable, powdery or crumbly may also be used.

The Standard Penetration Test (SPT) is carried out in accordance with AS 1289, 6.3.1. For completed tests the number of blows required to drive the split spoon sampler 300 mm are recorded as the N value. For incomplete tests the number of blows and the penetration beyond the seating depth of 150 mm are recorded. If the 150 mm seating penetration is not achieved the number of blows to achieve the measured penetration is recorded. SPT correlations may be subject to corrections for overburden pressure and equipment type.

Term	Symbol	Density Index	N Value (blows/0.3 m)
Very Loose	VL	0 to 15	0 to 4
Loose	L	15 to 35	4 to 10
Medium Dense	MD	35 to 65	10 to 30
Dense	D	65 to 85	30 to 50
Very Dense	VD	>85	>50

COHESIONLESS SOILS 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

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Rock Description

The rock is described with strength and weathering symbols as shown below. Other features such as bedding and dip angle are given.

ROCK QUALITY

The fracture spacing is shown where applicable and the Rock Quality Designation (RQD) or Total Core Recovery (TCR) is given where:

$$\text{RQD (\%)} = \frac{\text{Sum of Axial lengths of core} > 100\text{mm long}}{\text{total length considered}}$$

$$\text{TCR (\%)} = \frac{\text{length of core recovered}}{\text{length of core run}}$$

ROCK STRENGTH

Rock strength is described using AS1726 and ISRM – Commission on Standardisation of Laboratory and Field Tests, "Suggested method of determining the Uniaxial Compressive Strength of Rock materials and the Point Load Index", as follows:

Term	Symbol	Point Load Index $Is_{(50)}$ (MPa)
Extremely Low	EL	<0.03
Very Low	VL	0.03 to 0.1
Low	L	0.1 to 0.3
Medium	M	0.3 to 1
High	H	1 to 3
Very High	VH	3 to 10
Extremely High	EH	>10

ROCK MATERIAL WEATHERING

Rock weathering is described using the following abbreviation and definitions used in AS1726:

Abbreviation	Term
RS	Residual soil
XW	Extremely weathered
DW	Distinctly weathered
SW	Slightly weathered
FR	Fresh

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DEFECT SPACING/BEDDING THICKNESS

Measured at right angles to defects of same set or bedding.

Term	Defect Spacing	Bedding
Extremely closely spaced	<6 mm	Thinly Laminated
	6 to 20 mm	Laminated
Very closely spaced	20 to 60 mm	Very Thin
Closely spaced	0.06 to 0.2 m	Thin
Moderately widely spaced	0.2 to 0.6 m	Medium
Widely spaced	0.6 to 2 m	Thick
Very widely spaced	>2 m	Very Thick

DEFECT DESCRIPTION

Type:	Description
B	Bedding
F	Fault
C	Cleavage
J	Joint
S	Shear Zone
D	Drill break

Planarity/Roughness:

Class	Description
I	rough or irregular, stepped
II	smooth, stepped
III	slickensided, stepped
IV	rough or irregular, undulating
V	smooth, undulating
VI	slickensided, undulating
VII	rough or irregular, planar
VIII	smooth, planar
IX	slickensided, planar

The inclination if defects are measured from perpendicular to the core axis.

WATER

Water level at date shown Partial water loss

Water inflow Complete water loss

Groundwater not observed: The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.

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Graphic Symbols for Soils and Rocks

Typical symbols for soils and rocks are as follows. Combinations of these symbols may be used to indicated mixed materials such as clayey sand.

Soil Symbols

Main components


CLAY


SILT


SAND


GRAVEL


BOULDERS / COBBLES


TOPSOIL


PEAT

Minor Components


Clayey


Silty


Sandy


Gravelly

Other


FILL


BITUMEN


CONCRETE

Rock Symbols

Sedimentary Rocks


SANDSTONE


SILTSTONE


CLAYSTONE, MUDSTONE


SHALE


LAMINITE


COAL


LIMESTONE


CONGLOMERATE

Igneous Rocks


GRANITE


BASALT


UNDIFFERENTIATED IGNEOUS

Metamorphic Rocks


SLATE, PHYLLITE, SCHIST


GNEISS


QUARTZITE

Groundwater not encountered: The borehole/test pit was dry soon after excavation, however groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period.

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Engineering Classification of Shales and Sandstones in the Sydney Region – A Summary Guide

The Sydney Rock Class classification system is based on rock strength, defect spacing and allowable seams as set out below. All three factors must be satisfied.

CLASSIFICATION FOR SANDSTONE

Class	Uniaxial Compressive Strength (MPa)	Defect Spacing (mm)	Allowable Seams (%)
I	>24	>600	<1.5
II	>12	>600	<3
III	>7	>200	<5
IV	>2	>60	<10
V	>1	N.A.	N.A.

CLASSIFICATION FOR SHALE

Class	Uniaxial Compressive Strength (MPa)	Defect Spacing (mm)	Allowable Seams (%)
I	>16	>600	<2
II	>7	>200	<4
III	>2	>60	<8
IV	>1	>20	<25
V	>1	N.A.	N.A.

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UNIAXIAL COMPRESSIVE STRENGTH (UCS)

For expedience in field/construction situations the uniaxial (unconfined) compressive strength of the rock is often inferred, or assessed using the point load strength index (Is_{50}) test (AS 4133.4.1 – 1993). For Sydney Basin sedimentary rocks the uniaxial compressive strength is typically about 20 x (Is_{50}) but the multiplier may range from about 10 to 30 depending on the rock type and characteristics. In the absence of UCS tests, the assigned Sydney Rock Class classification may therefore include rock strengths outside the nominated UCS range.

DEFECT SPACING

The terms relate to spacing of natural fractures in NMLC, NQ and HQ diamond drill cores and have the following definitions:

Defect Spacing (mm)	Terms Used to Describe Defect Spacing[1]
>2000	Very widely spaced
600 – 2000	Widely spaced
200 – 600	Moderately spaced
60 – 200	Closely spaced
20 – 60	Very closely spaced
<20	Extremely closely spaced

[1]After ISO/CD14689 and ISRM.

ALLOWABLE SEAMS

Seams include clay, fragmented, highly weathered or similar zones, usually sub-parallel to the loaded surface. The limits suggested in the tables relate to a defined zone of influence. For pad footings, the zone of influence is defined as 1.5 times the least footing dimension. For socketed footings, the zone includes the length of the socket plus a further depth equal to the width of the footing. For tunnel or excavation assessment purposes the defects are assessed over a length of core of similar characteristics.

Source: Based on Pells et al (1978), as revised by Pells et al (1998).
Pells, P.J.N, Mostyn, G. and Walker, B.F. – Foundations on Sandstone and Shale in the Sydney Region. Australian Geomechanics Journal, No 33 Part 3, December 1998.

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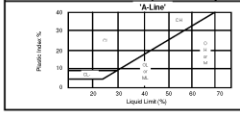
MACQUARIE GEOTECH

Summary of Soil Logging Procedures

Coarse Material: grain size - colour - particle shape - secondary components - minor constituents - moisture condition - relative density - origin - additional observations.
Fine Material: plasticity - colour - secondary components - minor constituents - moisture w.r.t. plasticity - consistency - origin - additional observations.

Guide to the Description, Identification and Classification of Soils

Major Divisions				SYMBOL	Typical Names
> 200mm		BOULDERS			
60 to 200mm		COBBLES			
COARSE GRAINED SOILS	More than 50% by dry mass less than 60mm is greater than 0.075mm	Gravelly Soils	GRAVEL More than 50% of coarse fraction > 2.36mm	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
				GP	Poorly graded gravels and gravel-sand mixtures, little or no fines, uniform gravels.
				GM	Silty gravels, gravel-sand-silt mixtures.
				GC	Clayey gravels, gravel-sand-clay mixtures
		Sandy Soils	SANDS More than 50% of coarse fraction < 2.36mm	SW	Well-graded sands, gravelly sands, little or no fines.
				SP	Poorly graded sands and gravelly sands; little or no fines, uniform sands.
				SM	Silty sands, sand-silt mixtures.
				SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	More than 50% by dry mass less than 60mm is less than 0.075mm		Liquid Limit < 50%	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts
				CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays.
				OL	Organic silts and organic silty clays of low plasticity.
			Liquid Limit > 50%	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
				CH	Inorganic clays of high plasticity, fat clays.
				OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS				Pt	Peat and other highly organic soils.



