GEOTECHNIQUE® PTY LTD

ABN 64 002 841 063

Job No: 13851/1
Our Ref: 13851/1-AA
26 October 2016

Legacy Property
Level 27, MLC Centre
19-29 Martin Place,
SYDNEY NSW 2000
Email: mwilliams@legacyproperty.com.au

Attention: Mr M Williams

Dear Sir

re: **Proposed Open Space**
Lot 754 in DP1180111 - 754 Caddens Road, Caddens
Salinity Assessment

Introduction
This letter report provides the results of a salinity assessment for the above site. It is understood that the site is not proposed for residential or commercial development and would be utilised for detention of stormwater and as an open space.

Site Location & Description
The site is located south of the Archives building and is registered as Lot 754 in DP1180111, located at 754 Caddens Road, Caddens. The site occupies about 5 hectares and is currently a vacant land along Caddens Road.

At the time, during the field work on 12 October 2016, there was salt encrustation observed on the bare ground surface of a local depression that is visual indicators of soil salinity. A vacant neighbouring land to the west was vacant, NSW Department of state records to the north and residential to the south and east. General site features are indicated on the attached Drawing No 13851/1-AA1.

Regional Geology
The Geological Map of Penrith (Geological Series Sheet 9030, Scale 1:100,000, Edition 1, 1991), published by the Department of Minerals and Energy indicates the residual soils within the site to be underlain by Triassic Age Shale of the Wianamatta Group, comprising shale, carbonaceous claystone, claystone, laminite, fine to medium grained lithic sandstone, rare coal and tuff.

Soil Landscape
The Soil Landscape Map of Penrith (Soil Landscape Series Sheet 9030, Scale 1:100,000, 1989), prepared by the Soil Conservation Service of NSW, indicates that the site is located within the South Creek comprising flood plains, valleys flats and drainage depressions of the channels on the Cumberland plains. Soils in this landscape comprise silty and sandy clays and are often very deep layers of sediments over bedrock or relict soils. This landscape is subjected to frequent flooding and erosion hazards.

The site is also located within the Luddenham landscape area and typically consists of poorly drained/relatively impermeable residual natural soils.

Field Work Methods

The salinity assessment was carried out on 12 October 2016. The following scope of work was completed:

- Carried out a walk-over survey of the site to assess existing site conditions and visual indicators of salinity.
- Obtained and review services plans from "Dial Before You Dig" to identify locations of underground services across the site.
- Scanned the proposed test locations for underground services to ensure test locations are located away from the existing services.
- Excavated eight test pits (TP1-TP8), using an excavator equipped with a 400mm bucket. The test pits were terminated at depths in the range of 2.5m to 2.8m. The test pit locations are shown on the attached Drawing No 13851/1-AA1.
- Recovered representative soil samples from the test pits for visual assessment and laboratory tests.

Subsurface Conditions

The subsurface conditions encountered in the test pits across the site are detailed in the attached engineering excavation logs. The general subsurface profile encountered in the test pits may be summarised in below:

Topsoil	Silty Clay, low plasticity, brown, with root fibres. Topsoil was encountered to 200mm below existing ground level (EGL)
Natural Soil	Alluvial Soils: Silty Clay, medium plasticity, brown to orange, soft to stiff, extending to 2.8m below EGL. Residual Soils: Underlying Alluvial soils. Silty Clay, medium to high plasticity, grey, stiff to very stiff, with ironstones extending to 2.7m below EGL.

Groundwater Conditions

Groundwater seepage was encountered in TP5 at a depth of 2.2m below EGL. All the test pits were backfilled immediately after logging was completed. Long term water monitoring was not part of this investigation. It should be noted that groundwater levels fluctuate and are affected by many factors which fall outside of the scope present report.

Desktop Study

Reference was made to salinity, topographic and geological maps pertinent to the site to assist in the salinity assessment discussed herein. Based on the Salinity Potential Map of Western Sydney (DIPNR, 2002), the site is mapped to be of moderate salinity potential. Typically this class is associated to areas associated with past or recent creek alignments/alluvial terraces.

The Penrith Development Control plan 2014 (Figure E1.21) indicates that the areas of potential salinity risk may be located within the site.

Laboratory Testing

Recovered soil samples obtained from the test pits were tested in a NATA accredited laboratory to determine the following:

- Electrical Conductivity (EC) & Agressivity (pH).
- Exchangeable Sodium Percentage (ESP).

