Assyrian Schools Limited
c/o - PMDL

Wastewater Assessment:
Lots 2320 and 2321 in DP 1223137,
17-19 Kosovich Place, Cecil Park, NSW

P1705798JR05V03
September 2018

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT
MANAGEMENT

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All enquiries regarding this project are to be directed to the Project Manager.

Contents

1 Introduction

1.1 Overview

This report has been prepared by Martens & Associates Pty Ltd (MA) to provide findings of a wastewater assessment to support a state significant development application (SSDA) for a proposed school at 17-19 Kosovich Place, Cecil Park, NSW (the 'site').

The school is proposed to be developed in several stages. The wastewater management solution is designed to be compatible with this staged approach.

1.2 Relevant Guidelines and Standards

This wastewater assessment has been prepared in accordance with the following guidelines and standards:

- Department of Local Government *et al.* (1998) *Environment and Health Protection Guidelines – Onsite Sewage Management for Single Households.*
- Australian/ New Zealand Standard 1547 (2012*) Disposal Systems for Effluent from Domestic Premises.*
- Fairfield City Council (2002) *Septic Safe Protect Your Health and Environment On-Site Sewage Management Strategy.*
- NSW DEC (2004) *Environmental Guidelines: Use of Effluent by Irrigation.*

1.3 Aims and Objectives of this Report

The main objectives of this wastewater assessment include:

- Identify physical and chemical soil conditions and site limitations to onsite effluent disposal.
- Determine land capability to accept treated effluent in accordance with relevant guidelines.
- Identify minimum effluent treatment standards and disposal area requirements based on soil and land capability assessment.
- Determine expected hydraulic loads (sewage generation) from the proposed development.

- Develop a sustainable wastewater management strategy for the site, including consideration for staged development.

2 Site Details

2.1 Overview

This section summarises site conditions considered relevant to this wastewater assessment. General site details are summarised in Table 1.

Table 1: General site description summary.

Element	Description/Detail
Lot / DP	Lots 2320 and 2321 in DP 1223137
Local Government Area (LGA)	Fairfield City Council (FCC)
Site Area	Approximately 2.935 ha
Existing site development	Predominantly open grassland.
Neighbouring environment	Site is surrounded by rural and rural residential properties. The western boundary is adjacent to a dam. The north-eastern boundary is Kosovich Place and the north-western boundary is a church.
Expected Geology	Bringelly Shale comprising shale, carbonaceous claystone, claystone, laminite, fine to medium-grained lithic sandstone, rare coal and tuff (*Penrith 1:100 000 Geological Sheet 9030, 1st edition*, Geological Survey of New South Wales, Sydney)
Site Topography	Mid-slope of a west facing slope within moderately undulating land and near-level valley floor in the west of the site
Site Aspect	West
Site Elevation	Ranges between approximately 89 mAHD (west) and 102 mAHD (east)
Typical Slope	Approximately 15 – 20 % in the east, and <5 % in the west
Existing Vegetation	Grass
Site Drainage	Via overland flow west to a drainage depression at the western boundary. This flows into Ropes Creek 100 m north-west of the site's north-western boundary

2.2 Field Investigations

Field investigations undertaken on 10 February 2017 included:

- General site walkover to assess existing site conditions.
- Drilling and logging of fourteen boreholes (BH101 to BH114) up to 4.0 metres below ground level (mBGL).
- Collection of soil samples for laboratory testing and for future reference.

2.3 Sub-surface Conditions

The sub-surface profile typically comprises the following units:

Unit A: Silty clay loam. Typically brown in colour and stiff, with some organic matter (mainly grass and rootlets).

Unit B: Residual light, light medium and medium clay. Typically brown to red/orange for light clays and light medium clays, and yellow-brown to grey for medium clays. Typically stiff to very stiff, becoming harder as depth increases.

Unit C: Layer of weathered sandstone/shale/laminite, distinctly weathered and very low to low strength.

Unit D: Fill material comprising light medium clay, clayey sand, silty clay loam, silty clay and ripped/crushed sandstone, encountered in BH113 and BH114.

Table 2 summarises depths of encountered sub-surface conditions across different sections of the site. Depth ranges vary across the site depending on borehole location. Refer to borehole logs in Attachment B for more details.

Table 2: Generalised depth range of sub-surface profile.

Unit	Indicative depth range of unit (mBGL)		
	Eastern half of site 15-20% slope	Western half of site near existing creek <5% slope	B114 [1]
A	0.0 – 0.5	0.00 – 0.15	-
B	0.5 – 2.0	0.15 – 1.50 [2]	-
C	2.0 – 2.5 [3]	-	-
D	-	0.0 – 0.3 [4]	0.0 – 4.0

Notes:

1. BH114 only contained fill material up to investigation termination depth of 4.0 mBGL.
2. BH111-BH113 terminated at investigation termination depth of 1.5 mBGL. Depth of unit likely to be greater.
3. Borehole terminated on inferred medium strength shale/laminite.
4. Fill material encountered in BH113.

2.4 Groundwater

2.4.1 NSW Department of Primary Industries Water (DPI-Water) Bore Search

The NSW DPI-Water online groundwater bore mapping website was reviewed on 1 March 2017 to identify licensed groundwater bores within an approximately 500 m radius of the site. One borehole was found within this radius. Bore details are provided in Table 3.

Table 3: Available hydrogeological information from the NSW DPI.

Bore ID	Distance from site	Surface RL (mAHD) [1]	Depth to groundwater (mBGL)	Groundwater RL (mAHD)	Water bearing zone material
GW108121	260 m NE	100.0	34.0	66.0	Shale

Notes:

1. Relative ground surface level at borehole based on Nearmap data.

Based on the data above, groundwater at the site is expected to be encountered at approximately 66.0 mAHD, or deeper. The drainage depression on the western boundary, dam to the west and presence of Ropes Creek north of the site suggest that an ephemeral or perched groundwater table may be shallow.

2.4.2 Findings

Groundwater was not encountered in any borehole up to 4.0 mBGL.

Should further information on permanent site groundwater levels be required, additional investigation would need to be carried out (i.e. rock coring and installation of groundwater monitoring wells).

2.5 Climate

Climate data for the site has been sourced from the Bureau of Meteorology. Available daily rainfall (1887-2013) and evaporation (1887-2013) data was taken from Prospect Reservoir (station number 67019) and summarised in Table 4.

Table 4: Summary of local rainfall and evaporation.

Month	Monthly Averages (mm)	
	Rainfall	Evaporation
January	94.4	168.7
February	97.2	139.2
March	96.2	124.9
April	74.7	92.2
May	71.1	64.0
June	75.8	51.1
July	56.6	56.8
August	49.5	81.0
September	46.7	111.1
October	58.7	140.6
November	72.7	153.2
December	75.2	178.3
Annual total	**871.1**	**1361.2**

3 Wastewater Management Options Assessment

3.1 Staged Development

The school is likely to be developed over several stages and so there is an option for the onsite wastewater management system to be staged to suit. Stages are generally summarised as follows:

1. Stage 1 – 210 student school including administration and general learning area buildings in the north-eastern part of the site, site access and parking, pedestrian entry and associated services (water, power, telecommunications, *etc.*) to the school.
2. Stage 2 and Ultimate – Full development of the school including all buildings, accesses, parking, bus drop-off, playground areas and associated services including wastewater management.

3.2 Available Wastewater Management Options

There are three potential wastewater solutions that may be viable for the school, subject to detailed design:

1. Private rising main to Sydney Water sewer – This option involves the construction of a private rising main to connect to a point in the existing reticulated Sydney Water sewer.
2. Public sewer construction by developer in conjunction with Sydney Water with handover to Sydney Water on completion.
3. Long-term onsite wastewater management including pump out tank / sewer treatment plant (STP), effluent storage tank (EST) and onsite effluent management area (EMA).

Both option 1 and 2 will need a feasibility assessment, undertaken by Sydney Water to determine their viability. Review of the Sydney Water (2017) *Growth Servicing Plan July 2017 to June 2022* shows that the site is not currently proposed to be serviced by a Sydney Water reticulated sewer within the next four years.

3.2.1 Option 1 – Private Rising Main to Sydney Water Sewer

Analyses of the existing Sydney Water system suggests that the nearest existing reticulated sewer is located on Isabel Street, Cecil Hills, approximately 1.8 km from the site. Any private sewer main would likely need to cross both Elizabeth Drive and the M7 Motorway in order to connect to the reticulated sewer network. Other considerations to be factored into this option include:

- Preferred connection point. Sydney Water would need to nominate a preferred connection point for the private rising main, which may be to the south at Cecil Hills but may also be elsewhere.
- Cost of construction. Whilst the overall costs are presently unknown, the cost of constructing the private main and the sewage pump station would be significant.
- Capacity of existing system to accept additional flows from the school. It is not known if the existing sewer system servicing Cecil Hills is capable of accommodating additional flows from unserviced areas.
- Crossing of other private and public utilities, most notably the Sydney Water supply canal and the Jemena trunk gas supply main, both of which are in the vicinity of Wallgrove Road to the south of the site.

This option may be more viable if other local owners / developers were sharing the cost of a private rising main.

3.2.2 Option 2 – Public Sewer Construction in Conjunction with Sydney Water and Transfer of Asset to Sydney Water

This option will have the same considerations as Option 1, the differences being that costs may be partially borne by Sydney Water and that Sydney Water may require an easement on the subject site to provide space for a sewage pump station. This would likely be positioned adjacent to Kosovich Place.

3.2.3 Option 3 – On Site Wastewater Management

Onsite wastewater management is likely to be the most appropriate solution, subject to feasibility assessment by a water servicing coordinator and confirmation of availability of reticulated sewerage to the site, until such time that Sydney Water sewer becomes available to the site.

This option may be staged with an initial solution for Stage 1 using a pump-out tank. If a Sydney Water sewerage system is available for Stage 2 the pump-out tank may be decommissioned and Sydney Water connection made. If not it would be replaced / reconfigured to a longer-term onsite wastewater management system (STP, EST and EMA).

4 Wastewater Assessment

4.1 Existing On-site Wastewater System

The site has no existing wastewater infrastructure.

4.2 Land Capability Assessment for Effluent Re-use

Site and soil suitability for effluent re-use have been determined for the proposed development according to Tables 4 and 6 of the NSW Department of Local Government *et al.* (1998) effluent management guidelines and are summarised in Table 5. This assessment refers to areas mapped as generally suitable on the site.

Table 5: Site and soil suitability as defined in Department of Local Government *et al.* (1998) and NSW DEC (2006) effluent management guidelines.

Soil Feature	Details of Irrigation Areas	Limitation Rating
Flood potential	> 1in 20 year flood level	Minor
Sun and wind exposure	High	Minor
Slope (%)	2 % - 10 %	Minor
Landform	Minor slopes in irrigation area	Minor
Erosion potential	No signs present	Minor
Site drainage	No signs of surface dampness	Minor
Fill	20 m – 30 m downslope of irrigation area	Minor
Rock outcrops	Nil	Minor
Geology	No major discontinuities	Minor
Depth to bedrock (m)	> 1	Minor
Depth to water table (m)	Not observed (> 1)	Minor
Soil permeability category	3 (topsoil) / 5 (subsoil) [2]	Minor/Moderate
Coarse fragments (%)	0 % - 20 %	Minor
pH	> 6.0 [3, 4]	Minor
Electrical conductivity (dS/m)	< 4 [3]	Minor
Phosphorus sorption (kg/ha)	> 6000 [3, 5]	Minor
Cation Exchange Capacity (cmol+/kg)	> 15 [3, 5]	Minor
Modified Emerson Aggregate Test	Class 5 and 6 [3]	Minor

<u>Notes:</u>

1. Sub-surface irrigation based on DLG *et al.* (1998).
2. Clay loam topsoil / silty clay.
3. Refer to laboratory test certificates in Attachment D for more information.
4. One sample was reported to have a pH < 6.0, however the site walkover indicated that the vegetation on site was healthy and pH appears to be a minor limitation to site vegetation growth.
5. Average value from test results.