Grain sizes			
Gravel		Sand	
Coarse -	63 to 20mm	Coarse -	2.36 to 0.6mm
Medium -	20 to 6 mm	Medium -	0.6 to 0.2mm
Fine -	6 to 2.36mm	Fine -	0.2 to 0.075mm

GEOLOGICAL ORIGIN:-
Fill - artificial soils / deposits
Alluvial - soils deposited by the action of water
Aeolian - soils deposited by the action of wind
Topsoil - soils supporting plant life containing significant organic content
Residual - soils derived from insitu weathering of parent rock.
Colluvial - transported debris usually unsorted, loose and deposited

Field Identification of Fine Grained Soils - Silt or Clay?
Dry Strength - Allow the soil to dry completely and then test its strength by breaking and crumbling between the fingers.
High dry strength - Clays; Very slight dry strength - Silts.
Toughness Test - the soil is rolled by hand into a thread about 3mm in diameter. The thread is then folded and re-rolled repeatedly until it has dried sufficiently to break into lumps. In this condition inorganic clays are fairly stiff and tough while inorganic silts produce a weak and often soft thread which may be difficult to form and readily breaks and crumbles.
Dilatancy Test - Add sufficient water to the soil, held in the palm of the hand, to make it soft but not sticky. Shake horizontally, striking vigorously against the other hand several times. Dilatancy is indicated by the appearance of a shiny film on the surface of the soil. If the soil is then squeezed or pressed with the fingers, the surface becomes dull as the soil stiffens and eventually crumbles. These reactions are pronounced only for predominantly silt size material. Plastic clays give no reaction.

Descriptive Terms for Material Portions

COARSE GRAINED SOILS		FINE GRAINED SOILS	
% Fines	*Term/Modifier*	*% Coarse*	*Term/Modifier*
< 5	Omit, or use "trace"	< 15	Omit, or use "trace"
> 5, < 12	"with clay/silt" as applicable	> 15, < 30	"with sand/gravel" as applicable
> 12	Prefix soil as "silty/clayey"	> 30	Prefix as "sandy/gravelly"

Moisture Condition

for non-cohesive soils:
Dry - runs freely through fingers.
Moist - does not run freely but no free water visible on soil surface.
Wet - free water visible on soil surface.

for cohesive soils:
MC > PL Moisture content estimated to be greater than the plastic limit.
MC ~ PL Moisture content estimated to be approximately equal to the plastic limit. The soil can be moulded
MC < PL Moisture content estimated to be less than the plastic limit. The soil is hard and friable, or powdery.

The plastic limit (PL) is defined as the moisture content (percentage) at which the soil crumbles when rolled into threads of 3mm dia.

Consistency - For Clays & Silts

Description	*UCS(kPa)*	*Field guide to consistency*
Very soft	< 25	Exudes between the fingers when squeezed in hand
Soft	25 - 50	Can be moulded by light finger pressure
Firm	50 - 100	Can be moulded by strong finger pressure
Stiff	100 - 200	Cannot be moulded by fingers. Can be indented by thumb.
Very stiff	200 - 400	Can be indented by thumb nail
Hard	> 400	Can be indented with difficulty by thumb nail
Friable	-	Crumbles or powders when scraped by thumbnail

Relative Density for Gravels and Sands

Description	*SPT "N" Value*	*Density Index (ID) Range %*
Very loose	0 - 4	< 15
Loose	4 - 10	15 - 35
Medium dense	10 - 30	35 - 65
Dense	30 - 50	65 - 85
Very dense	> 50	> 85

MACQUARIE GEOTECH

Summary of Rock Logging Procedures

Description order: constituents - rock name - grain size - colour - weathering - strength - minor constituents - additional observations.
- minor constituents - moisture w.r.t. plasticity - consistency - origin - additional observations.

Definition - Sedimentary Rock	
Conglomerate	more than 50% of the rock consists of gravel (> 2mm) sized fragments
Sandstone	more than 50% of the rock consists of sand (0.06 to 2mm) sized grains
Siltstone	more than 50% of the rock consists of silt sized granular particles and the rock is not laminated
Claystone	more than 50% of the rock consists of clay or mica material and the rock is not laminated
Shale	more than 50% of the rock consists of clay or silt sized particles and the rock is laminated

Weathering		
Residual Soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a change in volume but the soil has not significantly transported.
Extremely Weathered	EW	Rock is weathered to such an extent that it has 'soil' properties; ie. it either disintegrates or can be remoulded, in water
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 weathering products in pores.
Slightly Weathered	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh	FR	Rock shows no sign of decomposition or staining.

Stratification			
thinly laminated	< 6mm	medium bedded	0.2 - 0.6m
laminated	6 - 20mm	thickly bedded	0.6 - 2m
very thinly bedded	20 - 60mm	very thickly bedded	> 2m
thinly bedded	60mm - 0.2m		

Discontinuities

order of description: depth - type - orientation - spacing - roughness / planarity - thickness - coating

	Type	Class	Roughness/Planarity	Class	Roughness/Planarity
B	Bedding	I	rough or irregular, stepped	VI	slickensided, undulating
F	Fault	II	smooth, stepped	VII	rough or irregular, planar
C	Cleavage	III	slickensided, stepped	VIII	smooth, planar
J	Joint	IV	rough or irregular, undulating	IX	slickensided, planar
S	Shear Zone	V	smooth, undulating		
D	Drill break				

Rock Strength			
Term		Is (50)	Field Guide
Extremely Low	EL	0.03	Easily remoulded by hand to a material with soil properties.
Very low	VL	0.1	May be crumbled in the hand. Sandstone is "sugary" and friable
Low	L	0.3	A piece of core 150 mm long x 50 mm dia. may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.
Medium	M	1	A piece of core 150 mm long x 50 mm dia. can be broken by hand with considerable difficulty. Readily scored with knife.
High	H	3	A piece of core 150 mm long x 50 mm dia. core cannot be broken by unaided hands, can be slightly scratched or scored with knife.
Very High	VH	10	A piece of core 150 mm long x 50 mm dia. May be broken readily with hand held hammer. Cannot be scratched with pen knife.
Extremely High	EH		A piece of core 150 mm long x 50 mm dia. Is difficult to break with hand held hammer. Rings when struck with a hammer.

* - rock strength defined by point load strength (Is 50) in direction normal to bedding

Degree of fracturing	
fragmented	The core is comprised primarily of fragments of length less than 20mm, and mostly of width less than the core diameter
highly fractured	Core lengths are generally less than 20mm - 40mm with occasional fragments.
fractured	Core lengths are mainly 30mm - 100mm with occasional shorter and longer lengths
slightly fractured	Core lengths are generally 300mm - 1000mm with occasional longer sections and shorter sections of 100mm -- 300mm.
unbroken	The core does not contain any fracture.

- spacing of all types of natural fractures, but not artificial breaks, in cored bores.