Salinity, Aggressivity & Sodicity Testing

The results of the laboratory testing are presented below:

TP	Depth (m)	EC (µS/cm)	MF	Ec_e (dS/m)	Assessment	pH	Assessment	ESP (%)
1	0.4-0.6	630	8	5.0	Moderately Saline	8.5	Non-acidic	NT
1	1.2-1.4	750	8	6.0	Moderately Saline	8.5	Non-acidic	NT
2	0.4-0.6	550	8	4.4	Moderately Saline	5.3	Slightly-acidic	19
2	1.5-1.7	730	8	5.8	Moderately Saline	4.9	Slightly-acidic	NT
3	0.0-0.2	18	8.5	0.2	Non-Saline	5.8	Slightly-acidic	NT
3	2.3-2.5	340	7	2.4	Slightly Saline	5.2	Slightly-acidic	NT
4	0.0-0.2	29	8.5	0.2	Non-Saline	6.0	Slightly-acidic	NT
4	1.8-2.0	490	7	3.4	Slightly Saline	5.2	Slightly-acidic	27.5
5	0.2-0.4	490	8	3.9	Slightly Saline	7.9	Non-acidic	NT
5	0.9-1.1	1100	8	8.8	Very Saline	8.2	Non-acidic	24.9
6	0.2-0.4	130	8	1.0	Non-Saline	7.9	Non-acidic	26.2
6	2.5-2.6	340	8	2.7	Slightly Saline	8.6	Non-acidic	NT
7	0.0-0.2	72	8.5	0.6	Non-Saline	7.3	Non-acidic	NT
7	1.0-1.2	310	7	2.2	Slightly Saline	8.2	Non-acidic	NT
8	0.5-0.7	360	8	2.9	Slightly Saline	7.5	Non-acidic	21.3
8	2.0-2.2	830	8	6.6	Moderately Saline	8.3	Non-acidic	NT
Average				**3.5**	**Slightly Saline**	**7.1**	**Neutral**	**24**

NT: Not Tested

Soil Salinity

Soil samples were tested in a NATA accredited laboratory for $EC_{1.5}$, which is the electrical conductivity of a 1:5 soil/water paste. The soil salinity is then calculated using the formula, $EC_e = M \times EC_{1.5}$, where M is the multiplication factor based on the soil texture. The boundaries of salinity classes are presented below:

Classification	EC_e (dS/m)
Non-saline	<2
Slightly saline	2 – 4
Moderately saline	4 – 8
Very saline	8 – 16
Highly saline	>16

The foregoing results indicate the average soil condition of the site is classified as slightly to moderately saline soils; however there are some locations with moderately and very saline soils (TP5).

TP5: Upon inspection of ground surface within the vicinity of TP5, salt encrustation was observed on the bare ground surface which is a visual indication of saline soils. Furthermore, the laboratory results revealed the soil was very saline at a depth of 0.9m - 1.1m below excavated ground level. Groundwater seepage was encountered in TP5 indicating that it is likely the cause of local saline soils is due to the rising groundwater table.

Soil Acidity & Aggressivity

The results indicates that the pH of the soil underlying the site fall in the range of 4.9 to 8.6, varying in location and depth, with a numerical average of 7.1 (Neutral). Based on the foregoing, the soils can be assessed as non-acidic or neutral.

The aggressivity of the soil underlying the site was made based on the Australia Standard AS2159 (Piling Design and Installation for Condition B-low permeability soils, e.g. silts and clays or all soils above groundwater level). The aggressivity of soil applicable to iron/steel and concrete as per AS2159 is given below:

Aggressivity Classes with Respect to Steel

pH	Soil Condition
>5.0	Non-aggressive
4.0-5.0	Non-aggressive
3.0-4.0	Mild
<3.0	Moderate

Aggressivity Classes with Respect to Concrete

pH	Soil Condition
>5.5	Non-aggressive
4.5-5.5	Mild
4.0-4.5	Moderate
<4.0	Severe

Based on the criteria set within AS2159, the soils underlying the site are assessed to be non-aggressive to steel and concrete with the exception of four soil samples, which are assessed as mild aggressive for concrete.

Soil Sodicity

The chemical tests also included Exchangeable Sodium Percentage (ESP) testing to assess the sodicity of the soil. The recommended thresholds boundaries for sodicity are presented in below:

Sodicity Thresholds

ESP	Rating
<5%	Non-sodic
5-10%	Marginally sodic
>10%	Highly sodic

Based on the average ESP test result of about 24% and the soil classes presented in the table above, we assess that the soils underlying the site is generally highly sodic, indicating the possible presence of highly erodible soil.

Soil Management Plan

The objectives of the Soil Management Plan are as follows:

- Minimise water pollution due to erosion, siltation and sedimentation.
- Maximise re-use of on-site materials.
- Reduce and manage salinity within the site so that impacts on the environment are minimised and acceptable.

The following aspects of the proposed development are considered in developing the Soil Management Plan:

- Generally slightly to moderately saline soils will be encountered across the site, with pockets of very saline soils.
- The soils underlying the site are generally non-acidic to neutral with pockets of non-aggressive to mildly aggressive.
- Erodible soils are present at the site.