4.3 Proposed Treatment System and Design Effluent Quality

Wastewater from the ultimate development is to be treated by a secondary sewage treatment plant (STP). Typical secondary effluent quality is provided in Table 6. This information is used for the nutrient balance assessment. Refer to Attachment A for layout of proposed system.

Table 6: Typical secondary effluent quality.

Parameter	Design Value
BOD_5 (mg/L)	20
Suspended Solids	30
Faecal Coliforms (CFU/100mL)	30
Total Phosphorus (mg/L)	10
Total Nitrogen (mg/L)	37

4.4 Effluent Re-use

The site's capacity to assimilate treated effluent from the proposed school is determined through analyses of the proposed wastewater generation rates, the soil's effluent absorption capacity and availability of suitable land for effluent application.

The recommended option for re-use of secondary treated effluent at this site is sub-surface irrigation. Areas available are proposed to be used for student activities so sub-surface irrigation is required to prevent possible effluent-human interaction. The sub-surface irrigation shall also minimise the risk of effluent run-off and possible downslope environmental impacts.

4.5 Design Wastewater Load

Data from a comparable site (Northern Beaches Christian School 'NBCS') has been used to calculate design wastewater loads, together with available guidelines to develop a suitable design figure.

4.5.1 School Population

The primary school will have an ultimate total population of 665 persons (staff and students). The school will be developed in stages with a summary of Stage 1 and the ultimate school population provided in Table 7.

Table 7: Summary of school population.

Stage	Students	Staff	Total site population
1	210	12	222
Final	630	35	665

The anticipated time between Stages 1 and 2 shall be 3 – 4 years, with a likely intermediate construction stage with a student population of 450 plus staff.

4.5.2 Comparable Site Water Usage Data

Water usage invoices for a similar sized school (NBCS with a population of 950 persons) for an eighteen month period between November 2004 and May 2006. These invoices show that average water usage at the school was, approximately 13 litres per person per school day (Table 8), this figure included water used for irrigation and other outdoor purposes.

Table 8: Observed site water usage for NBCS.

Period	Days	School Days	Period Flow (kL)	Average School Day Flow (kL)	Average School Day Flow Per Person (L)
5 Nov 2004 – 25 Jan 2005	81	34	329	9.7	10.2
25 Jan 2005– 27 Apr 2005	92	52	666	12.8	13.5
27 Apr 2005 – 2 Aug 2005	97	55	700	12.7	13.4
2 Aug 2005 – 2 Nov 2005	92	56	714	12.8	13.4
2 Nov 2005 – 30 Jan 2006	90	36	658	18.3	19.2
30 Jan 2006 – 4 May 2006	94	55	426	7.8	8.2
Average				**12.3**	**13.0**

Past investigation at NBCS (Oliver-Higgins Consulting Pty Ltd, May 2003) based on water use records collected over a six month period indicated wastewater generation at the site of on average, 12,500 L/day, or 13.2 L/person/day. The two independent assessments (Martens and Oliver-Higgins) and flow data from different periods result in very similar per person water usage rates. The more conservative figure of 13.2 L/person/day is adopted for design and considered reliable for the proposed school and appropriate for use for design purposes. These figures were used for the design of wastewater management solutions at St Narsai and St Hurmizd schools and approved by Fairfield City Council.

Based on a future design population of 665 persons and per person generation rate of 13.2 L/day the site has a design wastewater load of 8.8 kL/day. For Stage 1 of the development, the wastewater load shall be approximately 2.9 kL/day.

4.5.3 AS 1547 Estimate

AS/NZS 1547 (2012) indicates development wastewater generation of approximately 30 litres per person per day. With a site population of 665 this equates to a total of 20.0 kL/day for the ultimate development. For stage 1, this would be 6.7 kL/day. This estimate is not considered appropriate for design based on experience and details above.

4.5.4 Water Services Association (WSA) Estimate

Based on the Water Services Association of Australia Sewerage Code (2002) guidelines, post-development wastewater generation at the site is estimated to be approximately 0.2 EP or 36 litres per person per day. With a site population of 665 this equates to a total of 24.0 kL/day. For Stage 1, this estimate would be 8.0 kL/day. This estimate is not considered appropriate for design based on experience and details above.

4.5.5 Design Hydraulic Load

Wastewater load estimated using site monitoring records from a similar size and style of school concludes an estimate wastewater load for the ultimate school population of 8.8 kL/day and for Stage 1, 2.9 kL/day is appropriate for design.

This rate is for school days; the average weekly and monthly flow is subject to significant reduction due to no use on weekends and through school holidays. In an average term week 43.90 kL shall be generated and treated by the STP (16.0 kL in Stage 1). With an effluent balancing tank the irrigation load from the site would be spread over 7 days giving a design irrigation rate of 6.27 kL/day (2.1 kL/day for Stage 1). For design purposes the following hydraulic loads are adopted:

Ultimate site population:

- STP treatment design capacity 8.8 kL/day.
- Irrigation rate design 6.27 kL/day.

Stage 1 population:

- STP treatment design capacity 2.9 kL/day.
- Irrigation rate design 2.1 kL/day.

4.6 Effluent Application Rates

Soil properties and corresponding recommended design irrigation rates (DIRs) according to AS/NZS 1547 (2012) are given in Table 9.

Table 9: DIR and soil properties for the site.

Depth (m) [1]	Texture	Structure	Indicative Permeability (K_{sat}) (m/d)	Design Irrigation Rate (DIR) (mm/day)
0.0 – 0.25	Silty clay loam	Weakly structured	0.12 – 0.50	3.5 [2]
0.25 – 0.5	Light clay Light medium clay	Moderately structured	0.06 – 0.12	3.0 [2]
Design				**3.0**

Notes:

1. Thickness of soil horizons vary across the site.
2. In accordance with AS/NZS 1547 (2012) Clause M3.1 – shallow sub-surface drip irrigation solution proposed utilised drip irrigation DIR from Table M1.

Review of site plans indicate that irrigation area proposed has grades generally <5 %; Table M2 of AS/NZS 1547 (2012) requires no reduction in DIR for these grades. Potential drainage impediment by deeper medium clay sub-soils is considered, medium clay has a DLR for ETA systems of 5.0 mm/day. Sub-soil is therefore not likely to result in impediment to drainage given the proposed effluent irrigation rate is 3.0 mm/day.

Assuming effluent balance tank is provided to spread flow over 7-day week the required irrigation field area is 2,090 m^2 (6,270 L/day / 3.0 mm/day) for final school population. This area is 698 m^2 (2,281 L/day / 3.0 mm/day) for Stage 1 only. These areas are further refined through water balance and nutrient modelling (Section 4.7).

4.7 Soil Water and Nutrient Modelling Summary

Details of the model outputs are summarised in Attachment C of this report. These are based on site investigations, laboratory analysis and our experience in similar soil environments. Sustainable irrigation areas are summarised in Table 10. Assessments of nutrient and water balance are completed for average weekly flows of 6,270 L/day. Design is conservative as it has not accounted for flow reduction during holiday periods.

Table 10: Modelling summary: area required for sustainable irrigation.

Parameter	Area Required Stage 1 (m^2)	Area Required Ultimate development (m^2)
Water Balance [1]	840	3,660
Nitrogen Uptake	1,180	3,530
Phosphorus Saturation	640	1,920
AS/NZS 1547 (2012) [2]	760	2,090
Design	**1,284**	**3,660**

Notes:

1. 87.5 kL of wet weather storage required.

4.8 Buffer Setbacks for Effluent Reuse

Irrigation area is to be located outside buffers as specified by NSW DLG *et al.* (1998), with recommended buffers summarised in Table 11. These buffers shall provide adequate protection for the creek west of the site.

Table 11: Adopted buffer setbacks in accordance with NSW DLG *et al.* (1998).

Buffer Distance	Feature
40 m	Waterways and drainage channels
6 m	Property boundary, driveways, buildings and pools (if downslope from disposal field)
3 m	Property boundary, driveways, buildings and pools (if upslope from disposal field)

4.9 Onsite Pump Out – Stage 1

A potential short-term design solution for Stage 1 of the development would be to install an onsite effluent pump out system, in anticipation of connection of the site to a Sydney Water reticulated sewer in the future or conversion to STP and onsite effluent management for the ultimate development. This option would comprise the following components:

- 50 kL wastewater collection tank. This would allow for approximately 1 week's storage capacity for the ultimate design population (approximately 17 school days storage for Stage 1 only) and allow for the expected volume of sludge.
- Automated high water emergency and pump-out warning system operated via float switches
- Submersible pump and 50 mm effluent transfer main to 50 mm Camlock fitting located to suit pump out tanker.

This option may be explored by the school as a possible short-term wastewater management solution, due to the lower costs to implement than an onsite STP and effluent disposal system, provided Sydney Water intends to construct a reticulated sewer that the school may connect to. In the long-term, this option is unlikely to be viable compared to an onsite wastewater management system, as the frequency and cost of pump-out will increase as the site population increases (from approximately once a week to two to three times a week). A full cost benefit analysis is required if a definitive answer in the financial performance of the two options is required.

The pump-out tank may be designed to be converted to accommodate the STP or effluent storage component of a future onsite wastewater management system.

5 Wastewater Management Recommendations

5.1 Overview

There are two options available for the school: temporary pump-out with eventual connection to Sydney Water sewer; or, onsite wastewater management with STP and effluent disposal area. Section 3.10 details likely components and recommendations for a temporary pump-out system whilst this section details onsite wastewater management requirements and recommendations.

5.2 System Requirements

5.2.1 Stage 1 – Pumpout Tank

For Stage 1 of the development, a pumpout tank with a storage capacity of not less than 50 kL as shown on the plan in Attachment A. This system will include camlock fitting, pump, control system and tanker stand area and shall be placed adjacent to the proposed stormwater management system in the south-east of the site.

5.2.2 Ultimate Development - Sewage Treatment Plant

A sewage treatment plant with a treatment capacity of 8.8 kL/day, treating effluent to quality as reported in Table 6. A flow balancing storage of 12.5 kL capacity and effluent storage of 87.5 kL capacity is to be provided to provide wet weather storage. These may be housed in separate storages within the same tank (minimum 100 kL capacity). The pumpout tank built in Stage 1 may be used to house the STP or be cleaned and converted to become part of the flow balancing / effluent wet weather storage systems.

5.2.3 Ultimate Development – Irrigation Area

A sub-surface effluent irrigation area design in accordance with AS/NZS 1547 (2012) is to be provided. The field is to be located within the identified 'suitable area' on drawing PS01-H200 (Attachment A) and is to have a minimum area of 3,660 m^2.

5.3 Maintenance Schedule

5.3.1 System Maintenance

Basic monitoring of the operation of the STP will be required on a regular basis. Critical system components including sewage transfer pumps;

aeration equipment; and effluent irrigation pumps should be alarmed, with redundant systems where appropriate.

Quarterly (or as specified by supplier if more frequent) inspections of the treatment systems by a qualified operator will be necessary to ensure routine plant maintenance is completed and to monitor aspects of plant operation.

The effluent distribution system will require monthly inspection by the site owner/operator to identify any leaks within the distribution system or any areas of over-irrigation within the re-use areas. STP maintenance inspections should include the cleaning of installed filters as required depending on the nature of the irrigation systems.

5.3.2 Vegetation Management

Prior to commencement of irrigation 100% grass cover of the field is required. Vegetation within the effluent re-use areas is to be maintained in a fashion that will maximise the uptake of both nutrients and water. That is, grassed areas should be maintained with blade length of not more than 75 mm.

5.4 On-going Environmental and System Monitoring

Monitoring of the performance of the treatment systems and re-use schemes is recommended to allow for the identification of any decline in system performance. We recommend an on-going environmental monitoring plan be implemented while the on-site sewage management scheme is in operation. Recommended monitoring is outlined in Table 12; this regime should be reviewed and reduced as appropriate after one year's acceptable site operation.

Table 12: Recommended environmental monitoring.

