Catholic Education Diocese of Bathurst
C/- TSA Management Pty Ltd

# Preliminary Salinity and Geotechnical Assessment: St Matthew's Catholic School – 48 Broadhead Road, Spring Flat, NSW

P1907109JR02V01
March 2020

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT
MANAGEMENT

**Copyright Statement**

**Limitations Statement**

The sole purpose of this report and the associated services performed by Martens & Associates Pty Ltd is to complete a preliminary salinity and geotechnical assessment in accordance with the scope of services set out by Catholic Education Diocese of Bathurst C/- TSA Management Pty Ltd (hereafter known as the Client). That scope of works and services were defined by the requests of the Client, by the time and budgetary constraints imposed by the Client, and by the availability of access to the site.

Martens & Associates Pty Ltd derived the data in this report primarily from a number of sources including site inspections, correspondence regarding the proposal, examination of records in the public domain, interviews with individuals with information about the site or the project, and field explorations conducted on the dates indicated. The passage of time, manifestation of latent conditions or impacts of future events may require further examination / exploration of the site and subsequent data analyses, together with a re-evaluation of the findings, observations and conclusions expressed in this report.

In preparing this report, Martens & Associates Pty Ltd may have relied upon and presumed accurate certain information (or absence thereof) relative to the site. Except as otherwise stated in the report, Martens & Associates Pty Ltd has not attempted to verify the accuracy of completeness of any such information (including for example survey data supplied by others).

The findings, observations and conclusions expressed by Martens & Associates Pty Ltd in this report are not, and should not be considered an opinion concerning the completeness and accuracy of information supplied by others. No warranty or guarantee, whether express or implied, is made with respect to the data reported or to the findings, observations and conclusions expressed in this report. Further, such data, findings and conclusions are based solely upon site conditions, information and drawings supplied by the Client *etc*. in existence at the time of the investigation.

This report has been prepared on behalf of and for the exclusive use of the Client, and is subject to and issued in connection with the provisions of the agreement between Martens & Associates Pty Ltd and the Client. Martens & Associates Pty Ltd accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

**Head Office**
Suite 201, 20 George Street
Hornsby, NSW 2077, Australia
ACN 070 240 890 ABN 85 070 240 890
**Phone: +61-2-9476-9999**
Fax: +61-2-9476-8767
Email: mail@martens.com.au
Web: www.martens.com.au

### Document and Distribution Status

| Author(s) | Reviewer(s) | Project Manager | Signature |
|---|---|---|---|
| Chris Li | Ralph Erni | Jeffrey Fulton | |

| Revision No. | Description | Status | Release Date | Document Location | | | |
|---|---|---|---|---|---|---|---|
| | | | | File Copy | TSA Management Pty Ltd | | |
| 1 | Preliminary Salinity and Geotechnical Assessment | Draft | 01.07.2019 | 1E, 1H, 1P | 1P | | |
| 1 | Amend Preliminary Salinity and Geotechnical Assessment | Final | 26.03.2020 | 1E, 1H, 1P | 1P | | |

Distribution Types: F = Fax, H = Hard copy, P = PDF document, E = Other electronic format. Digits indicate number of document copies.

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

# Contents

# 1 Proposed Development and Investigation Scope

The proposed development details and investigation scope are summarised in Table 1.

**Table 1:** Summary of proposed development and investigation scope.

| Item | Details |
|---|---|
| Property Address | 48 Broadhead Road, Spring Flat, NSW ('the site') |
| Lot/DP | Lot 40 in DP 756894 |
| Site Area | 12.14 ha (Barnson, 2019) |
| LGA | Mid-Western Regional Council ('Council') |
| Proposed Development | The proposal plans (AA, 2020) indicate that the development will include:<br>o Construction of a new catholic school comprising an administration build, a multipurpose hall, an art, science and TAS building, GLA buildings, a chapel, a sports oval and a parking lot.<br>For the purpose of this report, we have assumed that limited (< 1 m) cutting and / or filling will be required for construction works. |
| Assessment Purpose | Preliminary geotechnical and salinity assessment to support a Development Application (DA). |
| Investigation scope of work | Field investigations conducted between 7 and 9 May 2019 included:<br>o Review of DBYD survey plans.<br>o A general site walkover survey.<br>o Nineteen boreholes (BH101 to BH119) up to 7 mBGL (refer Attachment B for borehole logs, and associated explanatory notes in Attachment F).<br>o Collection of soil and rock samples for laboratory testing and for future reference.<br>o Sixteen Dynamic Cone Penetrometer (DCP) tests (DCP101 to DCP116) up to 1.53 mBGL (refer DCP 'N' counts in Attachment C).<br>Investigation locations are shown in Figure 1, Attachment A. |
| Laboratory Testing | Testing carried out by National Association of Testing Authorities (NATA) accredited laboratories included:<br>o Soil reactivity (Atterberg limits) and CBR testing on four soil samples by Resource Laboratories.<br>o Salinity testing on thirty soil samples and Emerson Aggregate and Cation Exchange Capacity testing on six soil samples by Envirolab Services.<br>Laboratory test certificates are provided as Attachment D. |

# 2 General Site Details and Subsurface Conditions

General site details and investigation findings of subsurface conditions are summarised in Table 2.

**Table 2:** Summary of general site details based on desktop review, site walkover and site investigations.

| Item | Comment |
|---|---|
| Topography | Within slightly undulating terrain. |
| Typical slopes, aspect, elevation | The site generally has a north easterly aspect with overall grades generally less than 2%.<br>Site elevation ranges between approximately 483.45 mAHD in the north eastern corner and 491.78 mAHD in the south western corner of the site (Barnson, 2019). |
| Expected Geology | Quaternary deposits comprising alluvial silt, clay and sand, variable humic content, sporadic pebble to cobble sized unconsolidated conglomeratic lenses underlie the majority of the site. Permian carbonaceous siltstne, quartz-lithic sandstone, conglomerate and coal lenses, with rare varves, may underlie the higher-lying eastern and southernmost portion of the site. We believe that the site mainly comprises quaternary deposits. Expected site geology is shown in Figure 2, Attachment A. |
| Existing Development | This site is a vacant grassland with a dam located near the northwest corner of the site. |
| Vegetation | Grass, shrubs and scattered trees along the south and west boundaries and in the north west portion of the site. |
| Drainage | Via overland flow towards the north east and towards the east and northeast from the northwest corner of the site. |
| Neighbouring environment | The site is bordered by Broadhead Road to the west, Bruce Road to the south, and vacant grassland to the north and east. |
| Sub-surface soil / rock units | Unit A: Topsoil comprising typically very stiff silty clay of up to approximately 50 mm thickness.<br>Unit B: Alluvium, comprising generally very stiff grading to hard silty clay, excavated up to investigation termination depth of 7.0 mBGL (BH110).<br>High DCP results and auger refusal are inferred to be as a result of gravels and cobbles being present within the soil profile. |
| Groundwater | Groundwater inflow was not encountered during drilling of the boreholes up to 7.0 mBGL. Ephemeral perched groundwater may be encountered within the soil profile and / or at the soil / rock interface at times of, and following, heavy or extended periods of rainfall.<br>Should further information on permanent site groundwater conditions be required, additional assessment would need to be carried out (i.e. installation of groundwater monitoring well). |

# 3 Salinity Assessment

## 3.1 Documented Salinity Risk Potential

The NSW Office of Environment and Heritage eSpade (eSpade, 2019) indicates that the site is located within the Craigmore soil landscape and that the site is located in an area of moderate salinity potential. Site location relative to hydrogeological map is shown in Figure 3, Attachment A.

## 3.2 Signs of Potential Saline Soils at the site

No obvious signs of saline conditions were observed across the site:

- Vegetation growth appeared healthy and uninhibited.
- No water marks or salt crystals were observed on the ground surface.
- Site surface drainage appeared generally good.
- No evidence of concentrated surface erosion was observed.

## 3.3 Laboratory Test Results

### 3.3.1 *Salinity Classification*

Laboratory test results for salinity classification are summarised in Table 3.

**Table 3:** Salinity test results.

| Sample ID [1] | Material | $EC_{(1:5)}$ (dS/m) | $EC_e$ (dS/m) [2] | Salinity Classification [3] |
|---|---|---|---|---|
| BH101/0.1 | Silty CLAY | 0.130 | 0.910 | Non – Saline |
| BH102/0.25 | Silty CLAY | 0.032 | 0.224 | Non – Saline |
| BH105/1.5 | Silty CLAY | 0.008 | 0.056 | Non – Saline |
| BH106/2.0 | Silty CLAY | 0.017 | 0.119 | Non – Saline |
| BH107/0.25 | Silty CLAY | 0.044 | 0.308 | Non – Saline |
| BH108/1.0 | CLAY | 0.019 | 0.114 | Non – Saline |
| BH109/0.5 | CLAY | 0.021 | 0.147 | Non – Saline |
| BH110/5.0 | CLAY | 0.096 | 0.576 | Non – Saline |

| Sample ID [1] | Material | $EC_{(1:5)}$ (dS/m) | $EC_e$ (dS/m) [2] | Salinity Classification [3] |
|---|---|---|---|---|
| BH111/0.1 | Silty CLAY | 0.042 | 0.294 | Non – Saline |
| BH111/0.25 | Silty CLAY | 0.046 | 0.322 | Non – Saline |
| BH111/0.5 | Silty CLAY | 0.058 | 0.377 | Non – Saline |
| BH111/1.0 | Silty CLAY | 0.040 | 0.260 | Non – Saline |
| BH112/0.1 | Silty CLAY | 0.031 | 0.217 | Non – Saline |
| BH112/0.25 | Silty CLAY | 0.025 | 0.175 | Non – Saline |
| BH112/0.5 | Silty CLAY | 0.022 | 0.154 | Non – Saline |
| BH112/1.0 | Silty CLAY | 0.017 | 0.119 | Non – Saline |
| BH112/2.0 | CLAY | 0.029 | 0.203 | Non – Saline |
| BH112/3.0 | CLAY | 0.027 | 0.189 | Non – Saline |
| BH113/0.1 | Silty CLAY | 0.043 | 0.301 | Non – Saline |
| BH113/0.25 | Silty CLAY | 0.025 | 0.175 | Non – Saline |
| BH113/0.5 | Silty CLAY | 0.026 | 0.182 | Non – Saline |
| BH113/1.0 | Silty CLAY | 0.016 | 0.104 | Non – Saline |
| BH117/0.1 | Silty CLAY | 0.039 | 0.254 | Non – Saline |
| BH117/0.25 | Silty CLAY | 0.028 | 0.182 | Non – Saline |
| BH117/0.5 | Silty CLAY | 0.030 | 0.195 | Non – Saline |
| BH118/0.1 | Silty CLAY | 0.041 | 0.267 | Non – Saline |
| BH118/0.25 | Silty CLAY | 0.033 | 0.215 | Non – Saline |
| BH118/0.5 | Silty CLAY | 0.035 | 0.228 | Non – Saline |
| BH119/0.1 | Silty CLAY | 0.040 | 0.260 | Non – Saline |
| BH119/0.25 | Silty CLAY | 0.042 | 0.273 | Non – Saline |

**Notes:**

1. Borehole#/Depth (mBGL).
2. Based on EC to $EC_e$ multiplication factors from Table 6.1 in DLWC (2002).
3. Based on Table 6.2 of DLWC (2002) where $EC_e$ <2 dS/m = non-saline, $EC_e$ of 2-4 dS/m = slightly saline, $EC_e$ of 4-8 dS/m = moderately saline, $EC_e$ of 8-16 dS/m = very saline and $EC_e$ of >16 dS/m = highly saline.

### 3.3.2 *Exposure Classification*

Test results for exposure classification are summarised in Table 4.