We recommended the following as part of the **Soil Management Plan** for earthworks in the site:

Flora and Fauna;

- Saline soils inhibits the growth and survival of certain plant species in affected areas, which consequently impacts the habitat and food source of resident animals.
- Areas impacted by soil salinity can be made suitable for revegetation by means of reclamation.
- Saline soil affected areas can be reclaimed by application of gypsum followed by ponding which drives the sodium ions deeper into the soil profile and raises the soil pH.
- Vegetation of the affected area with saline tolerant species to facilitated a deep rooting riparian zone which helps prevent the groundwater table rising high and mitigates the risk of erosion.
- Consult a bush regeneration consultant or native nursery for advice on planting native salinity tolerable species.

The site;

- Erosion and Sediment Control Plans must be developed and implemented. All sediment and erosion controls proposed by the Erosion and Sediment Control Plans are to be installed prior to commencement of any works.
- Ensure that all activities do not affect the natural flow of groundwater. If groundwater is intercepted during development works/excavation, the flow should be diverted to stormwater drains or creeks by providing appropriate surface and sub-surface drainage.
- Reduce groundwater recharge by minimising deep infiltration and provide a well compacted impermeable liner along surfaces of waterways (drains, channels, creeks etc).
- If fill is to be placed in low lying areas, a drainage layer should be placed beneath the fill to prevent groundwater rise and the drainage layer should be drained off the site.
- Utilise native and deep-rooted plants to minimise soil erosion.
- The soils on site may be classified as A2 (as defined in AS2870-2011), requiring concrete placed on the ground to have a minimum compressive strength of 25MPa.

General

Assessments and recommendations presented in this report are based on sub-surface profiles encountered in eight test pits, site observations and laboratory tests on selected sixteen soil samples. Although, we believe that the sub-surface profile presented in this report is indicative of the general profile across the site, it is possible that the sub-surface profile across the site could differ from that encountered in the test pits. We recommend that this company is contacted for further advice if actual site conditions encountered during construction differ from those presented in this report.

If you have any questions, please do not hesitate to contact the undersigned.