Item	Parameters [1]	Frequency
STP effluent quality sampling	BOD_5, SS, nutrients, EC, pH, E.Coli, FC	3 months
STP flow	Instantaneous and daily flow	Continuous monitoring – daily flow recording
Three monitoring bores (one upslope, two downslope) to 3 mBGL	BOD_5, nutrients, EC, pH, E.Coli, FC	3 months
Two surface water monitoring sites (one at upstream site boundary and one at downstream site boundary)	BOD_5, nutrients, EC, pH, E.Coli, FC	3 months
Three soil samples from effluent re-use field	pH, EC, TN, TP, ESP	Annually

Notes:

2. SS = Suspended Solids; EC = Electrical Conductivity; FC = Faecal Coliforms; ESP = Exchangeable Sodium Percentage.

5.5 Inspections

We recommend the following inspection schedule:

- After field installation to ensure the irrigation system has been appropriately constructed.
- On commission of the STP.
- After two months of operation to ensure the treatment and reuse system is operating according to engineering designs.

All inspections should be undertaken by Martens & Associates and should be confirmed by a written report submitted to Council.

6 References

Australian/New Zealand Standard 1547 (2012) *On-site domestic wastewater management*.

Department of Environment and Conservation (2004) *Use of Effluent by Irrigation*.

Department of Local Government, NSW Environment Protection Authority, NSW Health Department, NSW Department of Land and Water Conservation and the NSW Department of Urban Affairs and Planning (1998), *Environment and Health Protection Guidelines, On-site Sewage Management for Single Households.*

Fairfield City Council (2002) *Septic Safe Protect Your Health and Environment On-Site Sewage Management Strategy*.

NSW Health Department (2001) *Septic Tank and Collection Well Accreditation Guideline Part 4*.

7 Attachment A – Site Plan and Layout

KEY

─	APPROXIMATE EXTENTS OF 1 IN 20 YEAR ARI FLOOD
─	APPROXIMATE EXTENTS OF 1 IN 100 YEAR ARI FLOOD
─	APPROXIMATE EXTENTS OF PMF
─	40m OFFSET FROM WATERCOURSE
- - -	6m OFFSET FROM SITE BOUNDARY AND BUILDINGS
🟩	AREA SUITABLE FOR SUB-SURFACE IRRIGATION
▨	NOMINAL 3660 sqm AREA

DEVELOPMENT APPLICATION

REV	DESCRIPTION	DATE	DRAWN	DESIGNED	CHECKED	APPRVD
H	**MINOR AMENDMENT**	**05/09/2018**	**GM**	**MD**	**MD**	**TH**
G	AMENDED ARCHITECT LAYOUTS FROM EMAIL 31/08/2018	05/09/2018	GM	MD	MD	TH
F	MINOR AMENDMENT	29/08/2018	GM	MD	MD	TH
E	MINOR AMENDMENT	29/08/2018	GM	MD	MD	TH
D	MINOR AMENDMENT	29/08/2018	GM	MD	MD	TH
C	SSDA	25/7/2018	MD	MD	TH	AN
B	AMENDED AREAS	28/03/2017	MH	MH	AN	
A	ATTACHMENT A	10/03/2017	MH	MH	AN	

PRINTED: ---- - USER: CGENTILE

A1 / A3 LANDSCAPE (A1LC_v02.0.01)

SCALE
0 5 10 15 20 25 30 35 40 45 50 METRES
A1 (A3) 1:500 (1:1,000)

GRID	DATUM	PROJECT MANAGER
	MAHD	TH

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All measurements in millimetres unless otherwise specified.
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CLIENT
ASSYRIAN SCHOOLS LTD

PROJECT NAME/PLANSET TITLE
PETER PAUL ASSYRIAN PRIMARY SCHOOL
ENGINEERING WORKS
LOTS 2320 AND 2321 DP 1223137
KOSOVICH PLACE, CECIL PARK, NSW

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DRAWING TITLE
SITE PLAN - WASTEWATER MANAGEMENT

PROJECT NO.	PLANSET NO.	RELEASE NO.	DRAWING NO.	REVISION
P1705798	PS01	R09	PS01-H200	H

DRAWING ID: P1705798-PS01-R09-H200

8 Attachment B – Borehole Logs

CLIENT	Assyrian Schools Limited C/- PMDL	COMMENCED	10/02/2017	COMPLETED	10/02/2017	**REF BH101**
PROJECT	Geotechnical Investigation	LOGGED	RM/HD	CHECKED	RE	Sheet 1 OF 1
SITE	153-189 Wallgrove Rd, Cecil Park, NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P1705798
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	99 m	DATUM: AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.80 m depth	NORTHING		ASPECT	West	SLOPE: 15-20%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	M	Not Encountered		99.00	SPT 0.00-0.45 m 1,3,4 N=7 5798/101/0.40/S/1 D 0.40 m			SiCL	Silty Clay Loam, low plasticity, brown/red.	M	F	RESIDUAL SOIL
			0.5	*0.50* 98.50	5798/101/0.60/S/1 D 0.60 m			LMC	Light Medium Clay, medium plasticity, orange-brown.		St	
	H		1.0	*0.70* 98.30	5798/101/0.90/S/1 D 0.90 m SPT 1.00-1.45 m 21,15,8 HB N=23			LC	Light Clay, medium plasticity, brown.		St VSt	1.45: V-bit refusal.
AD/T			1.5	*1.50* 97.50					SANDSTONE/SHALE LAMINITE, inferred distinctly weathered, inferred very low to low strength.	D		WEATHERED ROCK
				1.80					Hole Terminated at 1.80 m			1.80: TC-bit refusal on inferred medium strength laminite.
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	Assyrian Schools Limited C/- PMDL	COMMENCED	10/02/2017	COMPLETED	10/02/2017	**REF BH102**
PROJECT	Geotechnical Investigation	LOGGED	RM/HD	CHECKED	RE	Sheet 1 OF 1
SITE	153-189 Wallgrove Rd, Cecil Park, NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P1705798

EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	96 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 2.10 m depth	NORTHING		ASPECT	West	SLOPE	15-20%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	M	Not Encountered		96.00	SPT 0.00-0.45 m 3,5,5 N=10			SiCL	Silty Clay Loam, low plasticity, dark brown.	M		RESIDUAL SOIL
				0.15 95.85	5798/102/0.25/S/1 D 0.25 m			SiC	Silty Clay, low plasticity, red/brown, sandstone gravels.		St	
			0.5		5798/102/0.50/S/1 D 0.50 m							
	H										VSt	
			1.0		SPT 1.00-1.45 m 12,18,18 HB N=36 5798/102/1.0/S/1 D 1.00 m						H	
AD/T												1.20: V-bit refusal.
			1.5									
				1.70 94.30				LMC	Light Medium Clay, low plasticity, brown.			
			2.0	*2.10*	5798/102/2.0/S/1 D 2.00 m							
									Hole Terminated at 2.10 m			2.10: TC-bit refusal on inferred medium strength sandstone.
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									

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Engineering Log - BOREHOLE

CLIENT	Assyrian Schools Limited C/- PMDL	COMMENCED	10/02/2017	COMPLETED	10/02/2017	**REF BH103**
PROJECT	Geotechnical Investigation	LOGGED	RM/HD	CHECKED	RE	Sheet 1 OF 1
SITE	153-189 Wallgrove Rd, Cecil Park, NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P1705798
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	92 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 4.00 m depth	NORTHING		ASPECT	West	SLOPE 15-20%

Drilling					Sampling	Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	M	Not Encountered	0.0	92.00	SPT 0.00-0.45 m 1,6,8 N=14	CL	Clay Loam, low plasticity, dark brown.	M	St	RESIDUAL SOIL
			0.5	0.20 91.80	5798/103/0.25/S/1 D 0.25 m 5798/103/0.5/S/1 D 0.50 m SPT 1.00-1.45 m 9,9,12 N=21	SiC	Silty Clay, medium plasticity, orange/brown, trace shale gravels. @0.60m - grading to orange/grey.			
	H		1.0 1.5 2.0	1.10 90.90	5798/103/1.5/S/1 D 1.50 m	MC	Medium Clay, medium-high plasticity, grey, shale gravel inclusions.		VSt	
AD/T			2.5		5798/103/2.5/S/1 D 2.50 m				H	2.00: V-bit refusal.
			3.0 3.5	2.90 89.10			Weathered SHALE, grey, inferred distinctly weathered, inferred very low to low strength.	D		WEATHERED ROCK
			4.0 4.5	4.00			Hole Terminated at 4.00 m (Investigation Limit)			

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Engineering Log - BOREHOLE

CLIENT	Assyrian Schools Limited C/- PMDL	COMMENCED	10/02/2017	COMPLETED	10/02/2017	**REF BH104**	
PROJECT	Geotechnical Investigation	LOGGED	RM	CHECKED	RE	Sheet	1 OF 1
SITE	153-189 Wallgrove Rd, Cecil Park, NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P1705798	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	103 m	DATUM	AHD
EXCAVATION DIMENSIONS	2.20 m depth	NORTHING		ASPECT	West	SLOPE	15-20%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
		Not Encountered		103.00				SiCL	Silty Clay Loam, low plasticity, brown.	M	S	RESIDUAL SOIL
				0.15 102.85				LMC	Light Medium Clay, medium plastcity, red/orange.		St	
			0.5		5798/104/0.40/S/1 D 0.40 m							
				0.70 102.30				MC	Medium Clay, medium plastcity, yellow/brown, trace sandstone gravels.			0.70: V-bit refusal.
			1.0		5798/104/0.85/S/1 D 0.85 m							
			1.5						@1.8m-grading to grey.			
			2.0								H	
				2.20					Hole Terminated at 2.20 m			2.20: TC-bit refusal on inferred medium strength shale.
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									

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CLIENT	Assyrian Schools Limited C/- PMDL	COMMENCED	10/02/2017	COMPLETED	10/02/2017	**REF BH105**
PROJECT	Geotechnical Investigation	LOGGED	RM/HD	CHECKED	RE	Sheet 1 OF 1
SITE	153-189 Wallgrove Rd, Cecil Park, NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P1705798
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	99 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 3.00 m depth	NORTHING		ASPECT	West	SLOPE 15-20%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	M	Not Encountered		99.00	5798/105/0.10/S/1 D 0.10 m			SCL	Sandy Clay Loam, low plasticity, brown.		St	RESIDUAL SOIL
			0.5	0.20 98.80	5798/105/0.40/S/1 D 0.40 m			LMC	Light Medium Clay, medium plasticity, yellow/brown.		St - H	
	H			0.60 98.40	5798/105/0.90/S/1 D 0.90 m			MC	Medium Clay, medium to high plasticity, grey, shale gravels.	M	H	
AD/T			1.0		5798/105/1.3/S/1 D 1.30 m							1.00: V-bit refusal.
			1.5 2.0 2.5	1.40 97.60					Weathered SHALE, grey, inferred very low strength.	D		WEATHERED ROCK
			3.0 3.5 4.0 4.5	3.00					Hole Terminated at 3.00 m			3.00: TC-bit refusal on inferred low strength shale.

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CLIENT	Assyrian Schools Limited C/- PMDL	COMMENCED	10/02/2017	COMPLETED	10/02/2017	**REF BH106**
PROJECT	Geotechnical Investigation	LOGGED	RM/HD	CHECKED	RE	Sheet 1 OF 1
SITE	153-189 Wallgrove Rd, Cecil Park, NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P1705798
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	102 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.70 m depth	NORTHING		ASPECT	West	SLOPE 15-20%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	M	Not Encountered		102.00	5798/106/0.20/S/1 D 0.20 m			SCL	Sandy Clay Loam, low plasticity, brown, fine sands.	M	St	RESIDUAL SOIL
			0.5	0.40 101.60				LMC	Light Medium Clay, medium plasticity, red/orange.		VSt	
	H			0.60 101.40	5798/106/0.20/S/1 D 0.90 m			MC	Medium Clay, medium to high plasticity, orange/grey, shale gravels.		St - H	0.80: V-bit refusal.
AD/T			1.0 1.5	1.00 101.00					Weathered SHALE, yellow, inferred low strength.	D		WEATHERED ROCK
			2.0 2.5 3.0 3.5 4.0 4.5	1.70					Hole Terminated at 1.70 m			1.70: TC-bit refusal on inferred low to medium strength sandstone.