**Table 4**: Exposure classification test results.

| Sample ID[1] | $EC_e$ (dS/m) [2] | pH | Sulphate ($SO_4$) (mg/kg) | Exposure Classification | | |
|---|---|---|---|---|---|---|
| | | | | AS 2159 [3] | AS 2159 [4] | AS 3600 [5] |
| BH101/0.1 | 0.910 | 8.0 | <10 | Non-aggressive | Non-aggressive | A1 |
| BH102/0.25 | 0.224 | 6.7 | 10 | Non-aggressive | Non-aggressive | A1 |
| BH105/1.5 | 0.056 | 7.1 | <10 | Non-aggressive | Non-aggressive | A1 |
| BH106/2.0 | 0.119 | 7.6 | <10 | Non-aggressive | Non-aggressive | A1 |
| BH107/0.25 | 0.308 | 6.5 | 10 | Non-aggressive | Non-aggressive | A1 |
| BH108/1.0 | 0.114 | 7.2 | 20 | Non-aggressive | Non-aggressive | A1 |
| BH109/0.5 | 0.147 | 7.2 | <10 | Non-aggressive | Non-aggressive | A1 |
| BH110/5.0 | 0.576 | 8.9 | 10 | Non-aggressive | Non-aggressive | A1 |
| BH111/0.1 | 0.294 | 6.3 | <10 | Non-aggressive | Non-aggressive | A1 |
| BH111/0.25 | 0.322 | 6.8 | 39 | Non-aggressive | Non-aggressive | A1 |
| BH111/0.5 | 0.377 | 7.0 | 50 | Non-aggressive | Non-aggressive | A1 |
| BH111/1.0 | 0.260 | 7.5 | 32 | Non-aggressive | Non-aggressive | A1 |
| BH112/0.1 | 0.217 | 6.5 | <10 | Non-aggressive | Non-aggressive | A1 |
| BH112/0.25 | 0.175 | 6.7 | <10 | Non-aggressive | Non-aggressive | A1 |
| BH112/0.5 | 0.154 | 6.8 | <10 | Non-aggressive | Non-aggressive | A1 |
| BH112/1.0 | 0.119 | 6.9 | 10 | Non-aggressive | Non-aggressive | A1 |
| BH112/2.0 | 0.203 | 7.8 | <10 | Non-aggressive | Non-aggressive | A1 |
| BH112/3.0 | 0.189 | 8.0 | <10 | Non-aggressive | Non-aggressive | A1 |

| Sample ID[1] | $EC_e$ (dS/m) [2] | pH | Sulphate ($SO_4$) (mg/kg) | Exposure Classification | | |
|---|---|---|---|---|---|---|
| | | | | AS 2159 [3] | AS 2159 [4] | AS 3600 [5] |
| BH113/0.1 | 0.301 | 6.5 | <10 | Non-aggressive | Non-aggressive | A1 |
| BH113/0.25 | 0.175 | 7.0 | <10 | Non-aggressive | Non-aggressive | A1 |
| BH113/0.5 | 0.182 | 6.9 | 10 | Non-aggressive | Non-aggressive | A1 |
| BH113/1.0 | 0.104 | 7.1 | <10 | Non-aggressive | Non-aggressive | A1 |
| BH117/0.1 | 0.254 | 6.1 | <10 | Non-aggressive | Non-aggressive | A1 |
| BH117/0.25 | 0.182 | 7.0 | 10 | Non-aggressive | Non-aggressive | A1 |
| BH117/0.5 | 0.195 | 7.1 | 20 | Non-aggressive | Non-aggressive | A1 |
| BH118/0.1 | 0.267 | 6.2 | <10 | Non-aggressive | Non-aggressive | A1 |
| BH118/0.25 | 0.215 | 6.8 | <10 | Non-aggressive | Non-aggressive | A1 |
| BH118/0.5 | 0.228 | 6.7 | <10 | Non-aggressive | Non-aggressive | A1 |
| BH119/0.1 | 0.260 | 6.3 | <10 | Non-aggressive | Non-aggressive | A1 |
| BH119/0.25 | 0.273 | 6.3 | <10 | Non-aggressive | Non-aggressive | A1 |

**Notes:**

1. Borehole#/Depth (mBGL).
2. From column 4 of Table 3.
3. Exposure classification for concrete piles in soil based on Table 6.4.2(C) of AS 2159 (2009).
4. Exposure classification for steel piles in soil based on Table 6.5.2(C) of AS 2159 (2009).
5. Exposure classification for buried reinforced concrete based on Tables 4.8.1 and 4.8.2 of AS 3600 (2018).

### 3.3.3 *Emerson Aggregate Test and Cation Exchange Capacity*

**Table 5:** EAT and CEC results

| Sample ID [1] | EAT | Dispersive Behaviour Potential | CEC (meq/100g) | Exchangeable Na (meg/100g) | ESP [2] (%) | Sodicity Rating [3] |
|---|---|---|---|---|---|---|
| BH111/1.0 | 2.0 | Moderate | 2.1 | <0.1 | <4.76 | Non-sodic |
| BH113/0.1 | 3b | Moderate to high | 5.6 | <0.1 | <1.79 | Non-sodic |
| BH117/0.25 | 3a | Moderate to high | 7.0 | <0.1 | <1.43 | Non-sodic |
| BH118/0.1 | 3b | Moderate to high | 4.2 | <0.1 | <2.38 | Non-sodic |
| BH118/0.5 | 3a | Moderate to high | 8.9 | <0.1 | <1.12 | Non-sodic |
| BH119/0.1 | 3b | Moderate to high | 8.9 | <0.1 | <1.12 | Non-sodic |

**Notes:**

1. Borehole#/Depth (mBGL).
2. ESP % = (Exchangeable sodium / CEC) x 100 (DLWC, 2002)
3. Sodicity rating given based on ESP % (DLWC, 2002).

Test results indicate the following:

- One sample (BH111/1.0) has a moderate potential in its natural state to disperse upon introduction of water.
- Five samples have a low to moderate potential for dispersive behaviour in its natural state but a moderate to high potential for dispersive behaviour when the soil is remoulded.
- All samples are non-sodic.

## 3.4 Conclusions and Recommendations

We conclude and recommend the following:

- Sub-surface materials at the site are categorised as non-saline. No specified saline soil management strategies are required.
- In accordance with AS2159 (2009), an exposure classification of Non-aggressive' may be adopted for buried concrete and steel piles. In accordance with AS3600 (2018), an exposure classification of 'A1' may be adopted for shallow concrete footings founding in alluvial soil.

- Sub-surface materials at the site generally have a moderate dispersive potential, requiring the inclusion of erosion mitigation measures in design and construction.
- Sub-surface materials at the site are categorised as non-sodic.

# 4 Geotechnical Assessment

## 4.1 Laboratory Test Results

### *4.1.1* Soil Reactivity Testing

A summary of soil reactivity test results are presented in Table 6.

**Table 6:** Summary of laboratory soil reactivity test results.

| BH | Depth (mBGL) | Soil Type | Atterberg Limits (%) | | | Plasticity Classification | Potential Volume Change [2] |
|---|---|---|---|---|---|---|---|
| | | | LL[1] | PL[1] | PI[1] | | |
| BH107 | 0.5-0.7 | Silty CLAY | 41 | 17 | 24 | Medium | Low to medium |
| BH109 | 0.5-0.8 | Silty CLAY | 36 | 15 | 21 | Low to medium | Low to medium |
| BH111 | 0.5-0.7 | Silty CLAY | 40 | 15 | 25 | Medium | Low to medium |
| BH113 | 0.8-1.0 | Silty CLAY | 31 | 14 | 17 | Low | Low to medium |

**Notes:**

1. LL = Liquid limit, PL= Plastic limit, PI=Plasticity index
2. Based on Hazelton and Murphy, 2016.

Laboratory test results indicate that the tested soil samples are generally of medium plasticity, which may result in low to moderate ground movement due to soil moisture changes.

### *4.1.2* California Bearing Ratio (CBR) Testing

Laboratory CBR test results are summarised in Table 7.

**Table 7:** CBR test results.

| Borehole Number | Sample Depth (mBGL) | Material | CBR [1] Value (%) |
|---|---|---|---|
| BH101 | 0.2-0.5 | Silty CLAY | 9 |
| BH102 | 0.2-0.5 | Silty CLAY | 12 |
| BH103 | 0.3-0.7 | Silty CLAY | 8 |
| BH104 | 0.2-0.5 | Silty CLAY | 7 |

**Notes:**

1. Four day soak, compacted to 98 % SMDD (±2 % of OMC), applying a 4.5 kg surcharge.

The test results are analogous to low plasticity silty clay, containing gravels.

## 4.2 Preliminary Geotechnical Design Parameters

Preliminary soil properties and geotechnical design parameters inferred from observations during borehole drilling, such as auger penetration resistance, DCP test results as well as engineering assumptions are summarised in Table 8.

**Table 8**: Preliminary material properties.

| **Layer**[1] | **$Y_{in\text{-}situ}$**[2] **(kN/m$^3$)** | **Cu**[3] **(kPa)** | **C'**[4] **(kPa)** | **Ø'**[5] **(deg)** | **E'**[6] **(MPa)** | **AEBC**[7] **(kPa)** |
|---|---|---|---|---|---|---|
| TOPSOIL: Silty CLAY (very stiff and very stiff to hard, dry) | 17 | NA[8] | NA[8] | NA[8] | NA[8] | NA[8] |
| ALLUVIUM: Silty CLAY (very stiff, dry) | 17 | 100 | 5 | 28 | 20 | 150 |
| ALLUVIUM: Silty CLAY (hard, dry) | 18 | 200 | 6 | 30 | 40 | 300 |

**Notes:**

1. Refer to borehole logs in Attachment B for material description details.
2. Inferred material in-situ unit weight, based on visual assessment (±10 %).
3. Undrained shear strength (± 5 kPa) estimate assuming normally consolidated clay.
4. Drained effective cohesion estimate assuming normally consolidated clay.
5. Effective internal friction angle (±2˚) estimate assuming drained conditions.
6. Effective elastic modulus (± 10 %) estimate.
7. Allowable end bearing capacity (AEBC) (kPa) for shallow footings embedded at least 0.3 m into the design material type, subject to inspection and approval on site by a geotechnical engineer during construction.
8. Not applicable.

# 5 Recommendations

## 5.1 Preliminary Pavement Thickness Design

### 5.1.1 *Overview*

For the proposed carpark, a flexible asphaltic concrete or rigid concrete pavement may be considered. Considering site location and usage, laboratory test results and performance of pavements of surrounding roads, an asphaltic concrete pavement is recommended.

### 5.1.2 *Design Parameters*

Equivalent Standard Axles (ESA)

A traffic loading of $5x10^4$ Equivalent Standard Axles (ESA) should be adopted in accordance with Austroads.

#### Design CBR

Given the limited laboratory test results, DCP-CBR correlations were carried out using Austroads (2012), returning CBR values of typically between 15 % and 35 %. Considering the variation in DCP 'N' counts, resulting from variable soil consistency, the potential variation in soil moisture conditions and gravel content as well as the likely variable cut and fill requirements across the site, we have adopted a CBR value of 7 % for preliminary design purposes.

Subgrade improvement / replacement will likely be required where material of inferior quality is uncovered during excavation (i.e. CBR < 7 %). Alternatively, or if material of superior quality is uncovered during excavation, CBR values and pavement material thickness may need to be revised. Adopted CBR values should be verified during construction by a geotechnical engineer and further on-site / laboratory testing.

### *5.1.3 Pavement Thickness*

Table 9 presents recommended pavement materials and material thicknesses for the proposed roads.

**Table 9:** Preliminary pavement material thickness design for CBR 7 %.

| Road Type | Total Thickness (mm) | Layer | Thickness (mm) | Materials |
|---|---|---|---|---|
| Access Road | 282<br>or<br>290<br>(depending on wearing course) | Wearing Course | 32<br>or<br>40 | Prime coat (single coat 7 mm seal) + 25 mm Asphalt Concrete (AC10)<br>or<br>40 mm Asphalt Concrete (AC10) without seal |
| | | Base | 100 [1] | DGB20 |
| | | Sub-base | 150 [1] | DGS20 or DGS40 |

**Notes:**

1. Based on Figure 13.8.2(A) (95% confidence limit curves) of AUSTROADS APRG21 (1998).

## 5.2 Geotechnical Recommendations

### *5.2.1* Overview

General geotechnical recommendations for the proposed development are provided in Attachment E. Additional recommendations are prescribed below.