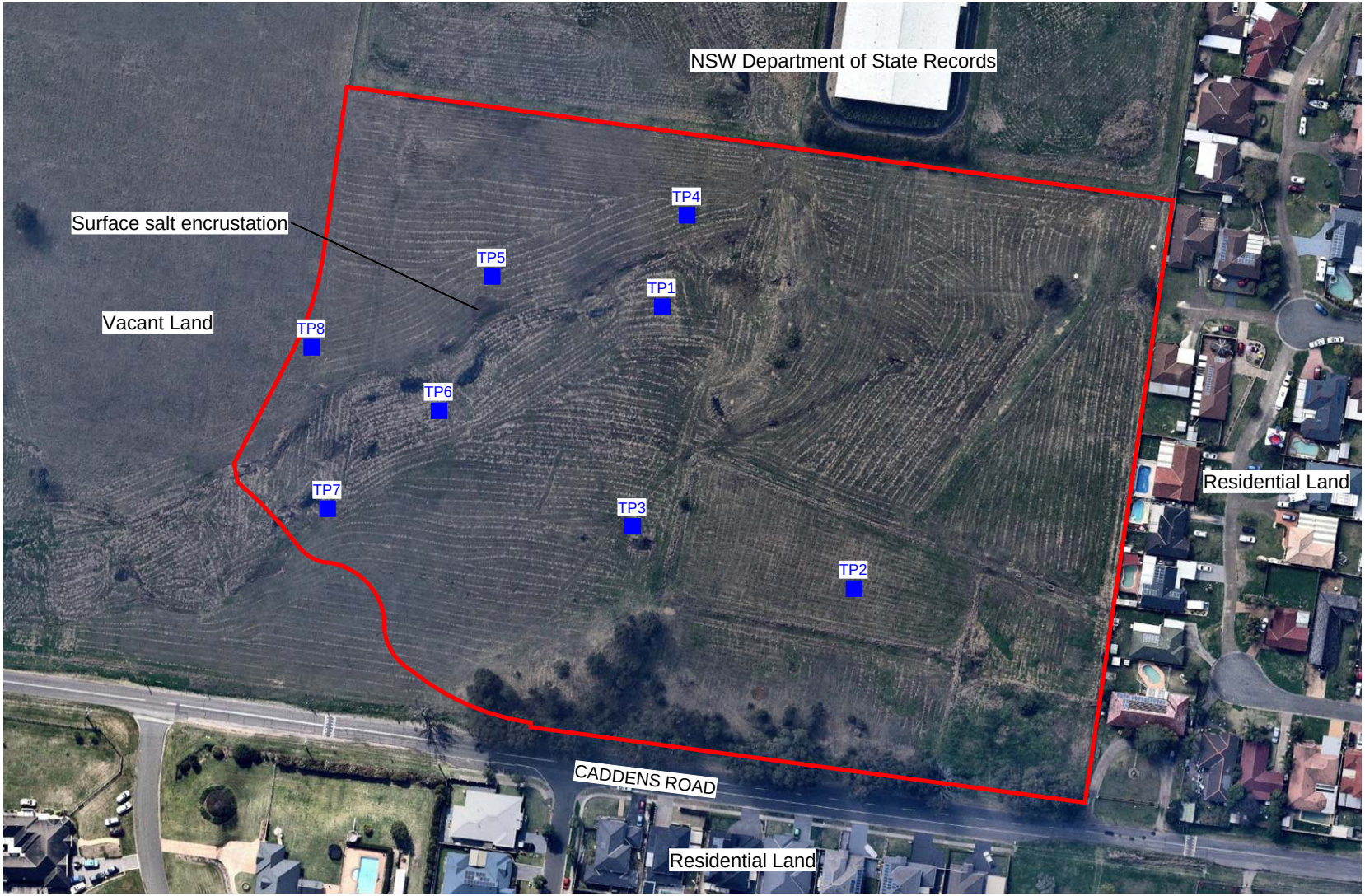
Yours faithfully
GEOTECHNIQUE PTY LTD

JUSTIN HOFMANN
Environmental Scientist

Reviewed By

EMGED RIZKALLA
Director

Attached: Drawing No 13851/1-AA1 – Test Pits Location Plan
Engineering Excavation Logs & Explanatory Notes



LEGEND

Test Pit

Imagery ©2016 NearMap.com

0 2 4 6 8 10m

Scale 1:200

GEOTECHNIQUE ® PTY LTD

PO Box 880
Penrith NSW 2750
Tel: 02 4722 2700
Fax: 02 4722 2777
e-mail:info@geotech.com.au
www.geotech.com.au

NOTES

1. Site features are indicative and are not to scale.
2. This drawing has been produced using a base plan provided by others to which additional information e.g test pits, borehole locations or notes have been added. Some or all of the plan may not be relevant at the time of producing this drawing

Legacy Property
Proposed Open Space
Lot 754 in DP1180111
Vivaldi Crescent, Caddens

Test Pit Locations

Drawing No: 13851/1-AA1
Job No: 13851/1
Drawn By: MH
Date: 12 October 2016
Checked By: JH/ER

File No: 13851-1
Layers: 0, AA1

GEOTECHNIQUE
PTY LTD

engineering log - excavation

Client : Legacy Property
Project : Proposed Open Space
Location : Lot 754 in DP1180111, 754 Caddens Road, Caddens

Job No : 13851/1
Pit No : 1
Date : 12/10/2016
Logged/Checked by: JH

Equipment type and model: 5 Tonne Excavator
R.L. surface : 40.14
Excavation dimensions : 2.0 **m long** 0.4 **m wide**
datum : AHD

groundwater	env samples	PID reading (ppm)	geo samples	field tests	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
					0			TOPSOIL: Silty Clay, low to medium plasticity, brown, trace of root fibres				
							CI	Silty CLAY, medium plasticity, brown	M<PL	F-St		Alluvial
			DS		0.5							
			DS		1							
					1.5							
					2							
					2.5			Test Pit No. 1 terminated at 2.5m				
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
PTY LTD

engineering log - excavation

Client : Legacy Property
Project : Proposed Open Space
Location : Lot 754 in DP1180111, 754 Caddens Road, Caddens

Job No : 13851/1
Pit No : 2
Date : 12/10/2016
Logged/Checked by: JH

Equipment type and model: 5 Tonne Excavator
R.L. surface : 39.51
Excavation dimensions : 2.0 **m long** 0.4 **m wide**
datum : AHD

groundwater	env samples	PID reading (ppm)	geo samples	field tests	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
					0			TOPSOIL: Silty Clay, low to medium plasticity, brown, trace of root fibres				
							CI	Silty CLAY, medium plasticity, orange-brown	M<PL	F		Alluvial
			DS		0.5							
					1							
			DS		1.5							
					2		CI-CH	Shale CLAY, medium to high plasticity, grey, with ironstone	M<PL	St		Residual
					2.5			Test Pit No. 2 terminated at 2.5m				
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
PTY LTD

engineering log - excavation

Client : Legacy Property
Project : Proposed Open Space
Location : Lot 754 in DP1180111, 754 Caddens Road, Caddens