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CLIENT	Assyrian Schools Limited C/- PMDL	COMMENCED	10/02/2017	COMPLETED	10/02/2017	**REF BH107**
PROJECT	Geotechnical Investigation	LOGGED	RM/HD	CHECKED	RE	Sheet 1 OF 1
SITE	153-189 Wallgrove Rd, Cecil Park, NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P1705798

EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	97 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 3.00 m depth	NORTHING		ASPECT	West	SLOPE	15-20%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	M	Not Encountered		97.00	5798/107/0.20/S/1 D 0.20 m			SCL	Sandy Clay Loam, low plasticity, brown.		St	RESIDUAL SOIL
				0.40 96.60				LMC	Light Medium Clay, medium plasticity, orange.			
			0.5		5798/107/0.50/S/1 D 0.50 m							
				0.60 96.40				MC	Medium Clay, medium to high plasticity, brown/grey.		VSt	
			1.0							M		
									@1.5m - grading to grey.		H	
AD/T			1.5									1.50: V-bit refusal
	H											
			2.0	2.00 95.00					Weathered SHALE, grey, inferred distinctly weathered, inferred low strength.			WEATHERED ROCK
			2.5							D		
			3.0	3.00					Hole Terminated at 3.00 m			
			3.5									
			4.0									
			4.5									

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CLIENT	Assyrian Schools Limited C/- PMDL	COMMENCED	10/02/2017	COMPLETED	10/02/2017	**REF BH108**
PROJECT	Geotechnical Investigation	LOGGED	RM/HD	CHECKED	RE	Sheet 1 OF 1
SITE	153-189 Wallgrove Rd, Cecil Park, NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P1705798

EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	93 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 2.80 m depth	NORTHING		ASPECT	West	SLOPE	15-20%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	M	Not Encountered		93.00	5798/108/0.20/S/1 D 0.20 m			SiCL	Silty Clay Loam, low plasticity, brown.	M	St	RESIDUAL SOIL
			0.5	0.50 92.50	5798/108/0.60/S/1 D 0.60 m			LMC	Light Medium Clay, low to medium plasticity, brown, with shale gravels.		H	
	H		1.0		5798/108/1.1/S/1 D 1.10 m				@1.0m - grading to grey.			
AD/T			1.5	1.50 91.50				MC	Medium Clay, medium plasticity, orange/grey.			1.50: V-bit refusal.
			2.0	2.00 91.00					Weathered SHALE, grey, inferred distinctly weathered, inferred very low to low strength.	D		WEATHERED ROCK
			2.5	2.80								
			3.0						Hole Terminated at 2.80 m			2.80: TC-bit refusal on inferred medium strength shale.
			3.5									
			4.0									
			4.5									

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Engineering Log - BOREHOLE

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P1705798BH01V01.GPJ <<DrawingFile>> 15/03/2017 10:24 8.30.004 Datgel Lab and In Situ Tool - DGD | Lib: Martens 2.00 2016-11-13 Prj: Martens 2.00 2016-11-13

CLIENT	Assyrian Schools Limited C/- PMDL	COMMENCED	10/02/2017	COMPLETED	10/02/2017	**REF BH109**
PROJECT	Geotechnical Investigation	LOGGED	RM/HD	CHECKED	RE	Sheet 1 OF 1
SITE	153-189 Wallgrove Rd, Cecil Park, NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P1705798
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	94 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 3.00 m depth	NORTHING		ASPECT	West	SLOPE 15-20%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	M	Not Encountered		94.00				SiCL	Silty Clay Loam, low plasticity, brown.	M	S	RESIDUAL SOIL
				0.15 93.85				LMC	Light Medium Clay, medium plasticity, red/orange/brown.		St - VSt	
	H		0.5		5798/109/0.40/S/1 D 0.40 m 5798/109/0.50/S/1 D 0.50 m							
			1.0						@1.2m - grading to grey.			
AD/T											H	1.20: V-bit refusal.
			1.5	1.50 92.50					Weathered SHALE, grey, inferred distinctly weathered, inferred very low strength.	D		WEATHERED ROCK
			2.0		5798/109/2.1/S/1 D 2.10 m							
			2.5									
			3.0	3.00					Hole Terminated at 3.00 m			
			3.5									
			4.0									
			4.5									

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Engineering Log - BOREHOLE

CLIENT	Assyrian Schools Limited C/- PMDL	COMMENCED	10/02/2017	COMPLETED	10/02/2017	**REF BH110**
PROJECT	Geotechnical Investigation	LOGGED	RM/HD	CHECKED	RE	Sheet 1 OF 1
SITE	153-189 Wallgrove Rd, Cecil Park, NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P1705798

EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	94 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 2.00 m depth	NORTHING		ASPECT	West	SLOPE	15-20%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	M	Not Encountered		94.00	5798/110/0.10/S/1 D 0.10 m			SiCL	Silty Clay Loam, low plasticity, brown.	M	S	RESIDUAL SOIL
			0.5 1.0	0.25 93.75	5798/110/0.50/S/1 D 0.50 m 5798/110/1.0/S/1 D 1.00 m			LMC	Light Medium Clay, medium plasticity, orange.		F	
	H			1.20 92.80				MC	Medium Clay, medium to high plastictity, grey.		H	1.30: V-bit refusal.
AD/T			1.5	1.50 92.50					Weathered SHALE, grey, inferred distinctly weathered, inferred low strength.	D		WEATHERED ROCK
			2.0	2.00					Hole Terminated at 2.00 m			2.00: TC-bit refusal on inferred medium strength shale.
			2.5 3.0 3.5 4.0 4.5									

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Engineering Log - BOREHOLE

CLIENT	Assyrian Schools Limited C/- PMDL	COMMENCED	10/02/2017	COMPLETED	10/02/2017	**REF BH111**
PROJECT	Geotechnical Investigation	LOGGED	RM	CHECKED	RE	Sheet 1 OF 1
SITE	153-189 Wallgrove Rd, Cecil Park, NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P1705798
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	91 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.50 m depth	NORTHING		ASPECT	West	SLOPE 15-20%

Drilling					**Sampling**		**Field Material Description**					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/T	M	Not Encountered		91.00				SiCL	Silty Clay Loam, low plasticity, brown.	M	S	RESIDUAL SOIL
					5798/111/0.10/S/1 D 0.10 m							
				0.15 90.85				LMC	Light Medium Clay, low to medium plasticity.			
					5798/111/0.30/S/1 D 0.30 m							
			0.5	0.50 90.50				MC	Medium Clay, medium plasticity, orange.		F	
					5798/111/0.60/S/1 D 0.60 m							
			1.0									
			1.5	1.50					Hole Terminated at 1.50 m (Investigation Limit)			
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

martens

Engineering Log - BOREHOLE

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P1705798BH01V01.GPJ <<DrawingFile>> 15/03/2017 10:24 8.30.004 Datgel Lab and In Situ Tool - DGD | Lib: Martens 2.00 2016-11-13 Prj: Martens 2.00 2016-11-13

CLIENT	Assyrian Schools Limited C/- PMDL	COMMENCED	10/02/2017	COMPLETED	10/02/2017	**REF BH112**
PROJECT	Geotechnical Investigation	LOGGED	RM	CHECKED	RE	Sheet 1 OF 1
SITE	153-189 Wallgrove Rd, Cecil Park, NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P1705798
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	90 m	DATUM: AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.50 m depth	NORTHING		ASPECT	West	SLOPE: 15-20%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	M	Not Encountered		90.00				SiCL	Silty Clay Loam, low plasticity, brown.	M	S	RESIDUAL SOIL
				0.15 89.85	5798/112/0.40/S/1 D 0.40 m			LMC	Light Medium Clay, low plasticity, grey.			
			0.5									
				0.60 89.40	5798/112/0.80/S/1 D 0.80 m			MC	Medium Clay, medium plasticity, orange/yellow/brown.		St	
			1.0									
			1.5	1.50					Hole Terminated at 1.50 m (Investigation Limit)			
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

martens

MARTENS & ASSOCIATES PTY LTD
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Engineering Log - BOREHOLE

CLIENT	Assyrian Schools Limited C/- PMDL	COMMENCED	10/02/2017	COMPLETED	10/02/2017	**REF BH113**
PROJECT	Geotechnical Investigation	LOGGED	RM	CHECKED	RE	Sheet 1 OF 1
SITE	153-189 Wallgrove Rd, Cecil Park, NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P1705798
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	90 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.50 m depth	NORTHING		ASPECT	West	SLOPE 15-20%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	M	Not Encountered		90.00	5798/113/0.20/S/1 D 0.20 m			LMC	FILL: Light Medium Clay, red/grey, sandstone gravels, brick inclusions.	M	S	FILL
				0.30 89.70	5798/113/0.20/S/2 D 0.20 m 5798/113/0.40/S/1 D 0.40 m			LMC	Light Medium Clay, low plasticity, grey.			RESIDUAL SOIL
			0.5									
				0.70 89.30	5798/113/0.80/S/1 D 0.80 m			MC	Medium Clay, medium plasticity, orange/yellow/brown.		St	
AD/V			1.0									
			1.5	1.50					Hole Terminated at 1.50 m (Investigation Limit)			
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	Assyrian Schools Limited C/- PMDL	COMMENCED	10/02/2017	COMPLETED	10/02/2017	**REF BH114**
PROJECT	Geotechnical Investigation	LOGGED	RM	CHECKED	RE	Sheet 1 OF 1
SITE	153-189 Wallgrove Rd, Cecil Park, NSW	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P1705798

EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING		RL SURFACE	90 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 4.00 m depth	NORTHING		ASPECT	West	SLOPE	5-10%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	M	Not Encountered		90.00	5798/114/0.10/S/1 D 0.10 m			SiCL	FILL: Silty Clay Loam, low plasticity, brown.	M		FILL
			0.5	*0.15* 89.85	5798/114/0.40/S/1 D 0.40 m			SiC	FILL: Silty Clay, dark grey, shale gravels.			
			1.0	*0.70* 89.30	5798/114/0.80/S/1 D 0.80 m				FILL: Ripped/Crushed SANDSTONE, yellow brown.			
			1.5 2.0 2.5 3.0 3.5	*1.50* 88.50	5798/114/2.0/S/1 D 2.00 m 5798/114/2.40/S/1 D 2.40 m			CLS	FILL: Clayey SAND, grey/dark grey, coarse grained sand, with plastic and metal inclusions.			
			4.0 4.5	*4.00*					Hole Terminated at 4.00 m (Investigation Limit)			

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

9 Attachment C – Nutrient and Water Balance Models

Effluent Disposal Field - Water Balance Assessment

Method ST-XX Revised 11.8.2010

martens

Suite 201, Level 2, 20 George St, Hornsby, NSW 2077, Ph: (02) 9476 9999 Fax: (02) 9476 8767, mail@martens.com.au, www.martens.com.au

PROJECT DETAILS

Project	17-19 Kosovich Place, Cecil Park, NSW		P1705798
Author	MD	Reviewed AN	25.07.2018