### *5.2.2* Footings and Foundations

Shallow footings, such as pad and strip footings, or slab-on-ground may be adopted founding on at least stiff residual silty clay or clay. Shallow footings may be designed adopting the geotechnical parameters in Table 8 and recommendations presented in Section 3.4 of this report. Suitability of foundation conditions and verification against design assumptions must be carried out by a geotechnical engineer during construction.

Should higher bearing pressures be required, further assessment will be required.

### *5.2.3* Earth Pressure Coefficients

For preliminary shoring or retaining wall design, if required, preliminary active, at rest and passive earth pressure coefficients of 0.4, 0.55 and 2.5, respectively, may be adopted.

### *5.2.4* Ground Vibrations

Excavations of soils is expected not to require ground vibration management.

### *5.2.5* Drainage requirements

Appropriate drainage measures should be provided to divert overland flows and potential perched groundwater away from foundations, and limit ponding of water near footings. Overland flow should be discharged into council approved stormwater systems downslope of the site.

### *5.2.6* Site Classification

The site is classified as a class “H1” site in accordance with AS 2870 (2011).

These site classifications are subject to the recommendations presented in this report and CSIRO BTF18 (CSIRO, 2003) and the following conditions:

- Footings extend through all topsoil, fill or root affected soils, into natural soils.
- Requirement for only minor changes to current site levels.

- Provision of adequate drainage of surface and subsurface water to limit soil moisture variations impacting on foundation conditions.

- Footings are unlikely to be impacted by the presence of environments that could lead to exceptional foundation material movements, such as existing or future trees or surface water accumulation.

## 5.3 Earthworks

### *5.3.1* Subgrade Preparation

The subgrade is to be trimmed and compacted, following the removal of topsoil and other unsuitable materials such as root containing soils, with density testing of the upper 300 mm layer at a rate of 1 test per 50 m of road length or no less than ten tests per >500 m$^2$ (refer Table 8.1 of AS3798). We recommend that any stripping of soil or sub-grades be undertaken at the on-set of excavation and suitably stockpiled for on-site re-use (where possible) or off-site disposal to a suitable location in accordance with NSW DECC (2009) Waste Classification Guidelines. All site earthworks should be undertaken in accordance with AS3798 (2007) and Aus-Spec 213 (2004).

Minimum relative density of subgrade shall be 100 % Maximum Dry Density (MDD) at a standard compactive effort within 2 % of optimum moisture content (OMC) beneath pavements and building slabs and 95 % MDD under landscape areas. Prior to placement of pavement material, the subgrade shall be proof rolled and approved by a geotechnical engineer. Subgrade improvement / replacement will likely be required where material of inferior quality is uncovered during excavation. Weak subgrade material can be treated by one of the following methods subject to final design:

- Removal and replacement with approved fill under geotechnical engineer's direction.
- *In-situ* stabilisation with lime or similar binding agent to a depth of at least 300 mm below finished level. Use of this method and extent will depend on the condition of material to be stabilised and further laboratory testing.

### *5.3.2* Subsoil Drainage

Surface and sub-soil drainage is to be provided in accordance with Council and Austroads requirements. Typically, subsurface drains are installed on the upslope side of all internal roads and generally extend

600 mm below pavement level. Austroads advises against extending subsurface drainage into highly reactive soils beneath the pavement.

#### *5.3.3* Placement and Testing of Pavement and Fill Material

Pavement materials shall be placed in layers (when compacted) not thicker than 200 mm or less than 100 mm. Pavement materials shall be compacted to the following condition:

- Sub-base - Minimum 98 % MDD at modified compactive effort (±2% OMC).
- Base - Minimum 98% MDD at modified compactive effort (±2% OMC).

Compaction testing shall be undertaken by a NATA accredited laboratory in accordance with procedures as outlined in Table 8.1 of AS3798 and at a rate of no less than ten tests per 5000 $m^3$ with a minimum of one test per 500 $m^3$ (refer Table 8.1 of AS3798). Each pavement layer shall be proof rolled under Geotechnical Engineers' supervision. Subsequent pavement layers shall not be placed prior to approval of underlying layer by the Geotechnical Engineer.

#### *5.3.4* Fill Placement

Should filling be required to raise site or subgrade levels, site-won excavated fill / natural soils are likely to be suitable for re-use due to their low reactivity to soil moisture variation. Should re-use be considered, stringent moisture conditioning (within +/- 2% of OMC) will be required to achieve adequate compaction. Mixing with lime may be undertaken to assist material placement. Alternatively, suitable granular fill, approved for use by a Geotechnical Engineer may be adopted. Proof rolling should be closely monitored by the project geotechnical engineer to detect soft or unstable areas which should be removed and replaced with engineered fill or alternatively stabilised or bridged. All earthworks specification is to be prepared by the supervising engineer and be implemented by the contractor.

# 6 Proposed Additional Works

## 6.1 Works Prior to Construction Certificate

We recommend the following additional geotechnical works are carried out to develop the final design and prior to construction:

1. Review of the final design by a senior geotechnical engineer to confirm adequate consideration of the geotechnical risks and adoption of the recommendations provided in this report.

## 6.2 Construction Monitoring and Inspections

We recommend the following is inspected and monitored during construction of the project (Table 7).

**Table 7**: Recommended inspection / monitoring requirements during site works.

| Scope of Works | Frequency/Duration | Who to Complete |
|---|---|---|
| Inspect exposed material at foundation / subgrade level to verify suitability as foundation / lateral support / subgrade. | Prior to reinforcement set-up and concrete placement, or fill placement | MA [1] |
| Monitor sediment and erosion control structures to assess adequacy and for removal of built up spoil. | After rainfall events | Builder |

**Notes:**

1. MA = Martens and Associates engineer.
2. MA inspection frequency to be determined based on initial inspection findings in line with construction program.

# 7 References

Alleanza Architecture Pty Ltd (2019) Site Plan (including future works) K-12 + ELC, Project No. 18150, Sheet No. DA004, Issue 7 1, dated March 2019 (AA, 2019).

Austroads Ltd (1998) A Guide to the Design of New Pavements for Light Traffic, APRG Report No. 21 (APRG21).

Barnson Pty Ltd (2019) *Overall Detail Survey Plan*, Drawing Number 30760-L00, Revision B, (Barnson, 2019).

Colqhoun G.P., Meakin N.S., Henderson G.A.M., Krynen J.P., Jagodzinski E.A., Watkins J.J. and Yoo E.K (2000) Mudgee *1:100 000 Geological Sheet 8832*, 1st edition, Geological Survey of New South Wales, Sydney (Colqhoun et al, 2000).

Lilicrap A. and McGhie S. (2002) *Site Investigations for Urban Salinity*, Department of Land and Water Conservation (DLWC), Sydney, NSW, Australia (DLWC, 2002).

Look B. G. (2007) *Handbook of Geotechnical Investigation and Design Tables*, CRC Press.

NSW Department of Environment & Heritage (*eSPADE, NSW soil and land information*), www.environment.nsw.gov.au.

Standards Australia Limited (1997) AS 1289.6.3.2:1997, *Determination of the penetration resistance of a soil – 9kg dynamic cone penetrometer test*, SAI Global Limited.

Standards Australia Limited (2017) AS 1726:2017, *Geotechnical site investigations*, SAI Global Limited.

Standards Australia Limited (2011) AS 2870:2011, *Residential slabs and footings*, SAI Global Limited.

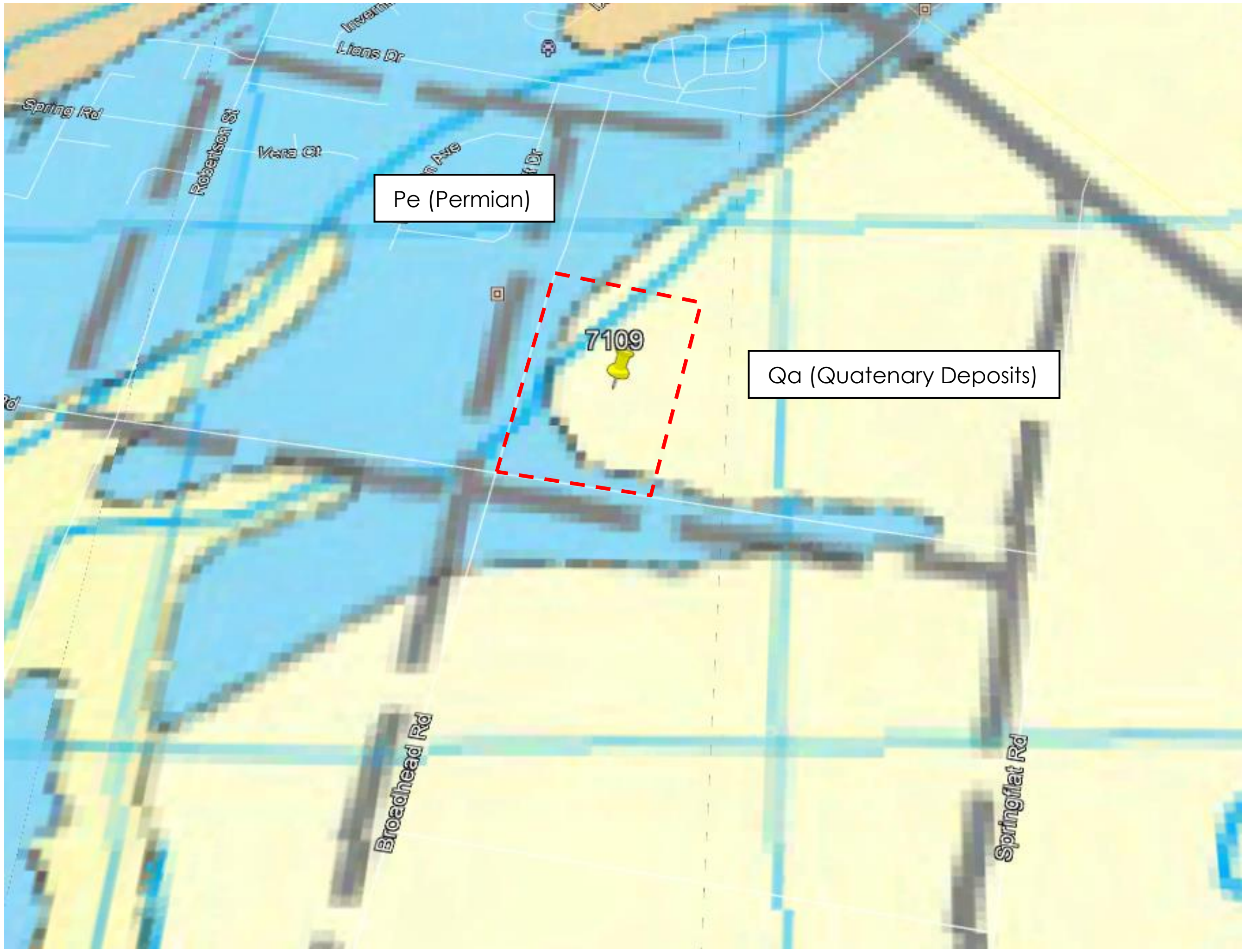
Standards Australia Limited (2018) AS 3600:2018, *Concrete Structures*, SAI Global Limited.

Standards Australia Limited (2007) AS 3798:2007, *Guidelines on earthworks for commercial and residential developments*, SAI Global Limited.