Job No : 13851/1
Pit No : 3
Date : 12/10/2016
Logged/Checked by: JH

Equipment type and model: 5 Tonne Excavator
R.L. surface : 41.28
Excavation dimensions : 2.0 **m long** 0.4 **m wide**
datum : AHD

groundwater	env samples	PID reading (ppm)	geo samples	field tests	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
			DS		0			TOPSOIL: Silty Clay, low to medium plasticity, brown, trace of root fibres				
							CI	Silty CLAY, medium plasticity, orange-brown	M<PL	S-F		Alluvial
					0.5							
					1							
					1.5							
					2							
			DS		2.5		CI-CH	Shaley CLAY, medium to high plasticity, grey, with ironstone	M<PL	VSt		Residual
								Test Pit No. 3 terminated at 2.5m				
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
PTY LTD

engineering log - excavation

Client : Legacy Property
Project : Proposed Open Space
Location : Lot 754 in DP1180111, 754 Caddens Road, Caddens

Job No : 13851/1
Pit No : 4
Date : 12/10/2016
Logged/Checked by: JH

Equipment type and model: 5 Tonne Excavator
R.L. surface : 40.5
Excavation dimensions : 2.0 **m long** 0.4 **m wide**
datum : AHD

groundwater	env samples	PID reading (ppm)	geo samples	field tests	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
			DS		0			TOPSOIL: Silty Clay, low to medium plasticity, brown, trace of root fibres				
					0.5		CI	Silty CLAY, medium plasticity, orange-brown	M<PL	F-St		Alluvial
					1							
					1.5							
			DS		2		CI-CH	Shaley CLAY, medium to high plasticity, grey, with ironstone	M<PL	St-VSt		Residual
					2.5			Test Pit No. 4 terminated at 2.5m				
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
PTY LTD

engineering log - excavation

Client : Legacy Property
Project : Proposed Open Space
Location : Lot 754 in DP1180111, 754 Caddens Road, Caddens

Job No : 13851/1
Pit No : 5
Date : 12/10/2016
Logged/Checked by: JH

Equipment type and model: 5 Tonne Excavator
R.L. surface : 41.26
Excavation dimensions : 2.0 **m long** 0.4 **m wide**
datum : AHD

groundwater	env samples	PID reading (ppm)	geo samples	field tests	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
					0			TOPSOIL: Silty Clay, low to medium plasticity, brown, trace of root fibres				
			DS					Silty CLAY, medium plasticity, brown	M<PL	F-St		Alluvial
					0.5							
			DS		1							
					1.5							
▼					2							Groundwater encountered at 2.2m
					2.5			Test Pit No. 5 terminated at 2.5m				
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
PTY LTD

engineering log - excavation

Client : Legacy Property
Project : Proposed Open Space
Location : Lot 754 in DP1180111, 754 Caddens Road, Caddens

Job No : 13851/1
Pit No : 6
Date : 12/10/2016
Logged/Checked by: JH

Equipment type and model: 5 Tonne Excavator
R.L. surface : 41.37
Excavation dimensions : 2.0 **m long** 0.4 **m wide**
datum : AHD

groundwater	env samples	PID reading (ppm)	geo samples	field tests	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
					0			TOPSOIL: Silty Clay, low to medium plasticity, brown, trace of root fibres				
			DS				CI	Silty CLAY, medium plasticity, brown	M<PL	F		Alluvial
			DS		0.5							
					1							
					1.5							
					2							
					2.5							
								Test Pit No. 6 terminated at 2.8m				
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
PTY LTD

engineering log - excavation

Client : Legacy Property
Project : Proposed Open Space
Location : Lot 754 in DP1180111, 754 Caddens Road, Caddens

Job No : 13851/1
Pit No : 7
Date : 12/10/2016
Logged/Checked by: JH

Equipment type and model: 5 Tonne Excavator
R.L. surface : 42.0
Excavation dimensions : 2.0 **m long** 0.4 **m wide**
datum : AHD

groundwater	env samples	PID reading (ppm)	geo samples	field tests	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
			DS		0			TOPSOIL: Silty Clay, low to medium plasticity, trace of root fibres				
							CI	Silty CLAY, medium plasticity, brown-orange	M<PL	F		Alluvial
			DS		0.5							
					1							
					1.5							
					2							
							CI-CH	Shaley CLAY, medium to high plasticity, grey, with ironstone	M<PL	VSt		Residual
					2.5			Test Pit No. 7 terminated at 2.7m				
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
PTY LTD

engineering log - excavation

Client : Legacy Property
Project : Proposed Open Space
Location : Lot 754 in DP1180111, 754 Caddens Road, Caddens

Job No : 13851/1
Pit No : 8
Date : 12/10/2016
Logged/Checked by: JH

Equipment type and model: 5 Tonne Excavator
R.L. surface : 42.56
Excavation dimensions : 2.0 **m long** 0.4 **m wide**
datum : AHD

groundwater	env samples	PID reading (ppm)	geo samples	field tests	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
					0			TOPSOIL: Silty Clay, low to medium plasticity, brown, trace of root fibres				
							CI	Silty CLAY, medium plasticity, brown-orange	M<PL	S		Alluvial
			DS		0.5							
					1							
					1.5							
			DS		2							
					2.5			Test Pit No. 8 terminated at 2.5m				
					3							
					3.5							
					4							
					4.5							

KEY TO SYMBOLS

Symbol Description

Strata symbols

Topsoil

Silty Clay
medium plasticity

Shaley Clay
medium to high plasticity

Shaley Clay
medium plasticity

Silty Clay
medium to high plasticity

Misc. Symbols

Groundwater

Descriptions of various line types (solid, dotted, etc.)