STEP 1 : ENTER SITE AND FIELD CHARACTERISTICS

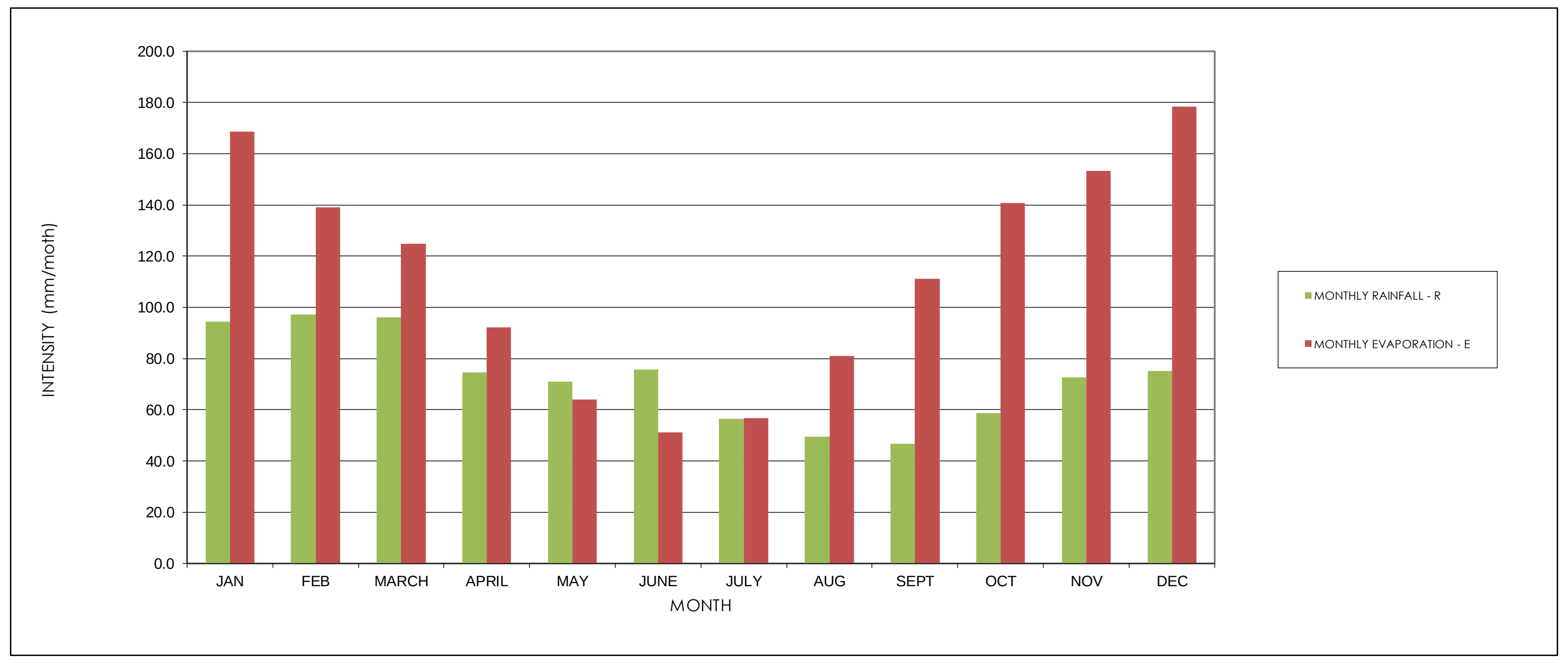
FACTOR	Enter Data	Unit
Runoff Factor - RF	0.35	-
Daily Effluent Load - DEL	6270	L/day
Effluent Disposal Area - A	3660	m^2
Design Percolation Rate (DPR)	1.4	mm/day

Effluent Application Rate	1.7	mm/day
Wet-Weather Storage (KL)	86.2	KL

STEP 2 : ENTER CLIMATE DATA

Source(s): Rainfall and Evaporation data from Prospect Dam Reservoir (station No: 67019)

	MONTHLY RAINFALL - R	MONTHLY EVAPORATION - E
MONTH	Enter Data	Enter Data
JAN	94.40	168.70
FEB	97.20	139.20
MARCH	96.20	124.90
APRIL	74.70	92.20
MAY	71.10	64.00
JUNE	75.80	51.10
JULY	56.60	56.80
AUG	49.50	81.00
SEPT	46.70	111.10
OCT	58.70	140.60
NOV	72.70	153.20
DEC	75.20	178.30



STEP 3 : ASSESSMENT

MONTH	NUMBER OF DAYS	MONTHLY RAINFALL (mm)	RETAINED RAINFALL	MONTHLY EVAPORATION	CROP FACTOR	EVAPO-TRANSPIRATION RATE	DESIGN PERCOLATION	AVAILABE IRRIGATION CAPACITY	EFFLUENT APPLIED	APPLICATION RATE	INCREASE IN PONDING DEPTH OF EFFLUENT	CUMULATIVE PONDING DEPTH OF EFFLUENT FROM PREVIOUS MONTH	DEPTH OF EFFLUENT	PONDING DEPTH OF EFFLUENT	WET-WEATHER STORAGE REQUIRED
-	(days)	(mm/month)	(mm/month)	(mm/month)	-	(mm/month)	(mm/day)	(mm/month)	(L/month)	(mm/month)	(mm)	(mm)	(mm/month)	(mm)	(KL)
-	DAY	R	RR = R x (1- RF)	E	CF	ETR = E x CF	DP = DPR x DAYS	AIC = ETR - RR +DP	EA = DEL x DAY	AR = EA / A	D = (AIC - AR)	CPD = PD from previous month	DE = D + CPD	PD	WWS
JAN	31	94.40	61.4	168.70	0.80	135.0	43.4	117.0	194370	53.1	-63.9	0.0	-63.9	**0.0**	**0.0**
FEB	28	97.20	63.2	139.20	0.80	111.4	39.2	87.4	175560	48.0	-39.4	0.0	-39.4	**0.0**	**0.0**
MARCH	31	96.20	62.5	124.90	0.80	99.9	43.4	80.8	194370	53.1	-27.7	0.0	-27.7	**0.0**	**0.0**
APRIL	30	74.70	48.6	92.20	0.80	73.8	42.0	67.2	188100	51.4	-15.8	0.0	-15.8	**0.0**	**0.0**
MAY	31	71.10	46.2	64.00	0.80	51.2	43.4	48.4	194370	53.1	4.7	0.0	4.7	**4.7**	**17.3**
JUNE	30	75.80	49.3	51.10	0.80	40.9	42.0	33.6	188100	51.4	17.8	4.7	22.5	**22.5**	**82.4**
JULY	31	56.60	36.8	56.80	0.80	45.4	43.4	52.1	194370	53.1	1.1	22.5	23.6	**23.6**	**86.2**
AUG	31	49.50	32.2	81.00	0.80	64.8	43.4	76.0	194370	53.1	-22.9	23.6	0.6	**0.6**	**2.4**
SEPT	30	46.70	30.4	111.10	0.80	88.9	42.0	100.5	188100	51.4	-49.1	0.6	-48.5	**0.0**	**0.0**
OCT	31	58.70	38.2	140.60	0.80	112.5	43.4	117.7	194370	53.1	-64.6	0.0	-64.6	**0.0**	**0.0**
NOV	30	72.70	47.3	153.20	0.80	122.6	42.0	117.3	188100	51.4	-65.9	0.0	-65.9	**0.0**	**0.0**
DEC	31	75.20	48.9	178.30	0.80	142.6	43.4	137.2	194370	53.1	-84.1	0.0	-84.1	**0.0**	**0.0**

Effluent Disposal Field - Annual Nutrient Balance Assessment

Method ST-14 Revised 20.3.2007

martens

6/37 Leighton Place, Hornsby, NSW 2077, Ph: (02) 9476 999 Fax: (02) 9476 8767, mail@martens.com.au, www.martens.com.au

PROJECT DETAILS

Project	17-19 Kosovich Place, Cecil Park, NSW	Ref. No.	P1705798JS07V01
Author	MD	Reviewed	AN
		Date Created	04.07.2018

STEP 1 : ENTER SITE AND FIELD CHARACTERISTICS

FACTOR	Enter Data	Unit
Treatment System	STP	-
Effluent flow rate	6270	L/day
Effluent N	37.0	mg/L
Effluent P	10.0	mg/L
Design soil depth	1.00	m
Soil P-sorption	270.0	mg/kg
Plant N uptake	240.0	kg/ha/year
Plant P uptake	30.0	kg/ha/year

STEP 2 : ASSESSMENT

NITROGEN BUDGET FOR RE-USE FIELD

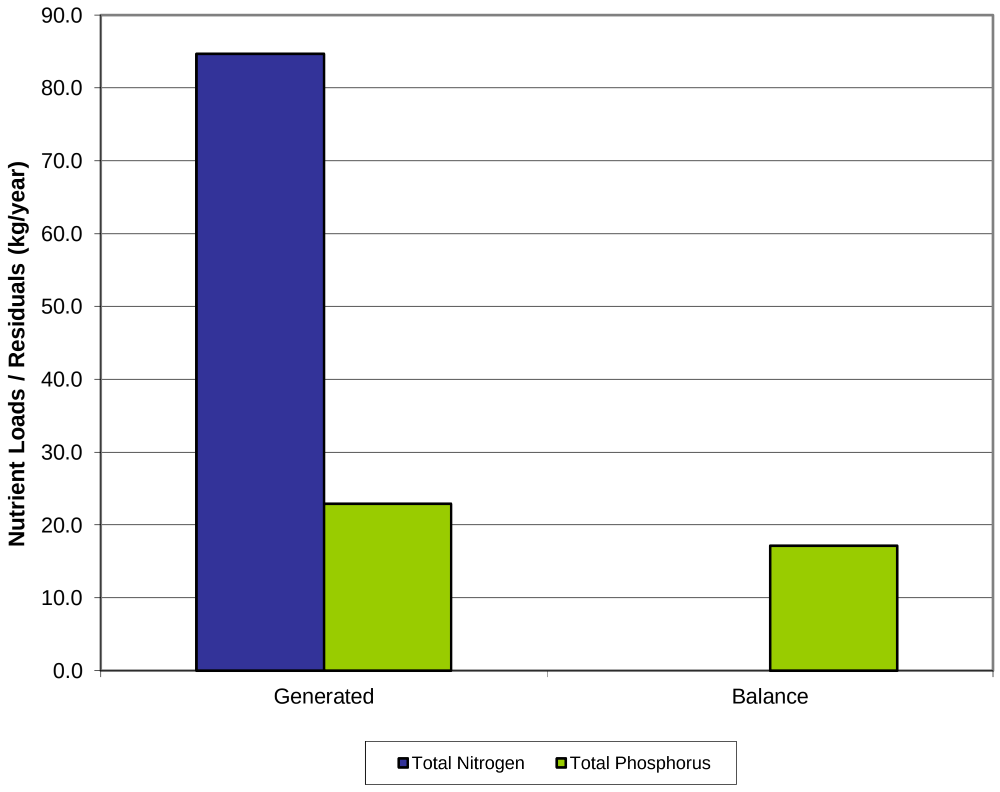
N generated	84.68	kg/year
N consumed	84.68	kg/year
N balance	0.00	kg/year
Min Area	3528	m^2

PHOSPHORUS BUDGET FOR RE-USE FIELD

P generated	22.89	kg/year
P consumed	5.76	kg/year
P balance	17.12	kg/year
P sorption	856.0	kg P/design soil depth
Field life (for P)	50.0	Years
Min Area	1922	m^2

MINIMUM NUTRIENT ASSIMILATION AREA

Minimum Area	**3528**	m^2



10 Attachment D – Laboratory Test Certificate (Wastewater)

NSW GOVERNMENT
Department of Primary Industries

Report No. **WN170180**

Biosecurity Laboratory Operations
Environmental Laboratory
1243 Bruxner Highway, WOLLONGBAR NSW 2477
Phone: 02 6626 1103 Email: wollongbar.csu@dpi.nsw.gov.au

Lynn Dunn
Soil Conservation Service
PO Box 283
SCONE NSW 2337

Soil Analysis Report

4 Sample(s) received on 3/03/17 . Tested as per the following methods.

Method	Method Description
S273	Gillman & Sumpter Exchangeable Cations

Notes:

Results relate only to the items tested.