The fracture spacing is shown where applicable and the Rock Quality Designation is given by:

$$RQD\ (\%) = \frac{\text{sum of unbroken core pieces 100 mm or longer}}{\text{total length considered}}$$

Appendix B

Site Plan & Test Pit Location

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Geotechnical & Environmental Drilling

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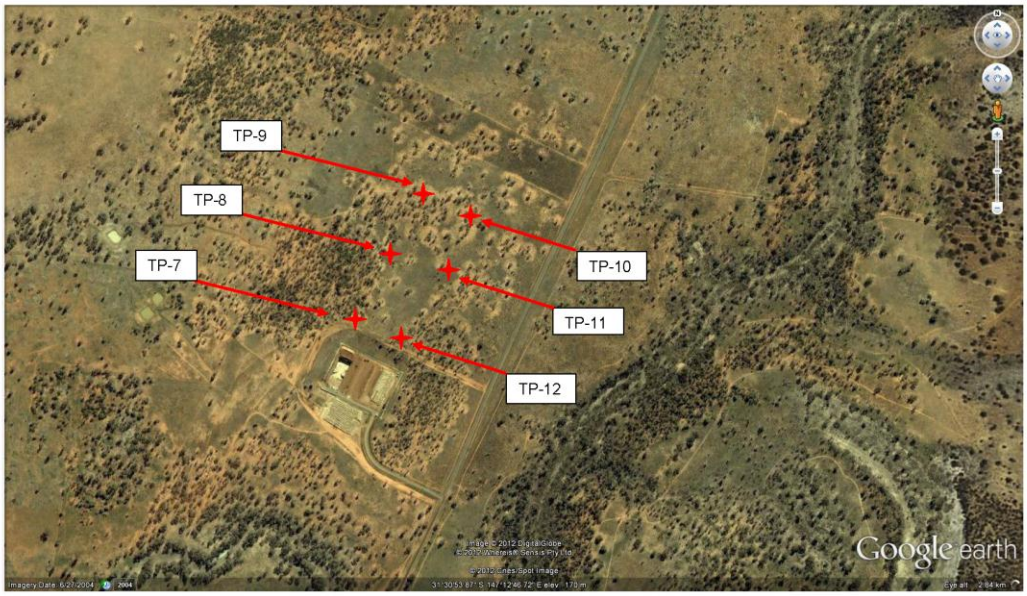
Test Pit Locations



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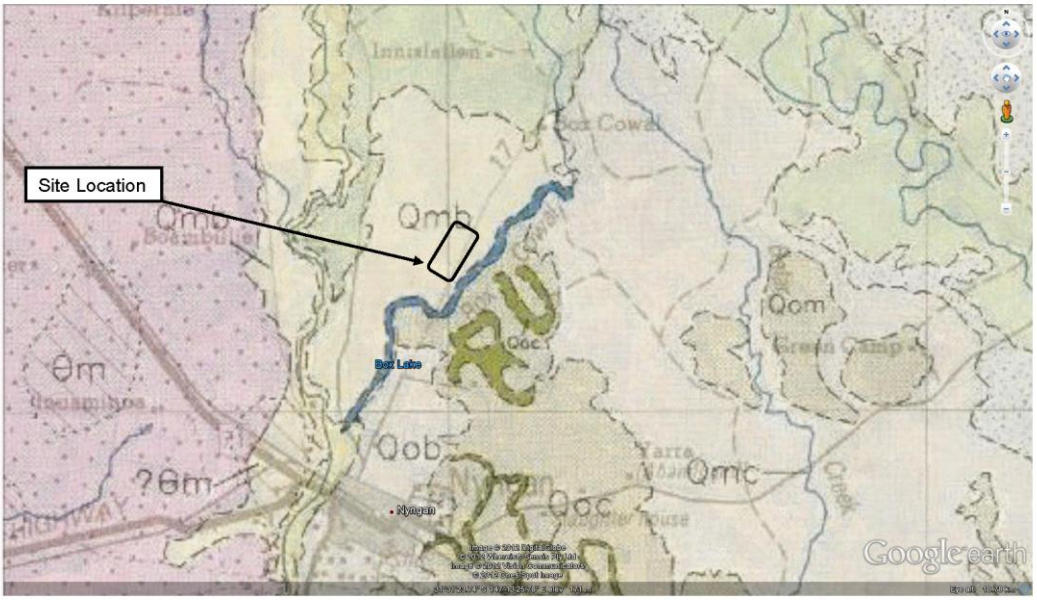
Site Location with Geological Map Overlay



KEY:
Qmb: "Unconsolidated dark yellow brown clay, slightly silty with rare carbonate nodules and quartz sand. Common desiccation cracks. Laminated and contains rootlets"
Qob: "Unconsolidated pale grey to grey brown silt, clay and sand with rare carbonate nodules. Very poorly sorted. Commonly cracking."

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Appendix C – Test Pit Logs

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3 Watt Drive
Bathurst
Telephone: 02 6332 2011
Fax: 02 6334 4213

TEST PIT NUMBER TP07

CLIENT Bogan Shire Council **PROJECT NAME** Proposed Waste Management Facility

PROJECT NUMBER 12-047 **PROJECT LOCATION** Nyngan

DATE STARTED 23/11/12 **COMPLETED** 23/11/12 **R.L. SURFACE** --- **DATUM** ---

EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---

EQUIPMENT Backhoe with 450mm Toothed Bucket **TEST PIT LOCATION** ---

TEST PIT SIZE 450mm **LOGGED BY** KA **CHECKED BY** JB

NOTES ---

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	DCP (blows/100mm) 0 5 10 15 20 25	Additional Observations
			0.0		SM	Silty SAND trace clay: light brown, fine to coarse sand, medium dense, dry (TOPSOIL).			
					CL	CLAY with sand: red brown, medium plasticity clay, fine to coarse sand, stiff, dry, moisture content < plastic limit (ALLUVIAL).			
			0.5						
			1.0						
						Borehole TP07 terminated at 1.2m			
			1.5						
			2.0						
			2.5						
			3.0						

MG LIB 00.GLB Log BOREHOLE / TEST PIT MG 00.GPJ <<DrawingFile>> 10/12/2012 16:34 8.2.900 Datgel Photo Tool

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3 Watt Drive
Bathurst
Telephone: 02 6332 2011
Fax: 02 6334 4213

TEST PIT NUMBER TP07

CLIENT Bogan Shire Council
PROJECT NAME Proposed Waste Management Facility
PROJECT NUMBER 12-047
PROJECT LOCATION Nyngan

TP07 - 1 Depth Range: 0.00 - 1.20 m

TP07 - 2 Depth Range: 0.00 - 1.20 m

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Telephone: 02 6332 2011
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TEST PIT NUMBER TP08

CLIENT Bogan Shire Council **PROJECT NAME** Proposed Waste Management Facility

PROJECT NUMBER 12-047 **PROJECT LOCATION** Nyngan

DATE STARTED 23/11/12 **COMPLETED** 23/11/12 **R.L. SURFACE** --- **DATUM** ---

EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---

EQUIPMENT Backhoe with 450mm Toothed Bucket **TEST PIT LOCATION** ---

TEST PIT SIZE 450mm **LOGGED BY** KA **CHECKED BY** JB

NOTES ---

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	DCP (blows/100mm) 0 5 10 15 20 25	Additional Observations
			0.0		SM	Silty SAND with clay: brown, fine to coarse sand, loose to medium dense, dry (TOPSOIL).			
					CL	CLAY with sand trace gravel and roots: brown, medium plasticity clay, fine to coarse sand, fine subangular to subrounded gravel, stiff, dry to slightly moist, moisture content < plastic limit (ALLUVIAL).			
			0.5						
			1.0						
			1.4			Borehole TP08 terminated at 1.4m			
			1.5						
			2.0						
			2.5						
			3.0						

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TEST PIT NUMBER TP08

CLIENT Bogan Shire Council
PROJECT NAME Proposed Waste Management Facility
PROJECT NUMBER 12-047
PROJECT LOCATION Nyngan

TP08 - 1 Depth Range: 0.00 - 1.30 m

TP08 - 2 Depth Range: 0.00 - 1.30 m

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TEST PIT NUMBER TP09

CLIENT Bogan Shire Council **PROJECT NAME** Proposed Waste Management Facility
PROJECT NUMBER 12-047 **PROJECT LOCATION** Nyngan

DATE STARTED 23/11/12 **COMPLETED** 23/11/12 **R.L. SURFACE** --- **DATUM** ---
EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---
EQUIPMENT Backhoe with 450mm Toothed Bucket **TEST PIT LOCATION** ---
TEST PIT SIZE 450mm **LOGGED BY** KA **CHECKED BY** JB
NOTES ---