Profile change

Gradual profile change

Notes:

1. **Exploratory borings were drilled between 12/10/2016 and 12/10/2016 using a 50, 100 and 125mm diameter continuous flight power auger.**

2. **These logs are subject to the limitations, conclusions and recommendations in this report.**

3. **Results of tests conducted on samples recovered are reported on the logs.**

Log Symbols & Abbreviations (Non-cored Borehole Log)

Log Column	Symbol/Value		Description
Drilling Method	V-bit TC-bit RR DB BB		Hardened steel 'V' shaped bit attached to auger Tungsten Carbide bit attached to auger Tricone (Rock Roller) bit Drag bit Blade bit
Groundwater	Dry ▼ ▶		Groundwater not encountered to the drilled or auger refusal depth Groundwater level at depths shown on log Groundwater seepage at depths shown on log
Environment Sample	GP G P		Glass bottle and plastic bag sample over depths shown on log Glass bottle sample over depths shown on log Plastic bag sample over depths shown on log
PID Reading	100		PID reading in ppm
Geotechnical Sample	DS DB U_{50}		Disturbed Small bag sample over depths shown on log Disturbed Bulk sample over depths shown on log Undisturbed 50mm tube sample over depths shown on log
Field Test	N=10 3,5,5 N=R 10,15/100		Standard Penetration Test (SPT) 'N' value. Individual numbers indicate blows per 150mm penetration. 'R' represents refusal to penetration in hard/very dense soils or in cobbles or boulders. The first number represents10 blows for 150mm penetration whereas the second number represents 15 blows for 100mm penetration where SPT met refusal
	DCP/PSP	5 6 R/10	Dynamic Cone Penetration (DCP) or Perth Sand Penetrometer (PSP). Each number represents blows per 100mm penetration. 'R/10' represents refusal after 10mm penetration in hard/very dense soils or in gravels or boulders.
Classification	GP GW GM GC SP SW SM SC ML MI MH CL CI CH		Poorly Graded GRAVEL Well graded GRAVEL Silty GRAVEL Clayey GRAVEL Poorly graded SAND Well graded SAND Silty SAND Clayey SAND SILT / Sandy SILT / clayey SILT, low plasticity SILT / Sandy SILT / clayey SILT, medium plasticity SILT / Sandy SILT / clayey SILT, high plasticity CLAY / Silty CLAY / Sandy CLAY / Gravelly CLAY, low plasticity CLAY / Silty CLAY / Sandy CLAY / Gravelly CLAY, medium plasticity CLAY / Silty CLAY / Sandy CLAY / Gravelly CLAY, high plasticity
Moisture Condition Cohesive soils Cohesionless soils	 M<PL M=PL M>PL D M W		 Moisture content less than Plastic Limit Moisture content equal to Plastic Limit Moisture content to be greater than Plastic Limit Dry - Runs freely through hand Moist - Tends to cohere Wet - Tends to cohere

Consistency Cohesive soils	Term	Undrained shear strength, C_u (kPa)	Hand Penetrometer (Qu)
VS	Very Soft	≤12	<25
S	Soft	>12 ≤25	25 – 50
F	Firm	>25 ≤50	50 – 100
St	Stiff	>50 ≤100	100 – 200
VSt	Very Stiff	>100 ≤200	200 – 400
H	Hard	>200	>400

Density Index Cohesionless soils	Term	Density Index, I_D (%)	SPT 'N' (blows/300mm)
VL	Very Loose	≤15	≤5
L	Loose	>15 ≤35	>5 ≤10
M	Medium Dense	>35 ≤65	>10 ≤30
D	Dense	>65 ≤85	>30 ≤50
VD	Very Dense	>85	>50

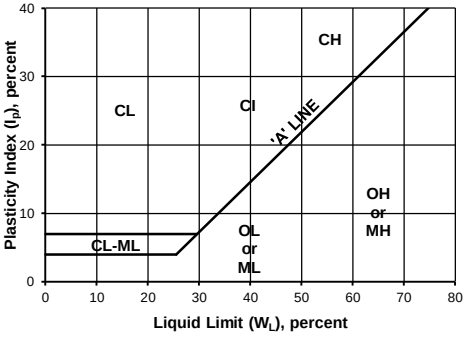
Hand Penetrometer	100 200	Unconfined compressive strength (q_u) in kPa determined using pocket penetrometer, at depths shown on log
Remarks	 Residual Alluvium Colluvial Aeolian Marine	Geological origin of soils Residual soils above bedrock River deposited Alluvial soils Gravity deposited Colluvial soils Wind deposited Aeolian soils Marine Soils