# 8 Attachment A – Figures

martens

| | | | |
|---|---|---|---|
| **Martens & Associates Pty Ltd** ABN 85 070 240 890 | | **Environment \| Water \| Wastewater \| Geotechnical \| Civil \| Management** | |
| Drawn: | YL | **GEOTECHNICAL TESTING PLAN**<br>**48 Broadhead Road, Spring Flat, NSW**<br>(Source: AA, 2020) | Drawing No:<br>**Figure 1** |
| Approved: | JF | | |
| Date: | 25.03.2020 | | |
| Scale: | Not to Scale | | Job No: P1907109JR02V01 |



**Key:**

— — — Approximate site boundary

**Martens & Associates Pty Ltd** ABN 85 070 240 890

**Environment | Water | Wastewater | Geotechnical | Civil | Management**

| | |
|---|---|
| Drawn: | CGL |
| Approved: | RE |
| Date: | 24.06.2019 |
| Scale: | Not to Scale |

**EXPECTED SITE GEOLOGY**
**48 Broadhead Road, Spring Flat, NSW**
(Source: Google Earth, 2019 & Colqhoun et al, 2000)

Drawing No:
**Figure 2**

Job No: P1907109JR02V01

**Key:**

▬ ▬ ▬ Approximate site boundary

**Martens & Associates Pty Ltd** ABN 85 070 240 890

**Environment | Water | Wastewater | Geotechnical | Civil | Management**

| | |
|---|---|
| Drawn: | CGL |
| Approved: | RE |
| Date: | 24.06.2019 |
| Scale: | Not to Scale |

**SITE LOCATION RELATIVE TO SOIL LANDSCAPE MAP**
**48 Broadhead Road, Spring Flat, NSW**
(Source: eSpade, 2019)

Drawing No:
**Figure 3**

Job No: P1907109JR02V01

# 9 Attachment B – Test Borehole Logs

|  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|
| CLIENT | Catholic Education Diocese of Bathurst | COMMENCED | 07/05/2019 | COMPLETED | 07/05/2019 | **REF BH101** |
| PROJECT | Geotechnical and Salinity Assessment | LOGGED | CGL/MV | CHECKED | RE | Sheet 1 OF 1 |
| SITE | 48 Broadhead Road, Spring Flat, NSW | GEOLOGY | Quaternary Deposits | VEGETATION | Grass | PROJECT NO. P1907109 |

|  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|
| EQUIPMENT | 4WD ute-mounted hydraulic drill rig | EASTING |  | RL SURFACE | 490.75 m | DATUM | AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 1.50 m depth | NORTHING |  | ASPECT | Northeast | SLOPE | <2% |

| 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 | L | Not Encountered |  | 490.70 | /0.1/S/1 D 0.10 m |  |  | CI | TOPSOIL: Silty CLAY: medium plasticity; brown; trace subangular fine gravels; trace rootlets | M (<<PL) | VSt | TOPSOIL |
|  | M |  |  |  | /0.3/S/1 D 0.30 m |  |  | CI | Silty CLAY: medium plasticity; brown; with sand; trace subangular fine gravels. |  |  | ALLUVIUM |
|  | H |  |  | *0.60* | /0.5/S/1 D 0.50 m |  |  |  |  |  |  |  |
| AD/T | L |  |  | 490.15 |  |  |  | CI-CH | Medium to high plasticity; pale brown; with subangular fine to medium gravels. |  | H | 0.60: V-bit refusal. |
|  |  |  | 1 |  | /1.0/S/1 D 1.00 m<br>/1.0/S/2 D 1.00 m |  |  |  |  |  |  |  |
|  |  |  |  |  | /1.3/S/1 D 1.30 m |  |  |  |  |  |  |  |
|  |  |  |  | *1.50* |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  | Hole Terminated at 1.50 m<br>(Target depth reached) |  |  |  |
|  |  |  | 2 |  |  |  |  |  |  |  |  |  |
|  |  |  | 3 |  |  |  |  |  |  |  |  |  |
|  |  |  | 4 |  |  |  |  |  |  |  |  |  |
|  |  |  | 5 |  |  |  |  |  |  |  |  |  |
|  |  |  | 6 |  |  |  |  |  |  |  |  |  |
|  |  |  | 7 |  |  |  |  |  |  |  |  |  |

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

MARTENS & ASSOCIATES PTY LTD
Suite 201, 20 George St. Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

# *Engineering Log - BOREHOLE*

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P1907109BH01V01.GPJ <<DrawingFile>> 01/07/2019 13:54 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 | Catholic Education Diocese of Bathurst | COMMENCED | 07/05/2019 | COMPLETED | 07/05/2019 | **REF BH102** |
| PROJECT | Geotechnical and Salinity Assessment | LOGGED | CGL/MV | CHECKED | RE | Sheet 1 OF 1 |
| SITE | 48 Broadhead Road, Spring Flat, NSW | GEOLOGY | Quaternary Deposits | VEGETATION | Grass | PROJECT NO. P1907109 |
| EQUIPMENT | 4WD ute-mounted hydraulic drill rig | EASTING | | RL SURFACE | 490.35 m | DATUM AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 1.50 m depth | NORTHING | | ASPECT | Northeast | SLOPE <2% |

| **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 | L | Not Encountered | | 490.30 | /0.1/S/1 D 0.10 m<br>/0.1/S/2 D 0.10 m | | | CI | TOPSOIL: Silty CLAY: medium plasticity; brown; trace rootlets. | | | TOPSOIL |
| | M | | | | /0.25/S/1 D 0.25 m | | | CI | Silty CLAY: medium plasticity; brown; with sand; trace subangular gravels. | | VSt | ALLUVIUM |
| | H | | | *0.50*<br>489.85 | | | | CI-CH | Medium to high plasticity; brown. | M (<<PL) | H | 0.50: V-bit refusal. |
| AD/T | M | | 1 | | /1.0/S/1 D 1.00 m | | | | | | | |
| | | | | *1.50* | /1.3/S/1 D 1.30 m | | | | | | | |
| | | | | | | | | | Hole Terminated at 1.50 m<br>(Target depth reached) | | | |
| | | | 2 | | | | | | | | | |
| | | | 3 | | | | | | | | | |
| | | | 4 | | | | | | | | | |
| | | | 5 | | | | | | | | | |
| | | | 6 | | | | | | | | | |
| | | | 7 | | | | | | | | | |

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

martens

MARTENS & ASSOCIATES PTY LTD
Suite 201, 20 George St. Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

**Engineering Log - BOREHOLE**

|  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|
| CLIENT | Catholic Education Diocese of Bathurst | COMMENCED | 07/05/2019 | COMPLETED | 07/05/2019 | **REF BH103** |
| PROJECT | Geotechnical and Salinity Assessment | LOGGED | CGL/MV | CHECKED | RE | Sheet 1 OF 1 |
| SITE | 48 Broadhead Road, Spring Flat, NSW | GEOLOGY | Quaternary Deposits | VEGETATION | Grass | PROJECT NO. P1907109 |
| EQUIPMENT | 4WD ute-mounted hydraulic drill rig | EASTING |  | RL SURFACE | 490.65 m | DATUM AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 1.50 m depth | NORTHING |  | ASPECT | Northeast | SLOPE <2% |

| 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 | L | Not Encountered |  | 490.60 | /0.1/S/1 D 0.10 m |  |  | CI | TOPSOIL: Silty CLAY: medium plasticity; pale brown; trace rootlets. | M (<<PL) | VSt | TOPSOIL |
|  |  |  |  |  | /0.25/S/1 D 0.25 m |  |  | CI | Silty CLAY: medium plasticity; pale brown; with sand; trace subangular fine gravels. |  |  | ALLUVIUM |
|  | H |  |  | *0.50*<br>490.15 |  |  |  | CI-CH | Medium to high plasticity; red and brown. |  | H | 0.50: V-bit refusal. |
| AD/T | L |  |  | *0.80*<br>489.85 |  |  |  | CI | Medium plasticity; with subrounded medium gravels. |  |  |  |
|  | M |  | 1 | *1.20*<br>489.45 |  |  |  |  | With subrounded fine gravels. |  |  |  |
|  | H |  |  | *1.50* |  |  |  |  |  |  |  |  |
|  |  |  | 2 |  |  |  |  |  | Hole Terminated at 1.50 m<br>(Target depth reached) |  |  |  |
|  |  |  | 3 |  |  |  |  |  |  |  |  |  |
|  |  |  | 4 |  |  |  |  |  |  |  |  |  |
|  |  |  | 5 |  |  |  |  |  |  |  |  |  |
|  |  |  | 6 |  |  |  |  |  |  |  |  |  |
|  |  |  | 7 |  |  |  |  |  |  |  |  |  |

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

martens

MARTENS & ASSOCIATES PTY LTD
Suite 201, 20 George St. Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

**Engineering Log - BOREHOLE**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CLIENT | Catholic Education Diocese of Bathurst | COMMENCED | 07/05/2019 | COMPLETED | 07/05/2019 | **REF BH104** | |
| PROJECT | Geotechnical and Salinity Assessment | LOGGED | CGL/MV | CHECKED | RE | Sheet | 1 OF 1 |
| SITE | 48 Broadhead Road, Spring Flat, NSW | GEOLOGY | Quaternary Deposits | VEGETATION | Grass | PROJECT NO. P1907109 | |
| EQUIPMENT | 4WD ute-mounted hydraulic drill rig | EASTING | | RL SURFACE | 488.75 m | DATUM | AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 1.50 m depth | NORTHING | | ASPECT | Northeast | SLOPE | <2% |

| **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 | L<br>H | Not Encountered | | 488.70 | /0.1/S/1 D 0.10 m | | | CI | TOPSOIL: Silty CLAY: medium plasticity; grey; trace rootlets. | | | TOPSOIL |
| | | | | | 0.25/S/1 D 0.25 m | | | CI | Silty CLAY: medium plasticity; red and brown; with sand; trace fine subangular gravels. | | VSt | ALLUVIUM |
| | | | | *0.50*<br>488.25 | | | | | | | | |
| AD/T | L<br>M<br>H | | 1 | | | | | CI-CH | Medium to high plasticity. | M (<<PL) | H | 0.50: V-bit refusal. |
| | | | | *1.50* | | | | | | | | |
| | | | 2<br>3<br>4<br>5<br>6<br>7 | | | | | | Hole Terminated at 1.50 m<br>(Target depth reached) | | | |

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

martens

MARTENS & ASSOCIATES PTY LTD
Suite 201, 20 George St. Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

## *Engineering Log - BOREHOLE*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CLIENT | Catholic Education Diocese of Bathurst | COMMENCED | 08/05/2019 | COMPLETED | 08/05/2019 | **REF BH105** | |
| PROJECT | Geotechnical and Salinity Assessment | LOGGED | CGL/MV | CHECKED | RE | Sheet | 1 OF 1 |
| SITE | 48 Broadhead Road, Spring Flat, NSW | GEOLOGY | Quaternary Deposits | VEGETATION | Grass | PROJECT NO. P1907109 | |
| EQUIPMENT | 4WD ute-mounted hydraulic drill rig | EASTING | | RL SURFACE | 489.8 m | DATUM | AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 3.60 m depth | NORTHING | | ASPECT | Northeast | SLOPE | <2% |

| 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 | | 489.75 | | | | CI | TOPSOIL: Silty CLAY: medium plasticity; brown; trace rootlets. | | VSt - H | TOPSOIL |
| | | | | | | | | CI | Silty CLAY: medium plasticity; brown. | | | ALLUVIUM |
| AD/T | H | | | | | | | | | | | 0.50: V-bit refusal. |
| | M | | 1 | *0.70*<br>489.10 | | | | | Red and brown; trace subangular fine to medium gravels. | | | |
| | H | | | *1.30*<br>488.50 | | | | | With sand; trace subrounded to subangular medium gravels. | | | |
| | M | | | | | | | | | | | |
| | H | | 2 | | | | | | | M (<<PL) | H | |
| | H | | 3 | | | | | | | | | |
| | | | | *3.60* | | | | | Hole Terminated at 3.60 m | | | 3.60: TC-bit refusal. |
| | | | 4 | | | | | | | | | |
| | | | 5 | | | | | | | | | |
| | | | 6 | | | | | | | | | |
| | | | 7 | | | | | | | | | |

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

martens

MARTENS & ASSOCIATES PTY LTD
Suite 201, 20 George St. Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