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	DCP (blows/100mm) 0 5 10 15 20 25	Additional Observations
			0.0		SM	Sandy SILT with clay trace gravel: red brown, fine to coarse sand, firm to stiff, slightly moist (TOPSOIL).			
					CL	CLAY with sand: brown in places white, medium plasticity clay, fine to coarse sand, stiff, slightly moist, moisture content < plastic limit (ALLUVIAL).			
			0.5						
			1.0						
			1.4			Borehole TP09 terminated at 1.4m			
			1.5						
			2.0						
			2.5						
			3.0						

MG LIB 00.GLB Log BOREHOLE / TEST PIT MG 00.GPJ <<DrawingFiles>> 10/12/2012 16:34 8.2.300 Datgel Photo Tool

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TEST PIT NUMBER TP09

CLIENT Bogan Shire Council
PROJECT NAME Proposed Waste Management Facility
PROJECT NUMBER 12-047
PROJECT LOCATION Nyngan

TP09 - 1 Depth Range: 0.00 - 1.40 m

TP09 - 2 Depth Range: 0.00 - 1.40 m

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TEST PIT NUMBER TP10

CLIENT Bogan Shire Council **PROJECT NAME** Proposed Waste Management Facility

PROJECT NUMBER 12-047 **PROJECT LOCATION** Nyngan

DATE STARTED 23/11/12 **COMPLETED** 23/11/12 **R.L. SURFACE** --- **DATUM** ---

EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---

EQUIPMENT Backhoe with 450mm Toothed Bucket **TEST PIT LOCATION** ---

TEST PIT SIZE 450mm **LOGGED BY** KA **CHECKED BY** JB

NOTES ---

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	DCP (blows/100mm) 0 5 10 15 20 25	Additional Observations
			0.0		SM	Sandy SILT with clay trace roots: brown, fine to coarse sand, firm to stiff, dry (TOPSOIL).			
					CL	CLAY with sand trace gravel: brown, medium plasticity clay, fine to coarse sand, fine subangular to subrounded gravel, stiff, dry to slightly moist, moisture content < plastic limit (ALLUVIAL).			
			0.5						
			1.0						
						Borehole TP10 terminated at 1.3m			
			1.5						
			2.0						
			2.5						
			3.0						

MG LIB 00.GLB Log BOREHOLE / TEST PIT MG 00.GPJ <<DrawingFile>> 10/12/2012 16:36 8.2.300 Datgel Photo Tool

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TEST PIT NUMBER TP10

PAGE 2 OF 2

CLIENT Bogan Shire Council
PROJECT NAME Proposed Waste Management Facility
PROJECT NUMBER 12-047
PROJECT LOCATION Nyngan

TP10 - 1 Depth Range: 0.00 - 1.30 m

TP10 - 2 Depth Range: 0.00 - 1.30 m

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TEST PIT NUMBER TP11

PAGE 1 OF 2

CLIENT Bogan Shire Council **PROJECT NAME** Proposed Waste Management Facility
PROJECT NUMBER 12-047 **PROJECT LOCATION** Nyngan

DATE STARTED 23/11/12 **COMPLETED** 23/11/12 **R.L. SURFACE** --- **DATUM** ---
EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---
EQUIPMENT Backhoe with 450mm Toothed Bucket **TEST PIT LOCATION** ---
TEST PIT SIZE 450mm **LOGGED BY** KA **CHECKED BY** JB
NOTES ---

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	DCP (blows/100mm) 0 5 10 15 20 25	Additional Observations
			0.0		SM	Sandy SILT with clay: light brown, fine to coarse sand, firm to stiff, dry (TOPSOIL).			
					CL	CLAY with sand trace gravel and roots: brown, medium plasticity clay, fine to coarse sand, fine subangular gravels, stiff, slightly moist, moisture content < plastic limit (ALLUVIAL).			
			0.5						
			1.0						
						Borehole TP11 terminated at 1.3m			
			1.5						
			2.0						
			2.5						
			3.0						

MG LIB 00.GLB Log BOREHOLE / TEST PIT MG 00.GPJ <<DrawingFile>> 10/12/2012 16:36 8.2.900 Datgel Photo Tool

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Bathurst
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TEST PIT NUMBER TP11

PAGE 2 OF 2

CLIENT Bogan Shire Council
PROJECT NAME Proposed Waste Management Facility
PROJECT NUMBER 12-047
PROJECT LOCATION Nyngan

TP11 - 1 Depth Range: 0.00 - 1.30 m

TP11 - 2 Depth Range: 0.00 - 1.30 m

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Fax: 02 6334 4213

TEST PIT NUMBER TP12

CLIENT Bogan Shire Council **PROJECT NAME** Proposed Waste Management Facility
PROJECT NUMBER 12-047 **PROJECT LOCATION** Nyngan

DATE STARTED 23/11/12 **COMPLETED** 23/11/12 **R.L. SURFACE** --- **DATUM** ---
EXCAVATION CONTRACTOR --- **SLOPE** --- **BEARING** ---
EQUIPMENT Backhoe with 450mm Toothed Bucket **TEST PIT LOCATION** ---
TEST PIT SIZE 450mm **LOGGED BY** KA **CHECKED BY** JB
NOTES ---

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	DCP (blows/100mm) 0 5 10 15 20 25	Additional Observations
			0.0		SM	Sandy SILT with clay: brown, fine to coarse sand, firm to stiff, dry (TOPSOIL).			
					CL	Sandy CLAY trace gravel: red brown, medium plasticity clay, fine to coarse sand, fine subangular to subrounded gravel, firm to stiff, slightly moist to moist, moisture content < plastic limit (ALLUVIAL).			
			0.5						
			1.0						
			1.4			Borehole TP12 terminated at 1.4m			
			1.5						
			2.0						
			2.5						
			3.0						

MG LIB 00.GLB Log BOREHOLE / TEST PIT MG 00.GPJ <<DrawingFile>> 10/12/2012 16:36 8.2.300 Datgel Photo Tool

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TEST PIT NUMBER TP12

CLIENT Bogan Shire Council
PROJECT NAME Proposed Waste Management Facility
PROJECT NUMBER 12-047
PROJECT LOCATION Nyngan

TP12 - 1 Depth Range: 0.00 - 1.40 m

TP12 - 2 Depth Range: 0.00 - 1.40 m

Appendix D – Laboratory Test Results

FALLING HEAD PERMEABILITY TEST REPORT

AS1289 6.7.2

Client:	Bogan Shire Council	**Source:**	TP7 0.8-1.0m
Address:	PO Box 221, Nyngan, NSW 2825	**Sample Description:**	Sandy CLAY
Project:	Nyngan	**Report No.:**	07-FHP
Job No.:	12-047	**Lab No.:**	9719 #1

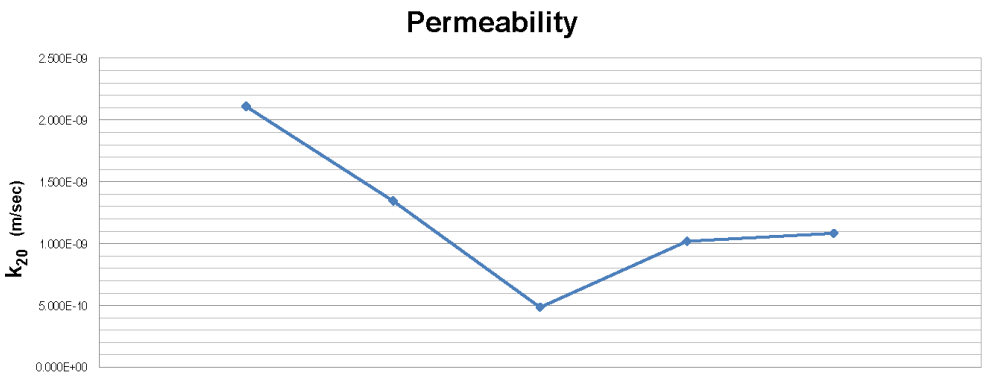
Test Procedure:
☑ AS1289 6.7.2 Soil strength and consolidation tests - Determination of a soil - Falling head method for a remoulded specimen
☑ AS1289 5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relationship of a soil using standard compactive effort