- *When required, samples air dried at 40ºC as per Soil Chemical Methods - Australasia (Rayment and Lyons 2011).*
- *Results are expressed on an air-dry weight basis unless otherwise stated.*
- *This report should not be reproduced except in full.*
- *Samples will be retained for one calendar month from the date of the final report. Samples will then be discarded.*
- *Clients wishing to recover their samples must contact the laboratory within this period. This laboratory will return residual samples at client expense.*

Date of issue 7/03/17

Accredited for compliance with ISO/IEC 17025 – Testing
Accreditation No. 14173

Approved for Release by: Craig. Hunt.
Craig Hunt
Technical Officer

Laboratory No. **Client's ID**	**Units**	**Limit of Reporting**	**1** **SCO17/ 031/1**	**2** **SCO17/ 032/2**	**3** **SCO17/ 031/3**	**4** **SCO17/ 031/4**
Exchangeable Cations						
Aluminium	cmol(+)/kg	0.1	<0.1	3.2	<0.1	<0.1
Calcium	cmol(+)/kg	0.03	13	3.6	4.7	9.6
Potassium	cmol(+)/kg	0.01	1.2	0.63	0.23	0.49
Magnesium	cmol(+)/kg	0.007	11	4.8	1.8	3.5
Sodium	cmol(+)/kg	0.03	1.5	0.56	0.35	0.42
CEC	cmol(+)/kg	0.20	27	13	7.1	14
Calcium/Magnesium			1.3	0.75	2.6	2.7
Aluminium Saturation	%		N/A	25	N/A	N/A
Exchangeable Calcium	%		50	28	66	69
Exchangeable Potassium	%		4.7	4.9	3.2	3.5
Exchangeable Magnesium	%		40	38	25	25
Exchangeable Sodium	%		5.5	4.3	4.9	3.0

NSW GOVERNMENT
Department of
Primary Industries
Soil Conservation Service

SOIL TEST REPORT

Scone Research Centre

REPORT NO: SCO17/031R2

REPORT TO:
Robert Mehaffey
Martens & Associates P/L
Suite 201, 20 George Street
Hornsby NSW 2159

REPORT ON:
Four soil samples
Your ref: Job P1705798

PRELIMINARY RESULTS ISSUED: 8 March 2017

REPORT STATUS: Final

DATE REPORTED: 16 March 2017

METHODS: Information on test procedures can be obtained from Scone Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
THIS DOCUMENT MAY NOT BE REPRODUCED EXCEPT IN FULL

L Dunn
Scone Laboratory

Report No: SCO17/031R2
Client Reference: Robert Mehaffey
Martens & Associates P/L
Suite 201, 20 George Street
Hornsby NSW 2159

Lab No	Method	C1A/5	C2A/4	C8B/1	P9B/2
	Sample Id	EC (dS/m)	pH	P sorp (mg/kg)	EAT
1	5798/BH110/0.5/S/1	0.07	7.4	620	5
2	5798/BH113/0.2/S/1	0.08	5.2	750	6
3	5798/BH113/0.4/S/1	0.02	6.4	240	5
4	5798/BH105/0.1/S/1	nt	6.5	nt	nt

nt=not tested

Lab No	Method	P18B/3 (%)		
	Sample Id	FC (0.3 bar)	WP (15 bar)	AWC
1	5798/BH110/0.5/S/1	38	21	17
2	5798/BH113/0.2/S/1	32	20	12
3	5798/BH113/0.4/S/1	25	8	17
4	5798/BH105/0.1/S/1	nt	nt	nt

Field capacity (FC), wilting point (WP) and available water capacity (AWC) = moisture content (%) by weight
nt=not tested

END OF TEST REPORT

11 Attachment E – Notes Relating To This Report

Important Information About Your Report (1 of 2)

These notes have been prepared by Martens to help you interpret and understand the limitations of your report. Not all are necessarily relevant to all reports but are included as general reference.

Engineering Reports - Limitations

The recommendations presented in this report are based on limited investigations and include specific issues to be addressed during various phases of the project. If the recommendations presented in this report are not implemented in full, the general recommendations may become inapplicable and Martens & Associates accept no responsibility whatsoever for the performance of the works undertaken.

Occasionally, sub-surface conditions between and below the completed boreholes or other tests may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact Martens & Associates.

Relative ground surface levels at borehole locations may not be accurate and should be verified by on-site survey.

Engineering Reports – Project Specific Criteria

Engineering reports are prepared by qualified personnel. They are based on information obtained, on current engineering standards of interpretation and analysis, and on the basis of your unique project specific requirements as understood by Martens. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the Client.

Where the report has been prepared for a specific design proposal (e.g. a three storey building), the information and interpretation may not be relevant if the design proposal is changed (e.g. to a twenty storey building). Your report should not be relied upon, if there are changes to the project, without first asking Martens to assess how factors, which changed subsequent to the date of the report, affect the report's recommendations. Martens will not accept responsibility for problems that may occur due to design changes, if not consulted.

Engineering Reports – Recommendations

Your report is based on the assumption that site conditions, as may be revealed through selective point sampling, are indicative of actual conditions throughout an area. This assumption often cannot be substantiated until project implementation has commenced. Therefore your site investigation report recommendations should only be regarded as preliminary.

Only Martens, who prepared the report, are fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report, there is a risk that the report will be misinterpreted and Martens cannot be held responsible for such misinterpretation.

Engineering Reports – Use for Tendering Purposes

Where information obtained from investigations is provided for tendering purposes, Martens recommend that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document.

Martens would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Engineering Reports – Data

The report as a whole presents the findings of a site assessment and should not be copied in part or altered in any way.

Logs, figures, drawings *etc* are customarily included in a Martens report and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel), desktop studies and laboratory evaluation of field samples. These data should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Engineering Reports – Other Projects

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

Subsurface Conditions - General

Every care is taken with the report in relation to interpretation of subsurface conditions, discussion of geotechnical aspects, relevant standards and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions - the potential will depend partly on test point (eg. excavation or borehole) spacing and sampling frequency, which are often limited by project imposed budgetary constraints.

- Changes in guidelines, standards and policy or interpretation of guidelines, standards and policy by statutory authorities.

- The actions of contractors responding to commercial pressures.

- Actual conditions differing somewhat from those inferred to exist, because no professional, no matter how qualified, can reveal precisely what is hidden by earth, rock and time.

  The actual interface between logged materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions.

If these conditions occur, Martens will be pleased to assist with investigation or providing advice to resolve the matter.

Subsurface Conditions - Changes

Natural processes and the activity of man create subsurface conditions. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Reports are based on conditions which existed at the time of the subsurface exploration / assessment.

Decisions should not be based on a report whose adequacy may have been affected by time. If an extended period of time has elapsed since the report was prepared, consult Martens to be advised how time may have impacted on the project.

Subsurface Conditions - Site Anomalies

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

Report Use by Other Design Professionals

To avoid potentially costly misinterpretations when other design professionals develop their plans based on a Martens report, retain Martens to work with other project professionals affected by the report. This may involve Martens explaining the report design implications and then reviewing plans and specifications produced to see how they have incorporated the report findings.

Subsurface Conditions – Geo-environmental Issues

Your report generally does not relate to any findings, conclusions, or recommendations about the potential for hazardous or contaminated materials existing at the site unless specifically required to do so as part of Martens' proposal for works.

Specific sampling guidelines and specialist equipment, techniques and personnel are typically used to perform geo-environmental or site contamination assessments. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Martens for information relating to such matters.

Responsibility

Geo-environmental reporting relies on interpretation of factual information based on professional judgment and opinion and has an inherent level of uncertainty attached to it and is typically far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded.

To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Martens to other parties but are included to identify where Martens' responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Martens closely and do not hesitate to ask any questions you may have.

Site Inspections

Martens will always be pleased to provide engineering inspection services for aspects of work to which this report relates. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site. Martens is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction.

Soil Data

Explanation of Terms (1 of 3)

Definitions

In engineering terms, soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material does not exhibit any visible rock properties and can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

The methods of description and classification of soils and rocks used in this report are typically based on Australian Standard 1726 and the Unified Soil Classification System (USCS) – refer Soil Data Explanation of Terms (2 of 3). In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

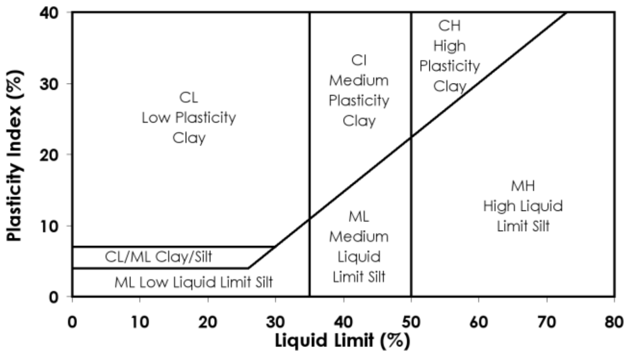
Particle Size

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (e.g. sandy CLAY). Unless otherwise stated, particle size is described in accordance with the following table.

Division	Subdivision	Size (mm)
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	20 to 63
	Medium	6 to 20
	Fine	2.36 to 6
SAND	Coarse	0.6 to 2.36
	Medium	0.2 to 0.6
	Fine	0.075 to 0.2
SILT		0.002 to 0.075
CLAY		< 0.002

Plasticity Properties

Plasticity properties of cohesive soils can be assessed in the field by tactile properties or by laboratory procedures.



Moisture Condition

Dry	Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.
Moist	Soil feels cool and damp and is darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	As for moist but with free water forming on hands when handled.

Consistency of Cohesive Soils

Cohesive soils refer to predominantly clay materials.

Term	C_u (kPa)	Approx. SPT "N"	Field Guide
Very Soft	<12	2	A finger can be pushed well into the soil with little effort. Sample extrudes between fingers when squeezed in fist.
Soft	12 - 25	2 – 4	A finger can be pushed into the soil to about 25mm depth. Easily moulded in fingers.
Firm	25 - 50	4 – 8	The soil can be indented about 5mm with the thumb, but not penetrated. Can be moulded by strong pressure in the figures.
Stiff	50 - 100	8 – 15	The surface of the soil can be indented with the thumb, but not penetrated. Cannot be moulded by fingers.
Very Stiff	100 - 200	15 – 30	The surface of the soil can be marked, but not indented with thumb pressure. Difficult to cut with a knife. Thumbnail can readily indent.
Hard	> 200	> 30	The surface of the soil can be marked only with the thumbnail. Brittle. Tends to break into fragments.
Friable	-	-	Crumbles or powders when scraped by thumbnail.

Density of Granular Soils

Non-cohesive soils are classified on the basis of relative density, generally from standard penetration test (SPT) or Dutch cone penetrometer test (CPT) results as below:

Relative Density	%	SPT 'N' Value* (blows/300mm)	CPT Cone Value (q_c MPa)
Very loose	< 15	< 5	< 2
Loose	15 - 35	5 - 10	2 - 5
Medium dense	35 - 65	10 - 30	5 - 15
Dense	65 - 85	30 - 50	15 - 25
Very dense	> 85	> 50	> 25

* Values may be subject to corrections for overburden pressures and equipment type.