GEOTECHNIQUE PTY LTD

AS1726 – Unified Soil Classification System

Major Divisions		Particle size (mm)	Group Symbol	Typical Names	Field Identifications Sand and Gravels			Laboratory classification				
	BOULDERS	200						% (2) < 0.075mm	Plasticity of Fine Fraction	$C_u = D_{60}/D_{10}$	$C_c = (D_{30})^2/(D_{10}D_{60})$	Notes
	COBBLES	63										
COARSE GRAINED SOILS (more than half of material less 63mm is larger than 0.075mm)	GRAVELS (more than half of coarse fraction is larger than 2.36mm)	Coarse 20	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength			0-5	-	>4	between 1 and 3	1. Identify lines by the method given for fine grained soils 2. Borderline classifications occur when the percentage of fines (fraction smaller than 0.075mm size) is greater than 5% and less than 12%. Borderline classifications require the use of dual symbols e.g. SP-SM, GW-GC
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines, uniform gravels	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength			0-5	-	Fails to comply with above		
		Medium 6	GM	Silty gravels, gravel-sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength			12-50	Below 'A' line or I_p<4	-	-	
		Fine 2.36	GC	Clayey gravels, gravel-sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength			12-50	Above 'A' line or I_p>7	-	-	
	SANDS (more than half of coarse fraction is smaller than 2.36mm)	Coarse 0.6	SW	Well-graded sands, gravelly sands, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength			0-5	-	>6	between 1 and 3	
		Medium 0.2	SP	Poorly graded sands and gravelly sands; little or no fines, uniform sands	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength			0-5	-	Fails to comply with above		
			SM	Silty sands, sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength			12-50	Below 'A' line or I_p<4	-	-	
		Fine 0.075	SC	Clayey sand, sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength			12-50	Above 'A' line of I_p>7	-	-	
FINE GRAINED SOILS (more than half of material less than 63mm is smaller than 0.075mm)					**Dry Strength**	**Dilatancy**	**Toughness**					
	SILTS & CLAYS (liquid limit < 50%)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	None to low	Quick to slow	None	More than 50% passing 0.075mm	Below 'A' line			
			CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Medium to high	None to very slow	Medium		Above 'A' line			
			OL	Organic silts and organic silty clays of low plasticity	Low to medium	Slow	Low		Below 'A' line			
	SILTS & CLAYS (liquid limit > 50%)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	Low to medium	Slow to none	Low to medium		Below 'A' line			
			CH	Inorganic clays of medium to high plasticity, fat clays	High to very high	None	High		Above 'A' line			
			OH	Organic clays of medium to high plasticity, organic silts	Medium to high	None to very slow	Low to medium		Below 'A' line			
	HIGHLY ORGANIC SOILS		Pt	Peat and highly organic soils	Identified by colour, odour, spongy feel and generally by fibrous texture			Effervesces with H_2O_2				

Use the gradation of material passing 63mm for classification of fractions according to the criteria given in 'Major Divisions'



Log Symbols & Abbreviations (Cored Borehole Log)

Log Column	Symbol	Description
Core Size		Nominal Core Size (mm)
	NQ	47
	NMLC	52
	HQ	63
Water Loss		Complete water loss Partial water loss
Weathering	FR	Fresh — Rock shows no sign of decomposition or staining
	SW	Slightly Weathered — Rock is slightly discoloured but shows little or no change of strength from fresh rock
	DW	Distinctly Weathered — Rock strength usually changed by weathering. The rock may be highly discoloured, usually by ironstaining. Porosity may be increased by leaching, or may be decreased by deposition of weathering products in pores
	EW	Extremely Weathered — Rock is weathered to such an extent that it has 'soil' properties, i.e. it either disintegrate or can be remoulded, in water
	RS	Residual Soil — Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but soil has not been significantly transported
Strength		Term — Point Load Strength Index (I_{s50}, MPa)
	EL	Extremely Low — ≤0.03
	VL	Very Low — >0.03 ≤0.1
	L	Low — >0.1 ≤0.3
	M	Medium — >0.3 ≤1
	H	High — >1 ≤3
	VH	Very High — >3 ≤10
	EH	Extremely High — >10
Defect Spacing		Description — Spacing (mm)
		Extremely closely spaced — <20
		Very closely spaced — 20 to 60
		Closely spaced — 60 to 200
		Medium spaced — 200 to 600
		Widely spaced — 600 to 2000
		Very widely spaced — 2000 to 6000
		Extremely widely spaced — >6000
Defect Description		
Type	Bp	Bedding parting
	Fp	Foliation parting
	Jo	Joint
	Sh	Sheared zone
	Cs	Crushed seam
	Ds	Decomposed seam
	Is	Infilled seam
Macro-surface geometry	St	Stepped
	Cu	Curved
	Un	Undulating
	Ir	Irregular
	Pl	Planar
Micro-surface geometry	Ro	Rough
	Sm	Smooth
	Sl	Slickensided
Coating or infilling	cn	clean
	sn	stained
	vn	veneer
	cg	coating