Sampling:	Sampled by Macquarie Geotechnical Staff in accordance with AS1289 1.1	**Date Sampled:**	23/11/2012
Preparation:	Prepared in accordance with AS1289 1.1		

RESULTS OF TESTING

Maximum Dry Density (t/m^3)	**1.70**	Hydraulic Gradient	**0.0**
Optimum Moisture Content (%)	**18.6**	Surcharge (kPa)	**0.0**
Placement Moisture Content (%)	**18.2**	Head Pressure Applied (kPa)	**0.00**
Moisture Ratio (%)	**98.1**	Compaction	**Standard**
Placement Dry Density (t/m^3)	**1.67**	Percentage Material Retained/Sieve Size (mm)	**0 % on 9.5 mm**
Density Ratio (%)	**98.3**	Sample Height and Diameter (mm)	**104 x 98mm**

PERMEABILITY $k_{(20)}$ = **1.08E-09 (m/sec)**



Remarks/Comments

4% Hydrated Lime

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BATHURST NSW 2795

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FALLING HEAD PERMEABILITY TEST REPORT

AS1289 6.7.2

Client:	Bogan Shire Council	**Source:**	TP8 0.8-1.0m
Address:	PO Box 221, Nyngan, NSW 2825	**Sample Description:**	Sandy CLAY
Project:	Nyngan	**Report No.:**	08-FHP
Job No.:	12-047	**Lab No.:**	9720 #1

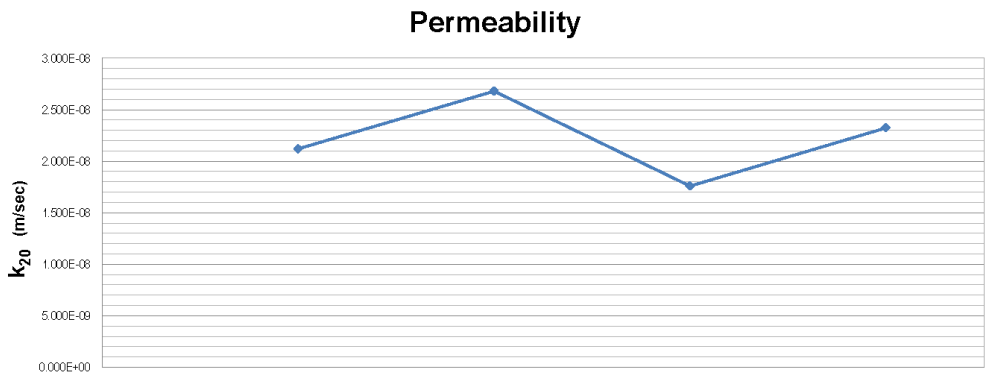
Test Procedure:
☑ AS1289 6.7.2 Soil strength and consolidation tests - Determination of a soil - Falling head method for a remoulded specimen
☑ AS1289 5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relationship of a soil using standard compactive effort

Sampling:	Sampled by Macquarie Geotechnical Staff in accordance with AS1289 1.1	**Date Sampled:**	23/11/12
Preparation:	Prepared in accordance with AS1289 1.1		

RESULTS OF TESTING

Maximum Dry Density (t/m^3)	**1.69**	Hydraulic Gradient	**0.0**
Optimum Moisture Content (%)	**18.7**	Surcharge (kPa)	**0.0**
Placement Moisture Content (%)	**18.8**	Head Pressure Applied (kPa)	**0.00**
Moisture Ratio (%)	**100.4**	Compaction	**Standard**
Placement Dry Density (t/m^3)	**1.65**	Percentage Material Retained/Sieve Size (mm)	**0 % on 9.5 mm**
Density Ratio (%)	**97.9**	Sample Height and Diameter (mm)	**104 x 98mm**

PERMEABILITY $k_{(20)}$ = **2.32E-08 (m/sec)**



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FALLING HEAD PERMEABILITY TEST REPORT

AS1289 6.7.2

Client:	Bogan Shire Council	**Source:**	TP9 0.8-1.0m
Address:	PO Box 221, Nyngan, NSW 2825	**Sample Description:**	Sandy CLAY
Project:	Nyngan	**Report No.:**	09-FHP
Job No.:	12-047	**Lab No.:**	9721 #1

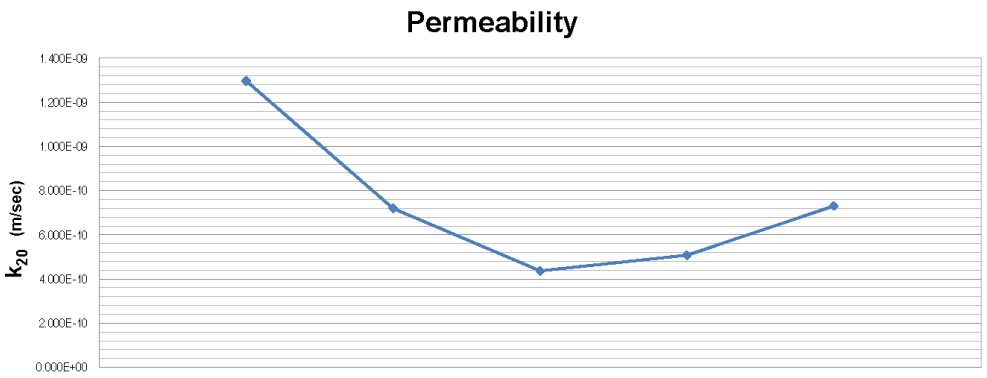
Test Procedure:
☑ AS1289 6.7.2 Soil strength and consolidation tests - Determination of a soil - Falling head method for a remoulded specimen
☑ AS1289 5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relationship of a soil using standard compactive effort

Sampling:	Sampled by Macquarie Geotechnical Staff in accordance with AS1289 1.1	**Date Sampled:**	23/11/2012
Preparation:	Prepared in accordance with AS1289 1.1		

RESULTS OF TESTING

Maximum Dry Density (t/m^3)	**1.66**	Hydraulic Gradient	**0.0**
Optimum Moisture Content (%)	**20.0**	Surcharge (kPa)	**0.0**
Placement Moisture Content (%)	**19.8**	Head Pressure Applied (kPa)	**0.00**
Moisture Ratio (%)	**99.1**	Compaction	**Standard**
Placement Dry Density (t/m^3)	**1.63**	Percentage Material Retained/Sieve Size (mm)	**0 % on 9.5 mm**
Density Ratio (%)	**98.2**	Sample Height and Diameter (mm)	**104 x 98mm**

PERMEABILITY $k_{(20)}$ = **7.31E-10 (m/sec)**



Remarks/Comments

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FALLING HEAD PERMEABILITY TEST REPORT

AS1289 6.7.2

Client:	Bogan Shire Council	**Source:**	TP10 0.8-1.0m
Address:	PO Box 221, Nyngan, NSW 2825	**Sample Description:**	Sandy CLAY
Project:	Nyngan	**Report No.:**	10-FHP
Job No.:	12-047	**Lab No.:**	9722 #1

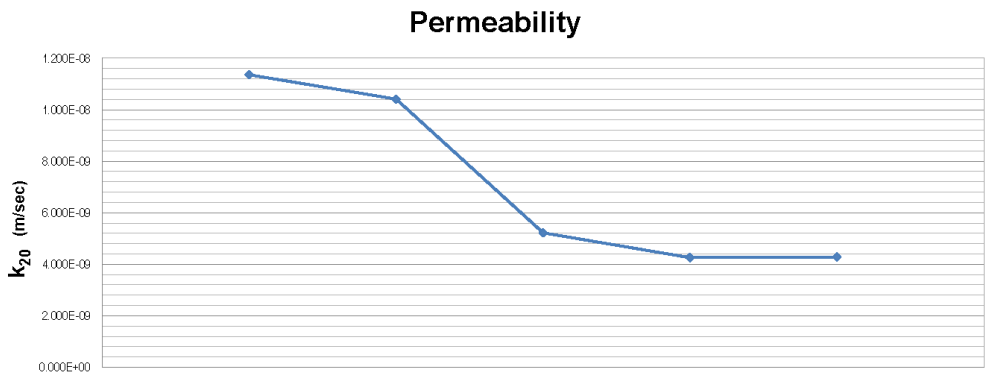
Test Procedure:
☑ AS1289 6.7.2 Soil strength and consolidation tests - Determination of a soil - Falling head method for a remoulded specimen
☑ AS1289 5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relationship of a soil using standard compactive effort