Minor Components

Minor components in soils may be present and readily detectable, but have little bearing on general geotechnical classification. Terms include:

Term	Assessment	Proportion of Minor component In:
Trace of	Presence just detectable by feel or eye. Soil properties little or no different to general properties of primary component.	Coarse grained soils: < 5 % Fine grained soils: < 15 %
With some	Presence easily detectable by feel or eye. Soil properties little different to general properties of primary component.	Coarse grained soils: 5 – 12 % Fine grained soils: 15 – 30 %

Symbols for Soils and Other

SOILS

- COBBLES/BOULDERS
- GRAVEL (GP OR GW)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- SAND (SP OR SW)
- SILTY SAND (SM)
- CLAYEY SAND (SC)
- SILT (ML OR MH)
- ORGANIC SILT (OH)
- CLAY (CL, CI OR CH)
- SILTY CLAY
- SANDY CLAY
- PEAT
- TOPSOIL

OTHER

- FILL
- TALUS
- ASPHALT
- CONCRETE

Unified Soil Classification Scheme (USCS)

<table>
<tr><th colspan="6">FIELD IDENTIFICATION PROCEDURES
(Excluding particles larger than 63 mm and basing fractions on estimated mass)</th><th>USCS</th><th>Primary Name</th></tr>
<tr><td rowspan="8">COARSE GRAINED SOILS
More than 50 % of material less than 63 mm is larger than 0.075 mm</td><td rowspan="16">(A 0.075 mm particle is about the smallest particle visible to the naked eye)</td><td rowspan="4">GRAVELS
More than half of coarse fraction is larger than 2.0 mm.</td><td rowspan="2">CLEAN GRAVELS (Little or no fines)</td><td colspan="2">Wide range in grain size and substantial amounts of all intermediate particle sizes.</td><td>GW</td><td>Gravel</td></tr>
<tr><td colspan="2">Predominantly one size or a range of sizes with more intermediate sizes missing</td><td>GP</td><td>Gravel</td></tr>
<tr><td rowspan="2">GRAVELS WITH FINES (Appreciable amount of fines)</td><td colspan="2">Non-plastic fines (for identification procedures see ML below)</td><td>GM</td><td>Silty Gravel</td></tr>
<tr><td colspan="2">Plastic fines (for identification procedures see CL below)</td><td>GC</td><td>Clayey Gravel</td></tr>
<tr><td rowspan="4">SANDS
More than half of coarse fraction is smaller than 2.0 mm</td><td rowspan="2">CLEAN SANDS (Little or no fines)</td><td colspan="2">Wide range in grain sizes and substantial amounts of intermediate sizes missing.</td><td>SW</td><td>Sand</td></tr>
<tr><td colspan="2">Predominantly one size or a range of sizes with some intermediate sizes missing</td><td>SP</td><td>Sand</td></tr>
<tr><td rowspan="2">SANDS WITH FINES (Appreciable amount of fines)</td><td colspan="2">Non-plastic fines (for identification procedures see ML below)</td><td>SM</td><td>Silty Sand</td></tr>
<tr><td colspan="2">Plastic fines (for identification procedures see CL below)</td><td>SC</td><td>Clayey Sand</td></tr>
<tr><td rowspan="8">FINE GRAINED SOILS
More than 50 % of material less than 63 mm is smaller than 0.075 mm</td><th colspan="6">IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 MM</th></tr>
<tr><th>DRY STRENGTH (Crushing Characteristics)</th><th>DILATANCY</th><th>TOUGHNESS</th><th>DESCRIPTION</th><th>USCS</th><th>Primary Name</th></tr>
<tr><td>None to Low</td><td>Quick to Slow</td><td>None</td><td>Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity</td><td>ML</td><td>Silt</td></tr>
<tr><td>Medium to High</td><td>None</td><td>Medium</td><td>Inorganic clays of low to medium plasticity [1], gravely clays, sandy clays, silty clays, lean clays</td><td>CL [2]</td><td>Clay</td></tr>
<tr><td>Low to Medium</td><td>Slow to Very Slow</td><td>Low</td><td>Organic slits and organic silty clays of low plasticity</td><td>OL</td><td>Organic Silt</td></tr>
<tr><td>Low to Medium</td><td>Slow to Very Slow</td><td>Low to Medium</td><td>Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts</td><td>MH</td><td>Silt</td></tr>
<tr><td>High</td><td>None</td><td>High</td><td>Inorganic clays of high plasticity, fat clays</td><td>CH</td><td>Clay</td></tr>
<tr><td>Medium to High</td><td>None</td><td>Low to Medium</td><td>Organic clays of medium to high plasticity</td><td>OH</td><td>Organic Silt</td></tr>
<tr><td colspan="2">HIGHLY ORGANIC SOILS</td><td colspan="4">Readily identified by colour, odour, spongy feel and frequently by fibrous texture</td><td>Pt</td><td>Peat</td></tr>
<tr><td colspan="8">**Notes:**
1. Low Plasticity – Liquid Limit $W_L < 35$ % Medium Plasticity – Liquid limit W_L 35 to 60 % High Plasticity - Liquid limit $W_L > 60$ %.
2. CI may be adopted for clay of medium plasticity to distinguish from clay of low plasticity.</td></tr>
</table>

Soil Agricultural Classification Scheme

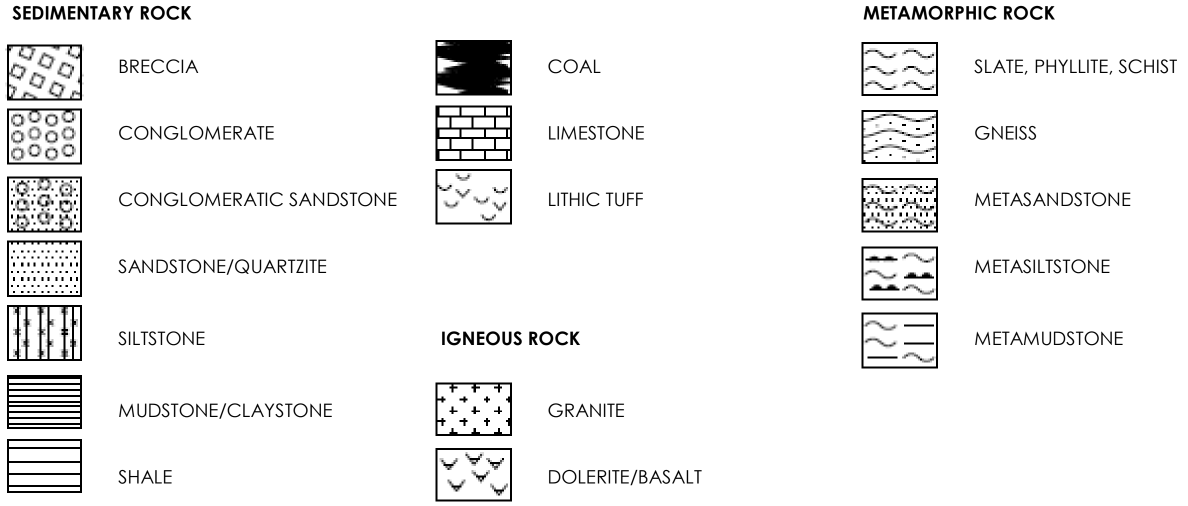
In some situations, such as where soils are to be used for effluent disposal purposes, soils are often more appropriately classified in terms of traditional agricultural classification schemes. Where a Martens report provides agricultural classifications, these are undertaken in accordance with descriptions by Northcote, K.H. (1979) *The factual key for the recognition of Australian Soils*, Rellim Technical Publications, NSW, p 26 - 28.

Symbol	Field Texture Grade	Behaviour of moist bolus	Ribbon length	Clay content (%)
S	Sand	Coherence nil to very slight; cannot be moulded; single grains adhere to fingers	0 mm	< 5
LS	Loamy sand	Slight coherence; discolours fingers with dark organic stain	6.35 mm	5
CLS	Clayey sand	Slight coherence; sticky when wet; many sand grains stick to fingers; discolours fingers with clay stain	6.35mm - 1.3cm	5 - 10
SL	Sandy loam	Bolus just coherent but very sandy to touch; dominant sand grains are of medium size and are readily visible	1.3 - 2.5	10 - 15
FSL	Fine sandy loam	Bolus coherent; fine sand can be felt and heard	1.3 - 2.5	10 - 20
SCL$^-$	Light sandy clay loam	Bolus strongly coherent but sandy to touch, sand grains dominantly medium size and easily visible	2.0	15 - 20
L	Loam	Bolus coherent and rather spongy; smooth feel when manipulated but no obvious sandiness or silkiness; may be somewhat greasy to the touch if much organic matter present	2.5	25
Lfsy	Loam, fine sandy	Bolus coherent and slightly spongy; fine sand can be felt and heard when manipulated	2.5	25
SiL	Silt loam	Coherent bolus, very smooth to silky when manipulated	2.5	25 + > 25 silt
SCL	Sandy clay loam	Strongly coherent bolus sandy to touch; medium size sand grains visible in a finer matrix	2.5 - 3.8	20 - 30
CL	Clay loam	Coherent plastic bolus; smooth to manipulate	3.8 - 5.0	30 - 35
SiCL	Silty clay loam	Coherent smooth bolus; plastic and silky to touch	3.8 - 5.0	30- 35 + > 25 silt
FSCL	Fine sandy clay loam	Coherent bolus; fine sand can be felt and heard	3.8 - 5.0	30 - 35
SC	Sandy clay	Plastic bolus; fine to medium sized sands can be seen, felt or heard in a clayey matrix	5.0 - 7.5	35 - 40
SiC	Silty clay	Plastic bolus; smooth and silky	5.0 - 7.5	35 - 40 + > 25 silt
LC	Light clay	Plastic bolus; smooth to touch; slight resistance to shearing	5.0 - 7.5	35 - 40
LMC	Light medium clay	Plastic bolus; smooth to touch, slightly greater resistance to shearing than LC	7.5	40 - 45
MC	Medium clay	Smooth plastic bolus, handles like plasticine and can be moulded into rods without fracture, some resistance to shearing	> 7.5	45 - 55
HC	Heavy clay	Smooth plastic bolus; handles like stiff plasticine; can be moulded into rods without fracture; firm resistance to shearing	> 7.5	> 50

Rock Data

Explanation of Terms (1 of 2)

Symbols for Rock



Definitions

Descriptive terms used for Rock by Martens are based on AS1726 and encompass rock substance, defects and mass.

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

Degree of Weathering

Rock weathering is defined as the degree of decline in rock structure and grain property and can be determined in the field.

Term	Symbol	Definition
Residual soil[1]	Rs	Soil derived from the weathering of rock. The mass structure and substance fabric are no longer evident. There is a large change in volume but the soil has not been significantly transported.
Extremely weathered[1]	EW	Rock substance affected by weathering to the extent that the rock exhibits soil properties - i.e. it can be remoulded and can be classified according to the Unified Classification System, but the texture of the original rock is still evident.
Highly weathered[2]	HW	Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength may be increased or decrease compared to the fresh rock usually as a result of iron leaching or deposition. The colour and strength of the original rock substance is no longer recognisable.
Moderately weathered[2]	MW	Rock substance affected by weathering to the extent that staining extends throughout the whole of the rock substance and the original colour of the fresh rock is no longer recognisable.
Slightly weathered	SW	Rock substance affected by weathering to the extent that partial staining or discolouration of the rock substance usually by limonite has taken place. The colour and texture of the fresh rock is recognisable.
Fresh	FR	Rock substance unaffected by weathering

Notes:
1 The term "Distinctly Weathered" (DW) may be used to cover the range of substance weathering between EW and SW.
2 Rs and EW material is described using soil descriptive terms.

Rock Strength

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the loading. The test procedure is described by the International Society of Rock Mechanics.

Term	Is (50) MPa	Field Guide	Symbol
Very low	>0.03 ≤0.1	May be crumbled in the hand. Sandstone is 'sugary' and friable.	VL
Low	>0.1 ≤0.3	A piece of core 150mm long x 50mm diameter may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.	L
Medium	>0.3 ≤1.0	A piece of core 150mm long x 50mm diameter can be broken by hand with considerable difficulty. Readily scored with a knife.	M
High	>1 ≤3	A piece of core 150mm long x 50mm diameter cannot be broken by unaided hands, can be slightly scratched or scored with a knife.	H
Very high	>3 ≤10	A piece of core 150mm long x 50mm diameter may be broken readily with hand held hammer. Cannot be scratched with pen knife.	VH
Extremely high	>10	A piece of core 150mm long x 50mm diameter is difficult to break with hand held hammer. Rings when struck with a hammer.	EH

Rock Data

Explanation of Terms (2 of 2)

Degree of Fracturing

This classification applies to diamond drill cores and refers to the spacing of all types of natural fractures along which the core is discontinuous. These include bedding plane partings, joints and other rock defects, but exclude fractures such as drilling breaks (DB) or handling breaks (HB).

Term	Description
Fragmented	The core is comprised primarily of fragments of length less than 20 mm, and mostly of width less than core diameter.
Highly fractured	Core lengths are generally less than 20 mm to 40 mm with occasional fragments.
Fractured	Core lengths are mainly 30 mm to 100 mm with occasional shorter and longer sections.
Slightly fractured	Core lengths are generally 300 mm to 1000 mm, with occasional longer sections and sections of 100 mm to 300 mm.
Unbroken	The core does not contain any fractures.