**Engineering Log - BOREHOLE**

| | | | | | | |
|---|---|---|---|---|---|---|
| CLIENT | Catholic Education Diocese of Bathurst | COMMENCED | 08/05/2019 | COMPLETED | 08/05/2019 | **REF BH106** |
| PROJECT | Geotechnical and Salinity Assessment | LOGGED | CGL/MV | CHECKED | RE | Sheet 1 OF 1 |
| SITE | 48 Broadhead Road, Spring Flat, NSW | GEOLOGY | Quaternary Deposits | VEGETATION | Grass | PROJECT NO. P1907109 |
| EQUIPMENT | 4WD ute-mounted hydraulic drill rig | EASTING | | RL SURFACE | 489.5 m | DATUM AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 2.70 m depth | NORTHING | | ASPECT | Northeast | SLOPE <2% |

| **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 | L<br>M<br>H | Not Encountered | | 489.45 | | | | CI | TOPSOIL: Silty CLAY: medium plasticity; brown; trace subangular fine gravels. trace rootlets. | M (<<PL) | VSt | TOPSOIL |
| | | | | | | | | CI | Silty CLAY: medium plasticity; orange and brown; with subangular fine gravels. | | | ALLUVIUM |
| AD/T | M | | 1<br>2 | *0.60*<br>488.90 | | | | | With sand. | | H | 0.60: V-bit refusal. |
| | | | | *2.70* | | | | | | | | |
| | | | 3<br>4<br>5<br>6<br>7 | | | | | | Hole Terminated at 2.70 m | | | 2.70: TC-bit refusal. |

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

martens

MARTENS & ASSOCIATES PTY LTD
Suite 201, 20 George St. Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

## *Engineering Log - BOREHOLE*

| | | | | | | |
|---|---|---|---|---|---|---|
| CLIENT | Catholic Education Diocese of Bathurst | COMMENCED | 08/05/2019 | COMPLETED | 08/05/2019 | **REF BH107** |
| PROJECT | Geotechnical and Salinity Assessment | LOGGED | CGL/MV | CHECKED | RE | Sheet 1 OF 1 |
| SITE | 48 Broadhead Road, Spring Flat, NSW | GEOLOGY | Quaternary Deposits | VEGETATION | Grass | PROJECT NO. P1907109 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| EQUIPMENT | 4WD ute-mounted hydraulic drill rig | EASTING | | RL SURFACE | 489.24 m | DATUM | AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 1.50 m depth | NORTHING | | ASPECT | Northeast | SLOPE | <2% |

| 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 | | 489.19 | | | | CI | TOPSOIL: Silty CLAY: medium plasticity; brown; trace subangular fine gravels. trace rootlets. | | | TOPSOIL |
| AD/T | H<br>L<br>M<br>H | | 1 | 1.50 | | | | CI | Silty CLAY: medium plasticity; red and brown. | M (<<PL) | H | ALLUVIUM<br>0.20: V-bit refusal. |
| | | | 2<br>3<br>4<br>5<br>6<br>7 | | | | | | Hole Terminated at 1.50 m | | | 1.50: TC-bit refusal. |

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

martens

MARTENS & ASSOCIATES PTY LTD
Suite 201, 20 George St. Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

**Engineering Log - BOREHOLE**

| | | | | | | |
|---|---|---|---|---|---|---|
| CLIENT | Catholic Education Diocese of Bathurst | COMMENCED | 08/05/2019 | COMPLETED | 08/05/2019 | **REF BH108** |
| PROJECT | Geotechnical and Salinity Assessment | LOGGED | CGL/MV | CHECKED | RE | Sheet 1 OF 1 |
| SITE | 48 Broadhead Road, Spring Flat, NSW | GEOLOGY | Quaternary Deposits | VEGETATION | Grass | PROJECT NO. P1907109 |
| EQUIPMENT | 4WD ute-mounted hydraulic drill rig | EASTING | | RL SURFACE | 488.75 m | DATUM AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 1.20 m depth | NORTHING | | ASPECT | Northeast | SLOPE <2% |

| 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 | L | Not Encountered | | 488.70 | P7109/108/0.1/S/1 D<br>0.10 m | | | CI-CH | TOPSOIL: Silty CLAY: medium to high plasticity; grey and brown; trace rootlets. | | VSt - H | TOPSOIL |
| | | | | | P7109/108/0.25/S/1 D<br>0.25 m | | | CI-CH | Silty CLAY: medium to high plasticity; grey. | | | ALLUVIUM |
| AD/T | M | | | *0.40*<br>488.35 | P7109/108/0.5/S/1 D<br>0.50 m | | | CI | Medium plasticity; yellow and brown. | M<br>(<<PL) | H | 0.40: V-bit refusal |
| | H | | 1 | *1.00*<br>487.75<br>*1.20* | | | | CH | CLAY: high plasticity; yellow and brown. | | | |
| | | | 2<br>3<br>4<br>5<br>6<br>7 | | | | | | Hole Terminated at 1.20 m | | | 1.20: TC-bit refusal. |

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

MARTENS & ASSOCIATES PTY LTD
Suite 201, 20 George St. Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

## *Engineering Log - BOREHOLE*

|  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|
| CLIENT | Catholic Education Diocese of Bathurst | COMMENCED | 08/05/2019 | COMPLETED | 08/05/2019 | **REF BH109** |
| PROJECT | Geotechnical and Salinity Assessment | LOGGED | CGL/MV | CHECKED | RE | Sheet 1 OF 1 |
| SITE | 48 Broadhead Road, Spring Flat, NSW | GEOLOGY | Quaternary Deposits | VEGETATION | Grass | PROJECT NO. P1907109 |
| EQUIPMENT | 4WD ute-mounted hydraulic drill rig | EASTING |  | RL SURFACE | 488.77 m | DATUM AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 1.70 m depth | NORTHING |  | ASPECT | Northeast | SLOPE <2% |

| 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 | L | Not Encountered |  | 488.72 |  |  |  | CI | TOPSOIL: Silty CLAY: medium plasticity; grey; trace rootlets. | M (<<PL) | VSt | TOPSOIL |
|  | M |  |  |  |  |  |  | CL-CI | Silty CLAY: low to medium plasticity; grey. |  |  | ALLUVIUM |
| AD/T |  |  |  | *0.40*<br>488.37 |  |  |  | CL-CI | CLAY: low to medium plasticity; yellow and brown; with sand; trace fine subrounded gravels. |  | H | 0.40: V-bit refusal. |
|  |  |  | 1 | *0.80*<br>487.97 |  |  |  | CI-CH | Medium to high plasticity. |  |  |  |
|  |  |  |  | *1.70* |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  | Hole Terminated at 1.70 m |  |  | 1.70: TC-bit refusal. |
|  |  |  | 2 |  |  |  |  |  |  |  |  |  |
|  |  |  | 3 |  |  |  |  |  |  |  |  |  |
|  |  |  | 4 |  |  |  |  |  |  |  |  |  |
|  |  |  | 5 |  |  |  |  |  |  |  |  |  |
|  |  |  | 6 |  |  |  |  |  |  |  |  |  |
|  |  |  | 7 |  |  |  |  |  |  |  |  |  |

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

martens

**Engineering Log - BOREHOLE**

| | | | | | | |
|---|---|---|---|---|---|---|
| CLIENT | Catholic Education Diocese of Bathurst | COMMENCED | 08/05/2019 | COMPLETED | 08/05/2019 | **REF BH110** |
| PROJECT | Geotechnical and Salinity Assessment | LOGGED | CGL/MV | CHECKED | RE | Sheet 1 OF 1 |
| SITE | 48 Broadhead Road, Spring Flat, NSW | GEOLOGY | Quaternary Deposits | VEGETATION | Grass | PROJECT NO. P1907109 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| EQUIPMENT | 4WD ute-mounted hydraulic drill rig | EASTING | | RL SURFACE | 488.89 m | DATUM | AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 7.00 m depth | NORTHING | | ASPECT | Northeast | SLOPE | <2% |

| 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 | L | Not Encountered | | | | | | CI-CH | TOPSOIL: Silty CLAY: medium to high plasticity; grey; trace rootlets. | M (<<PL) | VSt | TOPSOIL |
| | | | | 0.20<br>488.69 | | | | CI-CH | Silty CLAY: medium to high plasticity; grey. | | H | ALLUVIUM |
| | | | | | | | | CI | CLAY: medium plasticity; orange and brown; with subangular fine gravels; with sand. | | | |
| | M | | | | | | | | | | | |
| | H | | 1 | | | | | | | | | 1.30: V-bit refusal. |
| AD/T | M | | | 1.50<br>487.39 | | | | | Grading to red and brown; with subangular medium gravels. | | | |
| | | | 2 | 2.60<br>486.29 | | | | | Red, orange and white; with subangular fine gravels. | | | |
| | | | 3 | 3.00<br>485.89 | | | | | Red and brown; trace subrounded medium gravels. | | | |
| | | | 4 | 4.50<br>484.39 | | | | CI-CH | Medium to high plasticity; red, orange and white; trace sand. | | | |
| | | | 5 | 5.00<br>483.89 | | | | CH | High plasticity; red and brown; no sand. | | | |
| | | | 6 | | | | | | | | | |
| | | | 7 | 7.00 | | | | | Hole Terminated at 7.00 m<br>(Target depth reached) | | | |

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

martens

MARTENS & ASSOCIATES PTY LTD
Suite 201, 20 George St. Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

## Engineering Log - BOREHOLE

| | | | | | | |
|---|---|---|---|---|---|---|
| CLIENT | Catholic Education Diocese of Bathurst | COMMENCED | 09/05/2019 | COMPLETED | 09/05/2019 | **REF BH111** |
| PROJECT | Geotechnical and Salinity Assessment | LOGGED | CGL/MV | CHECKED | RE | Sheet 1 OF 1 |
| SITE | 48 Broadhead Road, Spring Flat, NSW | GEOLOGY | Quaternary Deposits | VEGETATION | Grass | PROJECT NO. P1907109 |
| EQUIPMENT | 4WD ute-mounted hydraulic drill rig | EASTING | | RL SURFACE | 487.79 m | DATUM AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 1.90 m depth | NORTHING | | ASPECT | Northeast | SLOPE <2% |

| 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 | L | Not Encountered | | 487.74 | | | | CI | TOPSOIL: Silty CLAY: medium plasticity; brown; trace rootlets. | | VSt | TOPSOIL |
| | | | | | | | | CI | Silty CLAY: medium plasticity; brown; trace subangular fine gravels. | | | ALLUVIUM |
| | H | | | *0.50*<br>487.29 | | | | | Orange and brown. | | | |
| AD/T | M | | | | | | | | | | | 0.70: V-bit refusal. |
| | H | | 1 | *0.90*<br>486.89 | | | | | With subrounded to subangular fine to medium gravels. | M (<<PL) | H | |
| | | | | *1.90* | | | | | | | | |
| | | | 2 | | | | | | Hole Terminated at 1.90 m | | | 1.90: TC-bit refusal. |
| | | | 3 | | | | | | | | | |
| | | | 4 | | | | | | | | | |
| | | | 5 | | | | | | | | | |
| | | | 6 | | | | | | | | | |
| | | | 7 | | | | | | | | | |

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

martens

MARTENS & ASSOCIATES PTY LTD
Suite 201, 20 George St. Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