Sampling:	Sampled by Macquarie Geotechnical Staff in accordance with AS1289 1.1	**Date Sampled:**	23/11/2012
Preparation:	Prepared in accordance with AS1289 1.1		

RESULTS OF TESTING

Maximum Dry Density (t/m^3)	**1.71**	Hydraulic Gradient	**0.0**
Optimum Moisture Content (%)	**18.0**	Surcharge (kPa)	**0.0**
Placement Moisture Content (%)	**17.9**	Head Pressure Applied (kPa)	**0.00**
Moisture Ratio (%)	**99.6**	Compaction	**Standard**
Placement Dry Density (t/m^3)	**1.68**	Percentage Material Retained/Sieve Size (mm)	**0 % on 9.5 mm**
Density Ratio (%)	**98.1**	Sample Height and Diameter (mm)	**164 x 98mm**

PERMEABILITY $k_{(20)}$ = **4.28E-09 (m/sec)**



Remarks/Comments

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FALLING HEAD PERMEABILITY TEST REPORT

AS1289 6.7.2

Client:	Bogan Shire Council	**Source:**	TP11 0.8-1.0m
Address:	PO Box 221, Nyngan, NSW 2825	**Sample Description:**	Sandy CLAY
Project:	Nyngan	**Report No.:**	11-FHP
Job No.:	12-047	**Lab No.:**	9723 #1

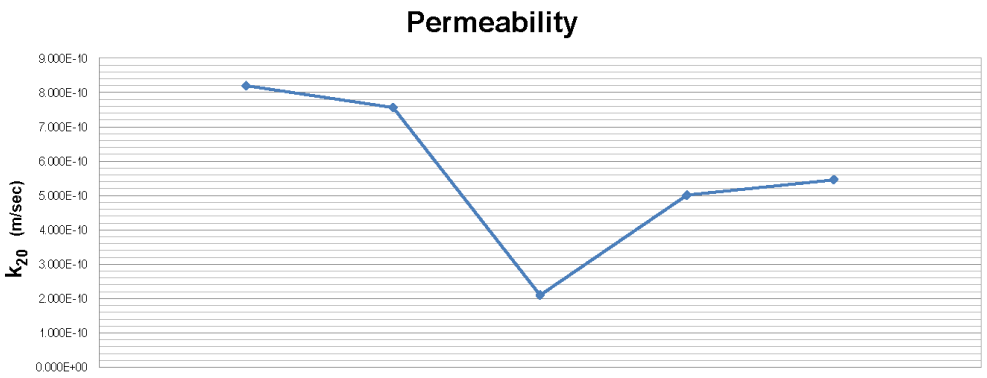
Test Procedure:
☑ AS1289 6.7.2 Soil strength and consolidation tests - Determination of a soil - Falling head method for a remoulded specimen
☑ AS1289 5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relationship of a soil using standard compactive effort

Sampling:	Sampled by Macquarie Geotechnical Staff in accordance with AS1289 1.1	**Date Sampled:**	23/11/2012
Preparation:	Prepared in accordance with AS1289 1.1		

RESULTS OF TESTING

Maximum Dry Density (t/m^3)	**1.75**	Hydraulic Gradient	**0.0**
Optimum Moisture Content (%)	**17.5**	Surcharge (kPa)	**0.0**
Placement Moisture Content (%)	**17.5**	Head Pressure Applied (kPa)	**0.00**
Moisture Ratio (%)	**99.9**	Compaction	**Standard**
Placement Dry Density (t/m^3)	**1.71**	Percentage Material Retained/Sieve Size (mm)	**0 % on 9.5 mm**
Density Ratio (%)	**97.9**	Sample Height and Diameter (mm)	**103 X 98mm**

PERMEABILITY $k_{(20)}$ = **5.46E-10 (m/sec)**



Remarks/Comments

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Authorised Signatory:

Lisa Durrant — 3/12/2012

Lisa Durrant | **Date:**

MACQUARIE GEOTECH

Macquarie Geotechnical
3 Watt Drive
BATHURST NSW 2795

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FALLING HEAD PERMEABILITY TEST REPORT

AS1289 6.7.2

Client:	Bogan Shire Council	**Source:**	TP12 0.8-1.0m
Address:	PO Box 221, Nyngan, NSW 2825	**Sample Description:**	Sandy CLAY
Project:	Nyngan	**Report No.:**	12-FHP
Job No.:	12-047	**Lab No.:**	9724 #1

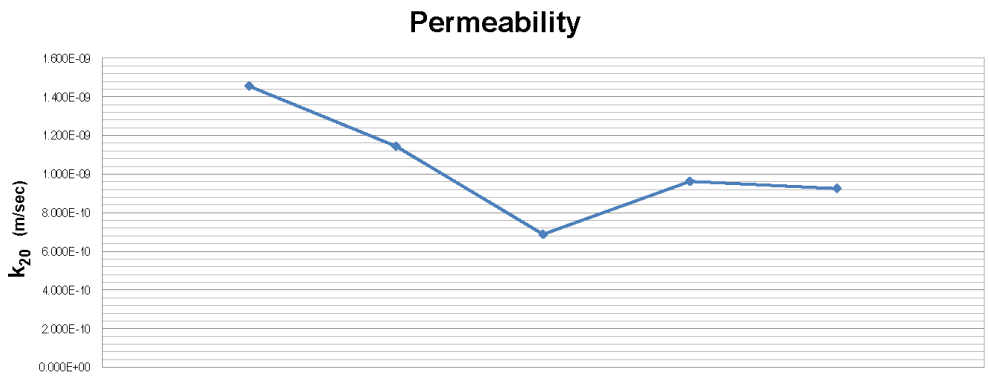
Test Procedure:
☑ AS1289 6.7.2 Soil strength and consolidation tests - Determination of a soil - Falling head method for a remoulded specimen
☑ AS1289 5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relationship of a soil using standard compactive effort

Sampling:	Sampled by Macquarie Geotechnical Staff in accordance with AS1289 1.1	**Date Sampled:**	23/11/2012
Preparation:	Prepared in accordance with AS1289 1.1		

RESULTS OF TESTING

Maximum Dry Density (t/m^3)	**1.66**	Hydraulic Gradient	**0.0**
Optimum Moisture Content (%)	**21.0**	Surcharge (kPa)	**0.0**
Placement Moisture Content (%)	**21.2**	Head Pressure Applied (kPa)	**0.00**
Moisture Ratio (%)	**100.8**	Compaction	**Standard**
Placement Dry Density (t/m^3)	**1.63**	Percentage Material Retained/Sieve Size (mm)	**0 % on 9.5 mm**
Density Ratio (%)	**97.9**	Sample Height and Diameter (mm)	**104 x 98mm**

PERMEABILITY $k_{(20)}$ = **9.26E-10 (m/sec)**



Remarks/Comments

2% Hydrated Lime

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FALLING HEAD PERMEABILITY TEST REPORT

AS1289 6.7.2

Client:	Bogan Shire Council	**Source:**	TP7 0.8-1.0m
Address:	PO Box 221, Nyngan, NSW 2825	**Sample Description:**	Sandy CLAY
Project:	Nyngan	**Report No.:**	13-FHP
Job No.:	12-047	**Lab No.:**	9719 #2

Test Procedure:

☑ AS1289 6.7.2 Soil strength and consolidation tests - Determination of a soil - Falling head method for a remoulded specimen