AS1726 – Identification of Sedimentary Rocks for Engineering Purposes

Grain Size mm		Bedded rocks (mostly sedimentary)									
More than 20	20	Grain Size Description		CONGLOMERATE Rounded boulders, cobbles and gravel cemented in a finer matrix		At least 50% of grains are of carbonate			At least 50% of grains are of fine-grained volcanic rock	
	6	RUDACEOUS		Breccia Irregular rock fragments in a finer matrix		LIMESTONE and DOLOMITE (undifferentiated)		Calcirudite	Fragments of volcanic ejecta in a finer matrix Rounded grains AGGLOMERATE Angular grains VOLCANIC BRECCIA	SALINE ROCKS Halite Anhydrite
	2									
	0.6	ARENACEOUS	Coarse	SANDSTONE Angular or rounded grains, commonly cemented by clay, calcite or iron minerals				Calcarenite	Cemented volcanic ash TUFF	Gypsum
	0.2		Medium	Quartzite Quartz grains and siliceous cement						
	0.06		Fine	Arkose Many feldspar grains Greywacke Many rock chips						
	0.002	ARGILLACEOUS		MUDSTONE	SILTSTONE Mostly silt	Calcareous Mudstone		Calcisiltite	Fine-grained TUFF	
	Less than 0.002			SHALE Fissile	CLAYSTONE Mostly clay			Calcilutite	Very fine-grained TUFF	
								CHALK		
Amorphous or crypto-crystalline				Flint: occurs as hands of nodules in the chalk Chert: occurs as nodules and beds in limestone and calcareous sandstone						COAL LIGNITE
				Granular cemented – except amorphous rocks						
				SILICEOUS		CALCAREOUS			SILICEOUS	CARBONACEOUS
				SEDIMENTARY ROCKS Granular cemented rocks vary greatly in strength, some sandstones are stronger than many Igneous rocks. Bedding may not show in hand specimens and is best seen in outcrop. Only sedimentary rocks, and some metamorphic rocks derived from them, contain fossils Calcareous rocks contain calcite (calcium carbonate) which effervesces with dilute hydrochloric acid						

AS1726 – Identification of Metamorphic and Igneous Rocks for Engineering Purposes

Obviously foliated rocks (mostly metamorphic)			Rocks with massive structure and crystalline texture (mostly igneous)					Grain size (mm)
Grain size description			Grain size description	Pegmatite			Pyrosenite	More than 20
		MARBLE						20
COARSE	GNEISS Well developed but often widely spaced foliation sometimes with schistose bands	QUARTZITE	COARSE	GRANITE	Diorite	GABBRO	Peridorite	6
	Migmatite Irregularly foliated: mixed schists and gneisses	Granulite HORNFELS		These rocks are sometimes phorphyritic and are then described, for example, as porphyritic granite				2
MEDIUM	SCHIST Well developed undulose foliation; generally much mica	Amphibolite	MEDIUM	Micorgranite	Microdiorite	Dolerite		0.6
		Serpentine		These rocks are sometimes phorphyritic and are then described as porphyries				0.2
								0.06
FINE	PHYLLITE Slightly undulose foliation; sometimes 'spotted'		FINE	RHYOLITE	ANDESITE	BASALT		0.002
	SLATE Well developed plane cleavage (foliation)			These rocks are sometimes phorphyritic and are then described as porphyries				Less than 0.002
	Mylonite Found in fault zones, mainly in igneous and metamorphic areas			Obsidian	Volcanic glass			Amorphous or cryptocrystalline
CRYSTALLINE				Pale<----------->Dark				
SILICEOUS		Mainly SILICEOUS		ACID Much quartz	INTERMEDIATE Some quartz	BASIC Little or no quartz	ULTRA BASIC	
METAMORPHIC ROCKS Most metamorphic rocks are distinguished by foliation which may impart fissility. Foliation in gneisses is best observed in outcrop. Non-foliated metamorphics are difficult to recognize except by association. Any rock baked by contact metamorphism is described as 'hornfels' and is generally somewhat stronger than the parent rock Most fresh metamorphic rocks are strong although perhaps fissile			IGNEOUS ROCKS Composed of closely interlocking mineral grains. Strong when fresh; not porous Mode of occurrence : 1 Batholith; 2 Laccoliths; 3 Sills; 4 Dykes; 5 Lava Flows; 6 Veins					