**Engineering Log - BOREHOLE**

| | | | | | | |
|---|---|---|---|---|---|---|
| CLIENT | Catholic Education Diocese of Bathurst | COMMENCED | 09/05/2019 | COMPLETED | 09/05/2019 | **REF BH112** |
| PROJECT | Geotechnical and Salinity Assessment | LOGGED | CGL/MV | CHECKED | RE | Sheet 1 OF 1 |
| SITE | 48 Broadhead Road, Spring Flat, NSW | GEOLOGY | Quaternary Deposits | VEGETATION | Grass | PROJECT NO. P1907109 |
| EQUIPMENT | 4WD ute-mounted hydraulic drill rig | EASTING | | RL SURFACE | 487.3 m | DATUM: AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 4.00 m depth | NORTHING | | ASPECT | Northeast | SLOPE: <2% |

| 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 | L | Not Encountered | | 487.25 | | | | CI | TOPSOIL: Silty CLAY: medium plasticity; brown; trace rootlets. | M (<<PL) | VSt | TOPSOIL |
| | H | | | | | | | CI | Silty CLAY: medium plasticity; brown; trace subangular fine gravels. | | H | ALLUVIUM |
| | | | | 0.40<br>486.90 | | | | | Red and brown. | | | |
| AD/T | L | | | | | | | | | | | 0.50: V-bit refusal. |
| | M | | | 1.50<br>485.80 | | | | CI | CLAY: medium plasticity; red and brown. | | | |
| | | | | 1.90<br>485.40 | | | | | Brown. | | | |
| | | | 4 | 4.00 | | | | | Hole Terminated at 4.00 m | | | 4.00: TC-bit refusal. |

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

martens

MARTENS & ASSOCIATES PTY LTD
Suite 201, 20 George St. Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

**Engineering Log - BOREHOLE**

| | | | | | | |
|---|---|---|---|---|---|---|
| CLIENT | Catholic Education Diocese of Bathurst | COMMENCED | 09/05/2019 | COMPLETED | 09/05/2019 | **REF BH113** |
| PROJECT | Geotechnical and Salinity Assessment | LOGGED | CGL/MV | CHECKED | RE | Sheet 1 OF 1 |
| SITE | 48 Broadhead Road, Spring Flat, NSW | GEOLOGY | Quaternary Deposits | VEGETATION | Grass | PROJECT NO. P1907109 |
| EQUIPMENT | 4WD ute-mounted hydraulic drill rig | EASTING | | RL SURFACE | 487.26 m | DATUM AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 1.50 m depth | NORTHING | | ASPECT | Northeast | SLOPE <2% |

| **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 | L | Not Encountered | | 487.21 | P7109/113/0.1/S/1 D<br>0.10 m | | | CI | TOPSOIL: Silty CLAY: medium plasticity; grey and brown; trace rootlets. | | VSt | TOPSOIL |
| | H | | | | P7109/113/0.25/S/1 D<br>0.25 m | | | CL | Silty CLAY: low plasticity; red and brown; trace subangular fine gravels; with sand. | | | ALLUVIUM |
| AD/T | L | | | | P7109/113/0.5/S/1 D<br>0.50 m | | | | | M<br>(<<PL) | H | 0.50: V-bit refusal. |
| | H | | 1 | *1.00*<br>486.26 | P7109/113/1.0/S/1 D<br>1.00 m | | | CI-CH | Grading to medium to high plasticity. | | | |
| | | | | *1.50* | | | | | | | | |
| | | | 2<br>3<br>4<br>5<br>6<br>7 | | | | | | Hole Terminated at 1.50 m | | | 1.50: TC-bit refusal. |

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

martens

MARTENS & ASSOCIATES PTY LTD
Suite 201, 20 George St. Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

# Engineering Log - BOREHOLE

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P1907109BH01V01.GPJ <<DrawingFile>> 01/07/2019 13:55 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 | Catholic Education Diocese of Bathurst | COMMENCED | 09/05/2019 | COMPLETED | 09/05/2019 | **REF BH114** |
| PROJECT | Geotechnical and Salinity Assessment | LOGGED | CGL/MV | CHECKED | RE | Sheet 1 OF 1 |
| SITE | 48 Broadhead Road, Spring Flat, NSW | GEOLOGY | Quaternary Deposits | VEGETATION | Grass | PROJECT NO. P1907109 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| EQUIPMENT | 4WD ute-mounted hydraulic drill rig | EASTING | | RL SURFACE | 488.27 m | DATUM | AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 1.40 m depth | NORTHING | | ASPECT | Northeast | SLOPE | <2% |

| 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 | L<br>M<br>H | Not Encountered | | 488.22 | P7109/114/0.1/S/1 D 0.10 m | | | CI | TOPSOIL: Silty CLAY: medium plasticity; grey. | | | TOPSOIL |
| | | | | | P7109/114/0.25/S/1 D 0.25 m | | | CI-CH | Silty CLAY: medium to high plasticity; orange and brown. | | VSt - H | ALLUVIUM |
| AD/T | L | | | *0.40*<br>487.87 | P7109/114/0.5/S/1 D 0.50 m | | | | Trace subangular fine gravels. | M (<<PL) | | 0.40: V-bit refusal. |
| | | | 1 | | P7109/114/1.0/S/1 D 1.00 m | | | | | | H | |
| | H | | | *1.40* | | | | | | | | |
| | | | | | | | | | Hole Terminated at 1.40 m | | | 1.40: TC-bit refusal. |
| | | | 2 | | | | | | | | | |
| | | | 3 | | | | | | | | | |
| | | | 4 | | | | | | | | | |
| | | | 5 | | | | | | | | | |
| | | | 6 | | | | | | | | | |
| | | | 7 | | | | | | | | | |

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

MARTENS & ASSOCIATES PTY LTD
Suite 201, 20 George St. Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

# *Engineering Log - BOREHOLE*

| | | | | | | |
|---|---|---|---|---|---|---|
| CLIENT | Catholic Education Diocese of Bathurst | COMMENCED | 09/05/2019 | COMPLETED | 09/05/2019 | **REF BH115** |
| PROJECT | Geotechnical and Salinity Assessment | LOGGED | CGL/MV | CHECKED | RE | Sheet 1 OF 1 |
| SITE | 48 Broadhead Road, Spring Flat, NSW | GEOLOGY | Quaternary Deposits | VEGETATION | Grass | PROJECT NO. P1907109 |
| EQUIPMENT | 4WD ute-mounted hydraulic drill rig | EASTING | | RL SURFACE | 488.32 m | DATUM AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 1.50 m depth | NORTHING | | ASPECT | Northeast | SLOPE <2% |

| **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 | L | Not Encountered | | 488.27 | P7109/115/0.1/S/1 D<br>0.10 m | | | CI | TOPSOIL: Silty CLAY: medium plasticity; grey; trace rootlets. | | VSt - H | TOPSOIL |
| | | | | | P7109/115/0.25/S/1 D<br>0.25 m | | | CI | Silty CLAY: low plasticity; orange and brown; with fine to medium gravels. | | | ALLUVIUM |
| | H | | | 0.40<br>487.92 | | | | | | | | |
| AD/T | M | | | | P7109/115/0.5/S/1 D<br>0.50 m | | | | Red and brown; with medium to coarse gravels. | M (<<PL) | H | 0.50: V-bit refusal. |
| | | | 1 | | P7109/115/1.0/S/1 D<br>1.00 m | | | | | | | |
| | | | | 1.50 | | | | | | | | |
| | | | | | | | | | Hole Terminated at 1.50 m | | | 1.50: TC-bit refusal. |
| | | | 2 | | | | | | | | | |
| | | | 3 | | | | | | | | | |
| | | | 4 | | | | | | | | | |
| | | | 5 | | | | | | | | | |
| | | | 6 | | | | | | | | | |
| | | | 7 | | | | | | | | | |

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

martens

**Engineering Log - BOREHOLE**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CLIENT | Catholic Education Diocese of Bathurst | COMMENCED | 09/05/2019 | COMPLETED | 09/05/2019 | **REF BH116** | |
| PROJECT | Geotechnical and Salinity Assessment | LOGGED | CGL/MV | CHECKED | RE | Sheet 1 OF 1 | |
| SITE | 48 Broadhead Road, Spring Flat, NSW | GEOLOGY | Quaternary Deposits | VEGETATION | Grass | PROJECT NO. P1907109 | |
| EQUIPMENT | 4WD ute-mounted hydraulic drill rig | EASTING | | RL SURFACE | 487.52 m | DATUM | AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 1.70 m depth | NORTHING | | ASPECT | Northeast | SLOPE | <2% |

| 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 | L<br>M<br>H | Not Encountered | | 487.47 | | | | CI | TOPSOIL: Silty CLAY: medium plasticity; grey; trace rootlets. | | | TOPSOIL |
| | | | | | | | | CI | Silty CLAY: medium plasticity; grey; trace subangular fine gravels. | | VSt | ALLUVIUM |
| AD/T | L<br>H | | 1 | *0.45*<br>487.07 | | | | | Orange and brown; with subrounded to subangular medium to coarse gravels. | M (<<PL) | H | 0.45: V-bit refusal. |
| | | | | *1.70* | | | | | | | | |
| | | | 2<br>3<br>4<br>5<br>6<br>7 | | | | | | Hole Terminated at 1.70 m | | | 1.70: TC-bit refusal. |

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

martens

MARTENS & ASSOCIATES PTY LTD
Suite 201, 20 George St. Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

**Engineering Log - BOREHOLE**

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P1907109BH01V01.GPJ <<DrawingFile>> 01/07/2019 13:55 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 | Catholic Education Diocese of Bathurst | COMMENCED | 09/05/2019 | COMPLETED | 09/05/2019 | **REF BH117** |
| PROJECT | Geotechnical and Salinity Assessment | LOGGED | CGL/MV | CHECKED | RE | Sheet 1 OF 1 |
| SITE | 48 Broadhead Road, Spring Flat, NSW | GEOLOGY | Quaternary Deposits | VEGETATION | Grass | PROJECT NO. P1907109 |
| EQUIPMENT | 4WD ute-mounted hydraulic drill rig | EASTING |  | RL SURFACE | 486.91 m | DATUM: AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 0.60 m depth | NORTHING |  | ASPECT | Northeast | SLOPE: <2% |

| **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 | L | Not Encountered |  | 486.86 |  |  |  | CI | TOPSOIL: Silty CLAY: medium plasticity; grey; trace rootlets. |  |  | TOPSOIL |
|  |  |  |  |  |  |  |  | CI-CH | Silty CLAY: medium to high plasticity; brown; trace subangular fine gravels. | M (<<PL) | VSt | ALLUVIUM |
|  | H |  |  | *0.60* |  |  |  |  |  |  | H |  |
|  |  |  |  |  |  |  |  |  | Hole Terminated at 0.60 m |  |  | 0.60: V-bit refusal. |
|  |  |  | 1 |  |  |  |  |  |  |  |  |  |
|  |  |  | 2 |  |  |  |  |  |  |  |  |  |
|  |  |  | 3 |  |  |  |  |  |  |  |  |  |
|  |  |  | 4 |  |  |  |  |  |  |  |  |  |
|  |  |  | 5 |  |  |  |  |  |  |  |  |  |
|  |  |  | 6 |  |  |  |  |  |  |  |  |  |
|  |  |  | 7 |  |  |  |  |  |  |  |  |  |

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

martens

**Engineering Log - BOREHOLE**

| | | | | | | |
|---|---|---|---|---|---|---|
| CLIENT | Catholic Education Diocese of Bathurst | COMMENCED | 09/05/2019 | COMPLETED | 09/05/2019 | **REF BH118** |
| PROJECT | Geotechnical and Salinity Assessment | LOGGED | CGL/MV | CHECKED | RE | Sheet 1 OF 1 |
| SITE | 48 Broadhead Road, Spring Flat, NSW | GEOLOGY | Quaternary Deposits | VEGETATION | Grass | PROJECT NO. P1907109 |
| EQUIPMENT | 4WD ute-mounted hydraulic drill rig | EASTING | | RL SURFACE | 487 m | DATUM AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 0.75 m depth | NORTHING | | ASPECT | East | 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 | L | Not Encountered | | 486.95 | P7109/118/0.1/S/1 D<br>0.10 m | | | CI | TOPSOIL: Silty CLAY: medium plasticity; brown; trace rootlets. | | | TOPSOIL |
| | | | | | P7109/118/0.25/S/1 D<br>0.25 m<br>P7109/118/0.5/S1 D<br>0.50 m | | | CI-CH | Silty CLAY: medium to high plasticity; brown; with subangular fine gravels. | M (<<PL) | VSt | ALLUVIUM |
| | H | | | *0.75* | | | | | | | H | |
| | | | | | | | | | Hole Terminated at 0.75 m | | | 0.75: V-bit refusal. |
| | | | 1 | | | | | | | | | |
| | | | 2 | | | | | | | | | |
| | | | 3 | | | | | | | | | |
| | | | 4 | | | | | | | | | |
| | | | 5 | | | | | | | | | |
| | | | 6 | | | | | | | | | |
| | | | 7 | | | | | | | | | |