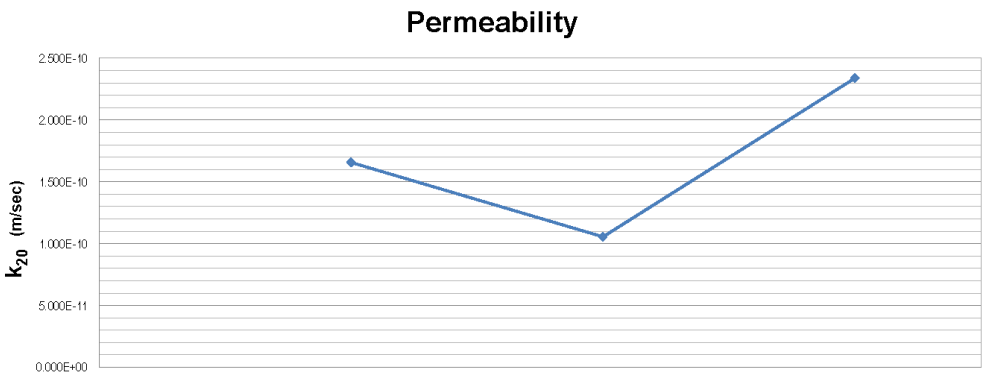
☑ AS1289 5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relationship of a soil using standard compactive effort

Sampling:	Sampled by Macquarie Geotechnical Staff in accordance with AS1289 1.1	**Date Sampled:**	23/11/2012
Preparation:	Prepared in accordance with AS1289 1.1		

RESULTS OF TESTING

Maximum Dry Density (t/m^3)	**1.70**	Hydraulic Gradient	**0.0**
Optimum Moisture Content (%)	**18.6**	Surcharge (kPa)	**0.0**
Placement Moisture Content (%)	**18.2**	Head Pressure Applied (kPa)	**0.00**
Moisture Ratio (%)	**98.1**	Compaction	**Standard**
Placement Dry Density (t/m^3)	**1.67**	Percentage Material Retained/Sieve Size (mm)	**0 % on 9.5 mm**
Density Ratio (%)	**98.3**	Sample Height and Diameter (mm)	**104 x 98mm**

PERMEABILITY $k_{(20)}$ = **2.34E-10 (m/sec)**



Remarks/Comments **2% Bentonite**

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FALLING HEAD PERMEABILITY TEST REPORT

AS1289 6.7.2

Client:	Bogan Shire Council	**Source:**	TP8 0.8-1.0m
Address:	PO Box 221, Nyngan, NSW 2825	**Sample Description:**	Sandy CLAY
Project:	Nyngan	**Report No.:**	14-FHP
Job No.:	12-047	**Lab No.:**	9720 #2

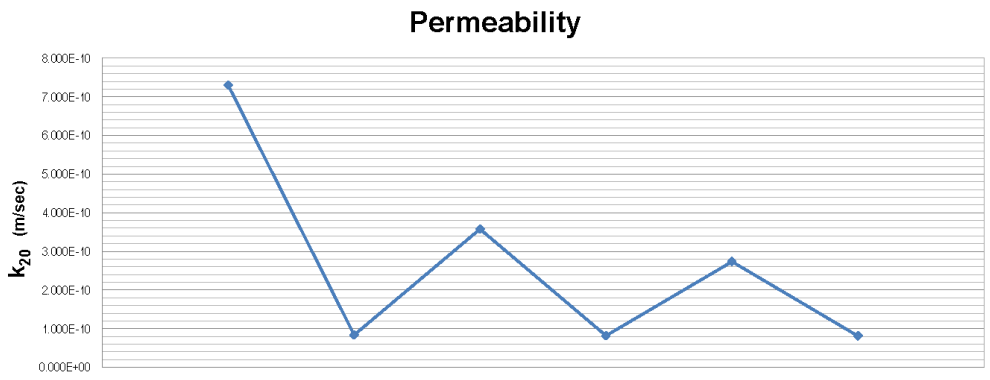
Test Procedure:
- ☑ AS1289 6.7.2 Soil strength and consolidation tests - Determination of a soil - Falling head method for a remoulded specimen
- ☑ AS1289 5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relationship of a soil using standard compactive effort

Sampling:	Sampled by Macquarie Geotechnical Staff in accordance with AS1289 1.1	**Date Sampled:**	23/11/12
Preparation:	Prepared in accordance with AS1289 1.1		

RESULTS OF TESTING

Maximum Dry Density (t/m^3)	**1.69**	Hydraulic Gradient	**0.0**
Optimum Moisture Content (%)	**18.7**	Surcharge (kPa)	**0.0**
Placement Moisture Content (%)	**18.8**	Head Pressure Applied (kPa)	**0.00**
Moisture Ratio (%)	**100.4**	Compaction	**Standard**
Placement Dry Density (t/m^3)	**1.65**	Percentage Material Retained/Sieve Size (mm)	**0 % on 9.5 mm**
Density Ratio (%)	**97.9**	Sample Height and Diameter (mm)	**104 x 98mm**

PERMEABILITY $k_{(20)}$ = **8.17E-11 (m/sec)**



Remarks/Comments **1% Bentonite**

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Authorised Signatory:

Lisa Durrant

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FALLING HEAD PERMEABILITY TEST REPORT

AS1289 6.7.2

Client:	Bogan Shire Council	**Source:**	TP9 0.8-1.0m
Address:	PO Box 221, Nyngan, NSW 2825	**Sample Description:**	Sandy CLAY
Project:	Nyngan	**Report No.:**	15-FHP
Job No.:	12-047	**Lab No.:**	9721 #2

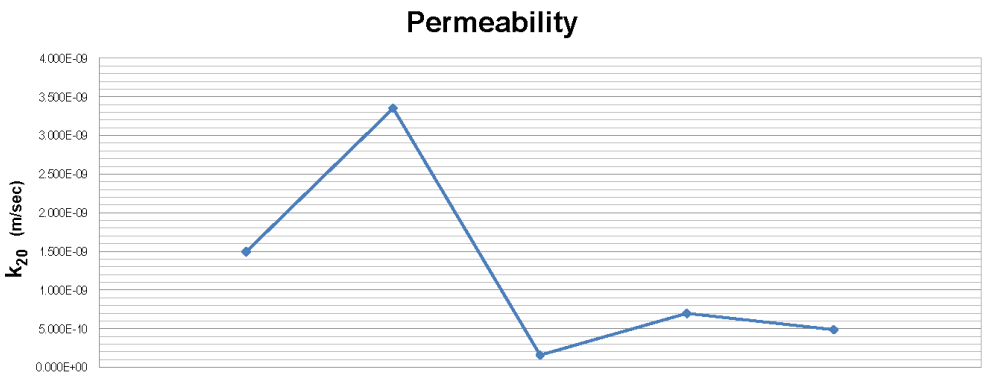
Test Procedure:
☑ AS1289 6.7.2 Soil strength and consolidation tests - Determination of a soil - Falling head method for a remoulded specimen
☑ AS1289 5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relationship of a soil using standard compactive effort

Sampling:	Sampled by Macquarie Geotechnical Staff in accordance with AS1289 1.1	**Date Sampled:**	23/11/2012
Preparation:	Prepared in accordance with AS1289 1.1		

RESULTS OF TESTING

Maximum Dry Density (t/m^3)	**1.66**	Hydraulic Gradient	**0.0**
Optimum Moisture Content (%)	**20.0**	Surcharge (kPa)	**0.0**
Placement Moisture Content (%)	**19.8**	Head Pressure Applied (kPa)	**0.00**
Moisture Ratio (%)	**99.1**	Compaction	**Standard**
Placement Dry Density (t/m^3)	**1.63**	Percentage Material Retained/Sieve Size (mm)	**0 % on 9.5 mm**
Density Ratio (%)	**98.2**	Sample Height and Diameter (mm)	**104 x 98mm**

PERMEABILITY $k_{(20)}$ = **4.87E-10 (m/sec)**



Remarks/Comments **2% Bentonite**

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FALLING HEAD PERMEABILITY TEST REPORT

AS1289 6.7.2

Client:	Bogan Shire Council	**Source:**	TP10 0.8-1.0m
Address:	PO Box 221, Nyngan, NSW 2825	**Sample Description:**	Sandy CLAY
Project:	Nyngan	**Report No.:**	16-FHP
Job No.:	12-047	**Lab No.:**	9722 #2