Rock Core Recovery

TCR = Total Core Recovery

$$= \frac{\text{Length of core recovered}}{\text{Length of core run}} \times 100\%$$

SCR = Solid Core Recovery

$$= \frac{\sum \text{Length of cylindrical core recovered}}{\text{Length of core run}} \times 100\%$$

RQD = Rock Quality Designation

$$= \frac{\sum \text{Axial lengths of core} > 100\,\text{mm long}}{\text{Length of core run}} \times 100\%$$

Rock Strength Tests

▼	Point load strength Index (Is50) - axial test (MPa)
▶	Point load strength Index (Is50) - diametral test (MPa)
●	Unconfined compressive strength (UCS) (MPa)

Defect Type Abbreviations and Descriptions

Defect Type (with inclination given)

BP	Bedding plane parting
FL	Foliation
CL	Cleavage
JT	Joint
FC	Fracture
SZ/SS	Sheared zone/ seam (Fault)
CZ/CS	Crushed zone/ seam
DZ/DS	Decomposed zone/ seam
FZ	Fractured Zone
IS	Infilled seam
VN	Vein
CO	Contact
HB	Handling break
DB	Drilling break

Planarity

Pl	Planar
Cu	Curved
Un	Undulating
St	Stepped
Ir	Irregular
Dis	Discontinuous

Roughness

Pol	Polished
Sl	Slickensided
Sm	Smooth
Ro	Rough
VR	Very rough

Thickness

Zone	> 100 mm
Seam	> 2 mm < 100 mm
Plane	< 2 mm

Coating or Filling

Cn	Clean
Sn	Stain
Ct	Coating
Vnr	Veneer
Fe	Iron Oxide
X	Carbonaceous
Qz	Quartzite
MU	Unidentified mineral

Inclination

Inclination of defect is measured from perpendicular to and down the core axis.

Direction of defect is measured clockwise (looking down core) from magnetic north.

Test, Drill and Excavation Methods

Explanation of Terms (1 of 3)

Sampling

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

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

Undisturbed samples may be taken by pushing a thin-walled sampling tube, e.g. U_{50} (50 mm internal diameter thin walled tube), into soils and withdrawing a soil sample in a relatively undisturbed state. Such samples yield information on structure and strength and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils. Other sampling methods may be used. Details of the type and method of sampling are given in the report.

Drilling / Excavation Methods

The following is a brief summary of drilling and excavation methods currently adopted by the Company and some comments on their use and application.

Hand Excavation - in some situations, excavation using hand tools, such as mattock and spade, may be required due to limited site access or shallow soil profiles.

Hand Auger - the hole is advanced by pushing and rotating either a sand or clay auger, generally 75-100 mm in diameter, into the ground. The penetration depth is usually limited to the length of the auger pole; however extender pieces can be added to lengthen this.

Test Pits - these are excavated with a backhoe or a tracked excavator, allowing close examination of the in-situ soils and, if it is safe to descend into the pit, collection of bulk disturbed samples. The depth of penetration is limited to about 3 m for a backhoe and up to 6 m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (e.g. Pengo) - the hole is advanced by a rotating plate or short spiral auger, generally 300 mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

Continuous Sample Drilling (Push Tube) - the hole is advanced by pushing a 50 - 100 mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling in soils, since moisture content is unchanged and soil structure, strength *etc.* is only marginally affected.

Continuous Spiral Flight Augers - the hole is advanced using 90 - 115 mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface or, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling - the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

Rotary Mud Drilling - similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. from SPT).

Continuous Core Drilling - a continuous core sample is obtained using a diamond tipped core barrel of usually 50 mm internal diameter. Provided full core recovery is achieved (not always possible in very weak or fractured rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

In-situ Testing and Interpretation

Cone Penetrometer Testing (CPT)
Cone penetrometer testing (sometimes referred to as Dutch Cone) described in this report has been carried out using an electrical friction cone penetrometer.

The test is described in AS 1289.6.5.1-1999 (R2013). In the test, a 35 mm diameter rod with a cone tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system.

Measurements are made of the end bearing resistance on the cone and the friction resistance on a separate 130 mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the push rod centre to an amplifier and recorder unit mounted on the control truck. As penetration occurs (at a rate of approximately 20 mm per second) the information is output on continuous chart recorders. The plotted results given in this report have been traced from the original records. The information provided on the charts comprises:

(i) Cone resistance (q_c) - the actual end bearing force divided by the cross sectional area of the cone, expressed in MPa.

(ii) Sleeve friction (q_f) - the frictional force of the sleeve divided by the surface area, expressed in kPa.

(iii) Friction ratio - the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower (A) scale (0 - 5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main (B) scale (0 - 50 MPa) is less sensitive and is shown as a full line.

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1 % - 2 % are commonly encountered in sands and very soft clays rising to 4 % - 10 % in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range:

$$q_c \text{ (MPa)} = (0.4 \text{ to } 0.6) \text{ N (blows/300 mm)}$$

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range:

$$q_c = (12 \text{ to } 18)\ C_u$$

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculation of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes *etc.* This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

Standard Penetration Testing (SPT)

Standard penetration tests are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample.

The test procedure is described in AS 1289.6.3.1-2004. The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm penetration depth increments and the 'N' value is taken as the number of blows for the last two 150 mm depth increments (300 mm total penetration). In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued. The test results are reported in the following form:

(i) Where full 450 mm penetration is obtained with successive blow counts for each 150 mm of say 4, 6 and 7 blows:

as 4, 6, 7
N = 13

(ii) Where the test is discontinued, short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm

as 15, 30/40 mm.

The results of the tests can be related empirically to the engineering properties of the soil. Occasionally, the test method is used to obtain samples in 50 mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borehole logs in brackets.

Dynamic Cone (Hand) Penetrometers

Hand penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150mm increments of penetration. Normally, there is a depth limitation of 1.2m but this may be extended in certain conditions by the use of extension rods. Two relatively similar tests are used.

Perth sand penetrometer (PSP) - a 16 mm diameter flat ended rod is driven with a 9 kg hammer, dropping 600 mm. The test, described in AS 1289.6.3.3-1997 (R2013), was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.

Cone penetrometer (DCP) - sometimes known as the Scala Penetrometer, a 16 mm rod with a 20 mm diameter cone end is driven with a 9 kg hammer dropping 510 mm. The test, described in AS 1289.6.3.2-1997 (R2013), was developed initially for pavement sub-grade investigations, with correlations of the test results with California Bearing Ratio published by various Road Authorities.

Pocket Penetrometers

The pocket (hand) penetrometer (PP) is typically a light weight spring hand operated device with a stainless steel loading piston, used to estimate unconfined compressive strength, q_u, (UCS in kPa) of a fine grained soil in field conditions. In use, the free end of the piston is pressed into the soil at a uniform penetration rate until a line, engraved near the piston tip, reaches the soil surface level. The reading is taken from a gradation scale, which is attached to the piston via a built-in spring mechanism and calibrated to kilograms per square centimetre (kPa) UCS. The UCS measurements are used to evaluate consistency of the soil in the field moisture condition. The results may be used to assess the undrained shear strength, C_u, of fine grained soil using the approximate relationship:

$q_u = 2 \times C_u$.

It should be noted that accuracy of the results may be influenced by condition variations at selected test surfaces. Also, the readings obtained from the PP test are based on a small area of penetration and could give misleading results. They should not replace laboratory test results. The use of the results from this test is typically limited to an assessment of consistency of the soil in the field and not used directly for design of foundations.

Test Pit / Borehole Logs

Test pit / borehole log(s) presented herein are an engineering and / or geological interpretation of the subsurface conditions. Their reliability will depend to some extent on frequency of sampling and methods of excavation / drilling. Ideally, continuous undisturbed sampling or excavation / core drilling will provide the most reliable assessment but this is not always practicable, or possible to justify on economic grounds. In any case, the test pit / borehole logs represent only a very small sample of the total subsurface profile.

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

Laboratory Testing

Laboratory testing is carried out in accordance with AS 1289 Methods of Testing Soil for Engineering Purposes. Details of the test procedure used are given on the individual report forms.

Ground Water

Where ground water levels are measured in boreholes, there are several potential problems:

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

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

Test, Drill and Excavation Methods

Explanation of Terms (3 of 3)

DRILLING / EXCAVATION METHOD

HA	Hand Auger	RD	Rotary Blade or Drag Bit	NQ	Diamond Core - 47 mm
AD/V	Auger Drilling with V-bit	RT	Rotary Tricone bit	NMLC	Diamond Core – 51.9 mm
AD/T	Auger Drilling with TC-Bit	RAB	Rotary Air Blast	HQ	Diamond Core – 63.5 mm
AS	Auger Screwing	RC	Reverse Circulation	HMLC	Diamond Core – 63.5 mm
HSA	Hollow Stem Auger	CT	Cable Tool Rig	DT	Diatube Coring
S	Excavated by Hand Spade	PT	Push Tube	NDD	Non-destructive digging
BH	Tractor Mounted Backhoe	PC	Percussion	PQ	Diamond Core - 83 mm
JET	Jetting	E	Tracked Hydraulic Excavator	X	Existing Excavation

SUPPORT

Nil	No support	S	Shotcrete	RB	Rock Bolt
C	Casing	Sh	Shoring	SN	Soil Nail
WB	Wash bore with Blade or Bailer	WR	Wash bore with Roller	T	Timbering

WATER

∇	Water level at date shown	◁	Partial water loss
▷	Water inflow	◀	Complete water loss

GROUNDWATER NOT OBSERVED (NO)	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.
GROUNDWATER NOT ENCOUNTERED (NX)	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.

PENETRATION / EXCAVATION RESISTANCE

L	Low resistance: Rapid penetration possible with little effort from the equipment used.
M	Medium resistance: Excavation possible at an acceptable rate with moderate effort from the equipment used.
H	High resistance: Further penetration possible at slow rate & requires significant effort equipment.
R	Refusal/ Practical Refusal. No further progress possible without risk of damage/ unacceptable wear to digging implement / machine.

These assessments are subjective and dependent on many factors, including equipment power, weight, condition of excavation or drilling tools, and operator experience.

SAMPLING

D	Small disturbed sample	W	Water Sample	C	Core sample
B	Bulk disturbed sample	G	Gas Sample	CONC	Concrete Core

U63 Thin walled tube sample - number indicates nominal undisturbed sample diameter in millimetres

TESTING

SPT	Standard Penetration Test to AS1289.6.3.1-2004
4,7,11	4,7,11 = Blows per 150mm.
N=18	'N' = Recorded blows per 300mm penetration following 150mm seating
DCP	Dynamic Cone Penetration test to AS1289.6.3.2-1997. 'n' = Recorded blows per 150mm penetration

Notes:

RW	Penetration occurred under the rod weight only
HW	Penetration occurred under the hammer and rod weight only
HB 30/80mm	Hammer double bouncing on anvil after 80 mm penetration
N=18	Where practical refusal occurs, report blows and penetration for that interval

CPT	Static cone penetration test
CPTu	CPT with pore pressure (u) measurement
PP	Pocket penetrometer test expressed as instrument reading (kPa)
FP	Field permeability test over section noted
VS	Field vane shear test expressed as uncorrected shear strength (sv = peak value, sr = residual value)
PM	Pressuremeter test over section noted
PID	Photoionisation Detector reading in ppm
WPT	Water pressure tests

SOIL DESCRIPTION

Density		Consistency		Moisture	
VL	Very loose	VS	Very soft	D	Dry
L	Loose	S	Soft	M	Moist
MD	Medium dense	F	Firm	W	Wet
D	Dense	St	Stiff	Wp	Plastic limit
VD	Very dense	VSt	Very stiff	Wl	Liquid limit
		H	Hard		

ROCK DESCRIPTION

Strength		Weathering	
VL	Very low	EW	Extremely weathered
L	Low	HW	Highly weathered
M	Medium	MW	Moderately weathered
H	High	SW	Slightly weathered
VH	Very high	FR	Fresh
EH	Extremely high		