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

MARTENS & ASSOCIATES PTY LTD
Suite 201, 20 George St. Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

## *Engineering Log - BOREHOLE*

| | | | | | | |
|---|---|---|---|---|---|---|
| CLIENT | Catholic Education Diocese of Bathurst | COMMENCED | 09/05/2019 | COMPLETED | 09/05/2019 | **REF BH119** |
| PROJECT | Geotechnical and Salinity Assessment | LOGGED | CGL/MV | CHECKED | RE | Sheet 1 OF 1 |
| SITE | 48 Broadhead Road, Spring Flat, NSW | GEOLOGY | Quaternary Deposits | VEGETATION | Grass | PROJECT NO. P1907109 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| EQUIPMENT | 4WD ute-mounted hydraulic drill rig | EASTING | | RL SURFACE | 484.19 m | DATUM | AHD |
| EXCAVATION DIMENSIONS | Ø100 mm x 0.30 m depth | NORTHING | | ASPECT | Northeast | SLOPE | <2% |

| **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 | H | Not Encountered | | 484.14<br>*0.30* | P7109/119/0.1/S/1 D<br>0.10 m<br>P7109/119/0.25/S/1 D<br>0.25 m<br>P7109/119/0.3/S/1 D<br>0.30 m | | | CI | TOPSOIL: Silty CLAY: medium plasticity; grey; trace rootlets. | M<br>(<<PL) | VSt<br>and<br>H | TOPSOIL |
| | | | | | | | | CI-CH | Silty CLAY: medium to high plasticity; brown. | | | ALLUVIUM |
| | | | | | | | | | Hole Terminated at 0.30 m | | | 0.30: V-bit refusal. |
| | | | 1 | | | | | | | | | |
| | | | 2 | | | | | | | | | |
| | | | 3 | | | | | | | | | |
| | | | 4 | | | | | | | | | |
| | | | 5 | | | | | | | | | |
| | | | 6 | | | | | | | | | |
| | | | 7 | | | | | | | | | |

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

martens

MARTENS & ASSOCIATES PTY LTD
Suite 201, 20 George St. Hornsby, NSW 2077 Australia
Phone: (02) 9476 9999 Fax: (02) 9476 8767
mail@martens.com.au WEB: http://www.martens.com.au

**Engineering Log - BOREHOLE**

# 10 Attachment C – DCP ‘N’ Counts

# Dynamic Cone Penetrometer Test Log Summary

martens
consulting engineers since 1989

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

| | | | |
|---|---|---|---|
| **Site** | 48 Broadhead Road, Spring Flat, NSW | **DCP Group Reference** | P1907109JS02V01 |
| **Client** | Catholic Education Diocese of Bathurst | **Log Date** | 07.05.2019 - 09.05.2019 |
| **Logged by** | CGL / MV | | |
| **Checked by** | RE | | |
| **Comments** | DCP commenced 50 mm below ground level. | | |

**TEST DATA**

| Depth Interval (m) | DCP101 | DCP102 | DCP103 | DCP104 | DCP105 | DCP106 | DCP107 | DCP108 | DCP109 | DCP110 | DCP111 | DCP112 | DCP113 | DCP114 | DCP115 | DCP116 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **0.15** | 10 | 12 | 10 | 12 | 15 | 10 | 17 | 15 | 10 | 12 | 9 | 10 | 11 | 10 | 12 | 8 |
| **0.30** | 13 | 14 | 12 | 14 | 17 | 15 | 29 | 13 | 20 | 27 | 21 | 16 | 18 | 15 | 15 | 14 |
| **0.45** | 17 | 42 | 17 | 12 | 25 | 24 | 29 | 30 | 17 | 21 | 17 | 25 | 21 | 14 | 22 | 13 |
| **0.60** | 22 | Terminated due to high N counts @ 0.5 mBGL | 22 | 19 | 36 | 39 | 18 | Terminated due to high N counts @ 0.5 mBGL | 20 | 24 | 18 | 24 | 29 | 18 | 32 | 24 |
| **0.75** | 39 | | 24 | 21 | Terminated due to high N counts @ 0.8 mBGL | Terminated due to high N counts @ 0.8 mBGL | 25 | | 27 | 30 | 26 | 34 | 31 | 26 | Terminated due to high N counts @ 0.65 mBGL | 27 |
| **0.90** | Terminated due to high N counts @ 0.8 mBGL | | 31 | 35 | | | 23 | | 29 | Terminated due to high N counts @ 0.8 mBGL | 29 | Terminated due to high N counts @ 0.8 mBGL | Terminated due to high N counts @ 0.8 mBGL | 39 | | 36 |
| **1.05** | | | 35 | Terminated due to high N counts @ 0.95 mBGL | | | 20 | | 28 | | 33 | | | Terminated due to high N counts @ 0.95 mBGL | | Terminated due to high N counts @ 0.95 mBGL |
| **1.20** | | | Terminated due to high N counts @ 1.1 mBGL | | | | 23 | | 32 | | Terminated due to high N counts @ 1.1 mBGL | | | | | |
| **1.35** | | | | | | | 23 | | Terminated due to high N counts @ 1.25 mBGL | | | | | | | |
| **1.50** | | | | | | | 30/130mm | | | | | | | | | |
| **1.65** | | | | | | | Terminated due to high N counts @ 1.53 mBGL | | | | | | | | | |
| **1.80** | | | | | | | | | | | | | | | | |
| **1.95** | | | | | | | | | | | | | | | | |
| **2.10** | | | | | | | | | | | | | | | | |
| **2.25** | | | | | | | | | | | | | | | | |
| **2.40** | | | | | | | | | | | | | | | | |
| **2.55** | | | | | | | | | | | | | | | | |
| **2.70** | | | | | | | | | | | | | | | | |
| **2.85** | | | | | | | | | | | | | | | | |
| **3.00** | | | | | | | | | | | | | | | | |
| **3.15** | | | | | | | | | | | | | | | | |
| **3.30** | | | | | | | | | | | | | | | | |
| **3.45** | | | | | | | | | | | | | | | | |
| **3.60** | | | | | | | | | | | | | | | | |
| **3.75** | | | | | | | | | | | | | | | | |
| **3.90** | | | | | | | | | | | | | | | | |
| **4.05** | | | | | | | | | | | | | | | | |
| **4.20** | | | | | | | | | | | | | | | | |
| **4.35** | | | | | | | | | | | | | | | | |
| **4.50** | | | | | | | | | | | | | | | | |
| **4.65** | | | | | | | | | | | | | | | | |
| **4.80** | | | | | | | | | | | | | | | | |
| **4.95** | | | | | | | | | | | | | | | | |
| **5.10** | | | | | | | | | | | | | | | | |
| **5.25** | | | | | | | | | | | | | | | | |
| **5.40** | | | | | | | | | | | | | | | | |

# 11 Attachment D – Laboratory Test Certificate

resource laboratories
AGGREGATE, ROCK, AND SOIL TESTING
**ABN:** 25 131 532 020
**Sydney:** 12/1 Boden Road Seven Hills NSW 2147 | PO Box 45 Pendle Hill NSW 2145
**Ph:** (02) 9674 7711 | **Fax:** (02) 9674 7755 | **Email:** info@resourcelab.com.au

# Test Report

**Customer:** Martens & Associates Pty Ltd
**Project:** P1907109
**Location:** 48 Broadhead Road, Mudgee, NSW

**Job number:** 19-0047
**Report number:** 1
**Page:** 1 of 1

## Soil Index Properties

**Sampling method:** Tested as received

**Test method(s):** AS 1289.1.1, 2.1.1, 3.1.2, 3.2.1, 3.3.1

| | **Results** | | | | |
|---|---|---|---|---|---|
| **Laboratory sample no.** | 18732 | 18733 | 18734 | 18735 | |
| **Customer sample no.** | 7109/BH107/ 0.5-0.7/S/1 | 7109/BH109/ 0.5-0.8/S/1 | 7109/BH111/ 0.5-0.7/S/1 | 7109/BH113/ 0.8-1.0/S/1 | |
| **Date sampled** | 08/05/2019 | 08/05/2019 | 08/05/2019 | 08/05/2019 | |
| Material description | silty CLAY, red-brown | silty CLAY, with sand, trace of gravel, brown | silty CLAY, brown | silty CLAY, with sand, trace of gravel, red-brown | |
| Liquid limit (%) | 41 | 36 | 40 | 31 | |
| Plastic limit (%) | 17 | 15 | 15 | 14 | |
| Plasticity index (%) | 24 | 21 | 25 | 17 | |
| Linear shrinkage (%) | - | - | - | - | |
| Cracking / Curling / Crumbling | - | - | - | - | |
| Sample history | Air dried | Air dried | Air dried | Air dried | |
| Preparation | Dry sieved | Dry sieved | Dry sieved | Dry sieved | |

**Approved Signatory:** E. Maldonado **Date:** 28/05/2019

Accredited for compliance with ISO/IEC 17025.

NATA Accredited Laboratory Number: **17062**

resource laboratories
AGGREGATE, ROCK, AND SOIL TESTING
**ABN:** 25 131 532 020
**Sydney:** 12/1 Boden Road Seven Hills NSW 2147 | PO Box 45 Pendle Hill NSW 2145
**Ph:** (02) 9674 7711 | **Fax:** (02) 9674 7755 | **Email:** info@resourcelab.com.au

# Test Report

**Customer:** Martens & Associates Pty Ltd
**Job number:** 19-0047
**Project:** P1907109
**Report number:** 2
**Location:** 48 Broadhead Road, Mudgee, NSW
**Page:** 1 of 1

## California Bearing Ratio

**Sampling method:** Tested as received
**Test method(s):** AS 1289.1.1, 2.1.1, 5.1.1, 6.1.1

| | **Results** | | | |
|---|---|---|---|---|
| **Laboratory sample no.** | 18736 | 18737 | 18738 | 18739 |
| **Customer sample no.** | 7109/BH101/ 0.2-0.5/S/1 | 7109/BH102/ 0.2-0.5/S/1 | 7109/BH103/ 0.3-0.7/S/1 | 7109/BH104/ 0.2-0.5/S/1 |
| **Date sampled** | 08/05/2019 | 08/05/2019 | 08/05/2019 | 08/05/2019 |
| Material description | silty CLAY, with sand, trace of gravel, red-brown | sandy silty CLAY, trace of gravel, brown | silty CLAY, with sand, trace of gravel, brown/ yellow-brown | silty CLAY, with sand, trace of gravel, yellow-brown/brown/grey |
| Maximum dry density (t/m$^3$) | 1.80 | 1.92 | 1.83 | 1.81 |
| Optimum moisture content (%) | 15.7 | 12.2 | 15.6 | 15.4 |
| Field moisture content (%) | n/a | n/a | n/a | n/a |
| Oversize retained on 19.0mm sieve (%) | 0 | 2 | 0 | 0 |
| Minimum curing time (hours) | 96 | 48 | 96 | 48 |
| Dry density before soak (t/m$^3$) | 1.76 | 1.88 | 1.80 | 1.78 |
| Dry density after soak (t/m$^3$) | 1.74 | 1.87 | 1.78 | 1.76 |
| Moisture content before soak (%) | 15.8 | 12.7 | 15.4 | 15.3 |
| Moisture content after soak (%) | 18.8 | 14.9 | 18.0 | 18.2 |
| Moisture content after test - top 30mm (%) | 20.4 | 15.0 | 19.1 | 20.0 |
| Moisture content after test - remaining depth (%) | 17.8 | 13.8 | 16.9 | 17.5 |
| Density ratio before soaking (%) | 98.0 | 98.0 | 98.5 | 98.5 |
| Moisture ratio before soaking (%) | 101.0 | 104.0 | 98.5 | 99.0 |
| Period of soaking (days) | 4 | 4 | 4 | 4 |
| Compactive effort | Standard | Standard | Standard | Standard |
| Mass of surcharge applied (kg) | 4.5 | 4.5 | 4.5 | 4.5 |
| Swell after soaking (%) | 1.0 | 0.5 | 1.0 | 1.0 |
| Penetration (mm) | 2.5 | 2.5 | 2.5 | 5.0 |
| **CBR Value (%)** | **9** | **12** | **8** | **7** |

Notes: Specified LDR: 98 ±1%

Method of establishing plasticity level - Visual / tactile

**Approved Signatory:** E. Maldonado **Date:** 28/05/2019

NATA
ACCREDITED FOR
TECHNICAL COMPETENCE

Accredited for compliance with ISO/IEC 17025.