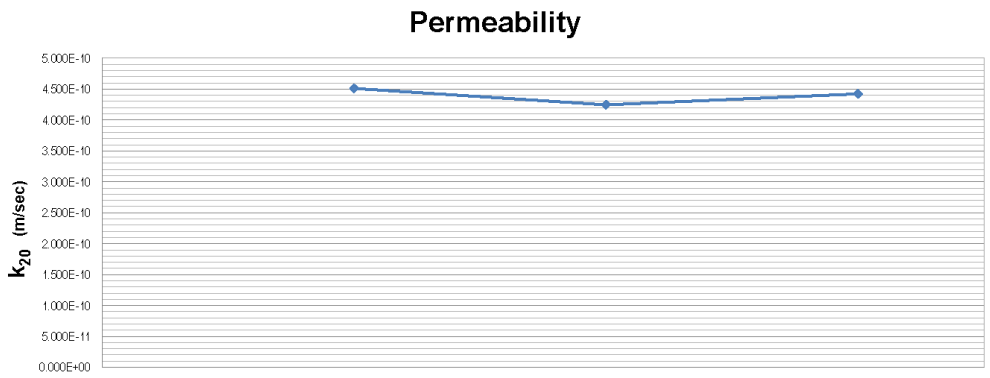
Test Procedure:
- ☑ AS1289 6.7.2 Soil strength and consolidation tests - Determination of a soil - Falling head method for a remoulded specimen
- ☑ AS1289 5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relationship of a soil using standard compactive effort

Sampling:	Sampled by Macquarie Geotechnical Staff in accordance with AS1289 1.1	**Date Sampled:**	23/11/2012
Preparation:	Prepared in accordance with AS1289 1.1		

RESULTS OF TESTING

Maximum Dry Density (t/m^3)	**1.71**	Hydraulic Gradient	**0.0**
Optimum Moisture Content (%)	**18.0**	Surcharge (kPa)	**0.0**
Placement Moisture Content (%)	**17.9**	Head Pressure Applied (kPa)	**0.00**
Moisture Ratio (%)	**99.6**	Compaction	**Standard**
Placement Dry Density (t/m^3)	**1.68**	Percentage Material Retained/Sieve Size (mm)	**0 % on 9.5 mm**
Density Ratio (%)	**98.1**	Sample Height and Diameter (mm)	**164 x 98mm**

PERMEABILITY $k_{(20)}$ = **4.42E-10 (m/sec)**



Remarks/Comments **2% Bentonite**

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FALLING HEAD PERMEABILITY TEST REPORT

AS1289 6.7.2

Client:	Bogan Shire Council	**Source:**	TP11 0.8-1.0m
Address:	PO Box 221, Nyngan, NSW 2825	**Sample Description:**	Sandy CLAY
Project:	Nyngan	**Report No.:**	17-FHP
Job No.:	12-047	**Lab No.:**	9723 #2

Test Procedure:

☑ AS1289 6.7.2 Soil strength and consolidation tests - Determination of a soil - Falling head method for a remoulded specimen

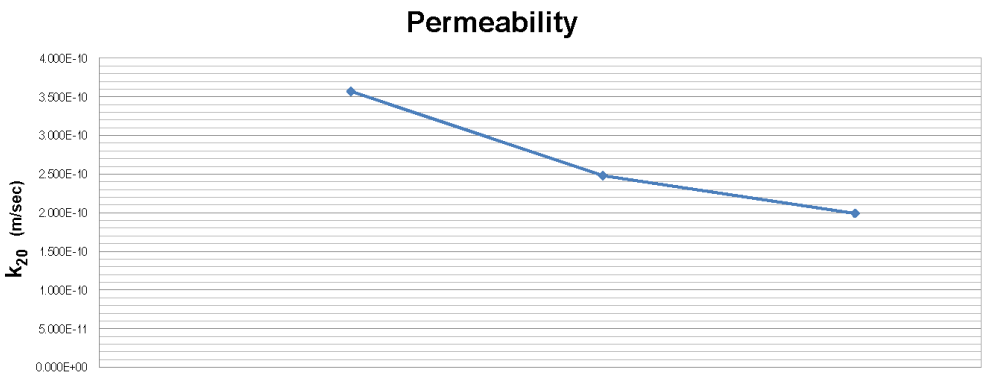
☑ AS1289 5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relationship of a soil using standard compactive effort

Sampling:	Sampled by Macquarie Geotechnical Staff in accordance with AS1289 1.1	**Date Sampled:**	23/11/2012
Preparation:	Prepared in accordance with AS1289 1.1		

RESULTS OF TESTING

Maximum Dry Density (t/m^3)	**1.75**	Hydraulic Gradient	**0.0**
Optimum Moisture Content (%)	**17.5**	Surcharge (kPa)	**0.0**
Placement Moisture Content (%)	**17.5**	Head Pressure Applied (kPa)	**0.00**
Moisture Ratio (%)	**99.9**	Compaction	**Standard**
Placement Dry Density (t/m^3)	**1.71**	Percentage Material Retained/Sieve Size (mm)	**0 % on 9.5 mm**
Density Ratio (%)	**97.9**	Sample Height and Diameter (mm)	**103 X 98mm**

PERMEABILITY $k_{(20)}$ = **1.99E-10 (m/sec)**



Remarks/Comments **1% Bentonite**

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FALLING HEAD PERMEABILITY TEST REPORT

AS1289 6.7.2

Client:	Bogan Shire Council	**Source:**	TP12 9.8-1.0m
Address:	PO Box 221, Nyngan, NSW 2925	**Sample Description:**	Sandy CLAY
Project:	Nyngan	**Report No.:**	18-FHP
Job No.:	12-047	**Lab No.:**	9724#3

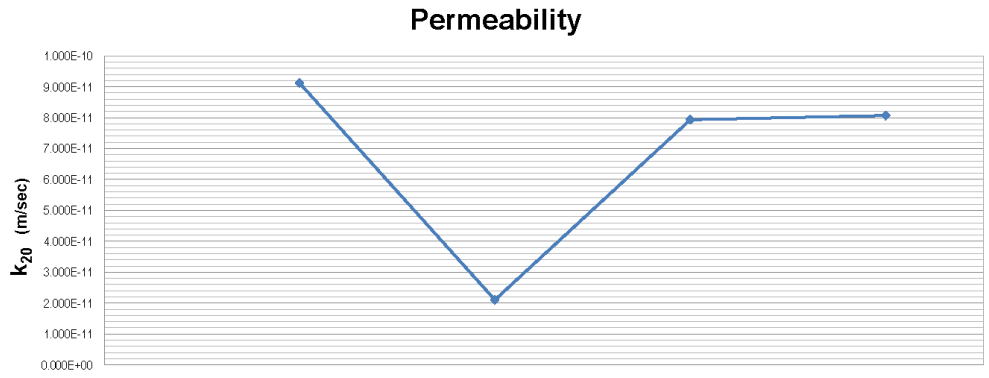
Test Procedure:
☑ AS1289 6.7.2 Soil strength and consolidation tests - Determination of a soil - Falling head method for a remoulded specimen
☑ AS1289 5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relationship of a soil using standard compactive effort

Sampling:	Sampled by Macquarie Geotechnical Staff in accordance with AS1289 1.1	**Date Sampled:**	23/11/2012
Preparation:	Prepared in accordance with AS1289 1.1		

RESULTS OF TESTING

Maximum Dry Density (t/m^3)	**1.66**	Hydraulic Gradient	**0.0**
Optimum Moisture Content (%)	**21.0**	Surcharge (kPa)	**0.0**
Placement Moisture Content (%)	**20.5**	Head Pressure Applied (kPa)	**0.00**
Moisture Ratio (%)	**97.7**	Compaction	**Standard**
Placement Dry Density (t/m^3)	**1.63**	Percentage Material Retained/Sieve Size (mm)	**0 % on 9.5 mm**
Density Ratio (%)	**97.9**	Sample Height and Diameter (mm)	**104 x 98 mm**

PERMEABILITY $k_{(20)}$ = **8.07E-11 (m/sec)**



Remarks/Comments **1% Bentonite**

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