NATA Accredited Laboratory Number: **17062**

**Envirolab Services Pty Ltd**
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200   fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

# CERTIFICATE OF ANALYSIS 218046

## Client Details

| | |
|---|---|
| **Client** | Martens & Associates Pty Ltd |
| **Attention** | Jeff Fulton |
| **Address** | Suite 201, 20 George St, Hornsby, NSW, 2077 |

## Sample Details

| | |
|---|---|
| **Your Reference** | **P1907109 - Mudgee** |
| **Number of Samples** | 30 soil |
| **Date samples received** | 22/05/2019 |
| **Date completed instructions received** | 22/05/2019 |

## Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

**Please refer to the last page of this report for any comments relating to the results.**

## Report Details

| | |
|---|---|
| **Date results requested by** | 31/05/2019 |
| **Date of Issue** | 30/05/2019 |

NATA Accreditation Number 2901. This document shall not be reproduced except in full.

Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

**Results Approved By**
Giovanni Agosti, Group Technical Manager
Jeremy Faircloth, Operations Manager, Sydney

**Authorised By**

Nancy Zhang, Laboratory Manager

| **Misc Inorg - Soil** | | | | | | |
|---|---|---|---|---|---|---|
| Our Reference | | 218046-1 | 218046-2 | 218046-3 | 218046-4 | 218046-5 |
| Your Reference | UNITS | 7109/BH01/0.1 | 7109/BH02/0.25 | 7109/BH05/1.5 | 7109/BH06/2.0 | 7109/BH07/0.25 |
| Date Sampled | | 07/05/2019 | 07/05/2019 | 07/05/2019 | 07/05/2019 | 07/05/2019 |
| Type of sample | | soil | soil | soil | soil | soil |
| Date prepared | - | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 |
| Date analysed | - | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 |
| pH 1:5 soil:water | pH Units | 8.0 | 6.7 | 7.1 | 7.6 | 6.5 |
| Electrical Conductivity 1:5 soil:water | µS/cm | 130 | 32 | 8 | 17 | 44 |
| Sulphate, SO4 1:5 soil:water | mg/kg | <10 | 10 | <10 | <10 | 10 |

| **Misc Inorg - Soil** | | | | | | |
|---|---|---|---|---|---|---|
| Our Reference | | 218046-6 | 218046-7 | 218046-8 | 218046-9 | 218046-10 |
| Your Reference | UNITS | 7109/BH08/1.0 | 7109/BH09/0.5 | 7109/BH10/5.0 | 7109/BH11/0.1 | 7109/BH11/0.25 |
| Date Sampled | | 07/05/2019 | 07/05/2019 | 07/05/2019 | 07/05/2019 | 07/05/2019 |
| Type of sample | | soil | soil | soil | soil | soil |
| Date prepared | - | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 |
| Date analysed | - | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 |
| pH 1:5 soil:water | pH Units | 7.2 | 7.2 | 8.9 | 6.3 | 6.8 |
| Electrical Conductivity 1:5 soil:water | µS/cm | 19 | 21 | 96 | 42 | 46 |
| Sulphate, SO4 1:5 soil:water | mg/kg | 20 | <10 | 10 | <10 | 39 |

| **Misc Inorg - Soil** | | | | | | |
|---|---|---|---|---|---|---|
| Our Reference | | 218046-11 | 218046-12 | 218046-13 | 218046-14 | 218046-15 |
| Your Reference | UNITS | 7109/BH11/0.5 | 7109/BH11/1.0 | 7109/BH12/0.1 | 7109/BH12/0.25 | 7109/BH12/0.5 |
| Date Sampled | | 07/05/2019 | 07/05/2019 | 07/05/2019 | 07/05/2019 | 07/05/2019 |
| Type of sample | | soil | soil | soil | soil | soil |
| Date prepared | - | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 |
| Date analysed | - | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 |
| pH 1:5 soil:water | pH Units | 7.0 | 7.5 | 6.5 | 6.7 | 6.8 |
| Electrical Conductivity 1:5 soil:water | µS/cm | 58 | 40 | 31 | 25 | 22 |
| Sulphate, SO4 1:5 soil:water | mg/kg | 50 | 32 | <10 | <10 | <10 |
| Emerson Aggregate Test | - | [NA] | 2.0 | [NA] | [NA] | [NA] |

| **Misc Inorg - Soil** | | | | | | |
|---|---|---|---|---|---|---|
| Our Reference | | 218046-16 | 218046-17 | 218046-18 | 218046-19 | 218046-20 |
| Your Reference | UNITS | 7109/BH12/1.0 | 7109/BH12/2.0 | 7109/BH12/3.0 | 7109/BH13/0.1 | 7109/BH13/0.25 |
| Date Sampled | | 07/05/2019 | 07/05/2019 | 07/05/2019 | 07/05/2019 | 07/05/2019 |
| Type of sample | | soil | soil | soil | soil | soil |
| Date prepared | - | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 |
| Date analysed | - | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 |
| pH 1:5 soil:water | pH Units | 6.9 | 7.8 | 8.0 | 6.5 | 7.0 |
| Electrical Conductivity 1:5 soil:water | µS/cm | 17 | 29 | 27 | 43 | 25 |
| Sulphate, SO4 1:5 soil:water | mg/kg | 10 | <10 | <10 | <10 | <10 |
| Emerson Aggregate Test | - | [NA] | [NA] | [NA] | 3b | [NA] |

| **Misc Inorg - Soil** | | | | | | |
|---|---|---|---|---|---|---|
| Our Reference | | 218046-21 | 218046-22 | 218046-23 | 218046-24 | 218046-25 |
| Your Reference | UNITS | 7109/BH13/0.5 | 7109/BH13/1.0 | 7109/BH17/0.1 | 7109/BH17/0.25 | 7109/BH17/0.5 |
| Date Sampled | | 07/05/2019 | 07/05/2019 | 07/05/2019 | 07/05/2019 | 07/05/2019 |
| Type of sample | | soil | soil | soil | soil | soil |
| Date prepared | - | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 |
| Date analysed | - | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 |
| pH 1:5 soil:water | pH Units | 6.9 | 7.1 | 6.1 | 7.0 | 7.1 |
| Electrical Conductivity 1:5 soil:water | µS/cm | 26 | 16 | 39 | 28 | 30 |
| Sulphate, SO4 1:5 soil:water | mg/kg | 10 | <10 | <10 | 10 | 20 |
| Emerson Aggregate Test | - | [NA] | [NA] | [NA] | 3a | [NA] |

| **Misc Inorg - Soil** | | | | | | |
|---|---|---|---|---|---|---|
| Our Reference | | 218046-26 | 218046-27 | 218046-28 | 218046-29 | 218046-30 |
| Your Reference | UNITS | 7109/BH18/0.1 | 7109/BH18/0.25 | 7109/BH18/0.5 | 7109/BH19/0.1 | 7109/BH19/0.25 |
| Date Sampled | | 07/05/2019 | 07/05/2019 | 07/05/2019 | 07/05/2019 | 07/05/2019 |
| Type of sample | | soil | soil | soil | soil | soil |
| Date prepared | - | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 |
| Date analysed | - | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 | 23/05/2019 |
| pH 1:5 soil:water | pH Units | 6.2 | 6.8 | 6.7 | 6.3 | 6.3 |
| Electrical Conductivity 1:5 soil:water | µS/cm | 41 | 33 | 35 | 40 | 42 |
| Sulphate, SO4 1:5 soil:water | mg/kg | <10 | <10 | <10 | <10 | <10 |
| Emerson Aggregate Test | - | 3b | [NA] | 3a | 3b | [NA] |

| ESP/CEC | | | | | | |
|---|---|---|---|---|---|---|
| Our Reference | | 218046-12 | 218046-19 | 218046-24 | 218046-26 | 218046-28 |
| Your Reference | UNITS | 7109/BH11/1.0 | 7109/BH13/0.1 | 7109/BH17/0.25 | 7109/BH18/0.1 | 7109/BH18/0.5 |
| Date Sampled | | 07/05/2019 | 07/05/2019 | 07/05/2019 | 07/05/2019 | 07/05/2019 |
| Type of sample | | soil | soil | soil | soil | soil |
| Date prepared | - | 24/05/2019 | 24/05/2019 | 24/05/2019 | 24/05/2019 | 24/05/2019 |
| Date analysed | - | 24/05/2019 | 24/05/2019 | 24/05/2019 | 24/05/2019 | 24/05/2019 |
| Exchangeable Ca | meq/100g | 1.0 | 4.3 | 4.7 | 2.7 | 3.7 |
| Exchangeable K | meq/100g | <0.1 | 0.5 | 0.2 | 0.6 | 0.7 |
| Exchangeable Mg | meq/100g | 1.0 | 0.73 | 2.1 | 0.86 | 4.4 |
| Exchangeable Na | meq/100g | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Cation Exchange Capacity | meq/100g | 2.1 | 5.6 | 7.0 | 4.2 | 8.9 |
| ESP | % | [NT] | [NT] | [NT] | [NT] | [NT] |

| ESP/CEC | | |
|---|---|---|
| Our Reference | | 218046-29 |
| Your Reference | UNITS | 7109/BH19/0.1 |
| Date Sampled | | 07/05/2019 |
| Type of sample | | soil |
| Date prepared | - | 24/05/2019 |
| Date analysed | - | 24/05/2019 |
| Exchangeable Ca | meq/100g | 6.4 |
| Exchangeable K | meq/100g | 0.5 |
| Exchangeable Mg | meq/100g | 1.9 |
| Exchangeable Na | meq/100g | <0.1 |
| Cation Exchange Capacity | meq/100g | 8.9 |
| ESP | % | [NT] |

| Method ID | Methodology Summary |
|---|---|
| **Ext-037** | Analysed by Sydney Environmental & Soil Laboratory |
| **Inorg-001** | pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times. |
| **Inorg-002** | Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons. |
| **Inorg-081** | Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis.<br>Alternatively determined by colourimetry/turbidity using Discrete Analyser. |
| **Metals-009** | Determination of exchangeable cations and cation exchange capacity in soils using 1M Ammonium Chloride exchange and ICP-AES analytical finish. |

| QUALITY CONTROL: Misc Inorg - Soil | | | | | Duplicate | | | | Spike Recovery % | |
|---|---|---|---|---|---|---|---|---|---|---|
| Test Description | Units | PQL | Method | Blank | # | Base | Dup. | RPD | LCS-1 | 218046-4 |
| Date prepared | - | | | 24/05/2019 | 3 | 23/05/2019 | 23/05/2019 | | 24/05/2019 | 24/05/2019 |
| Date analysed | - | | | 24/05/2019 | 3 | 23/05/2019 | 23/05/2019 | | 24/05/2019 | 24/05/2019 |
| pH 1:5 soil:water | pH Units | | Inorg-001 | [NT] | 3 | 7.1 | 7.1 | 0 | 101 | [NT] |
| Electrical Conductivity 1:5 soil:water | µS/cm | 1 | Inorg-002 | <1 | 3 | 8 | 8 | 0 | 98 | [NT] |
| Sulphate, SO4 1:5 soil:water | mg/kg | 10 | Inorg-081 | <10 | 3 | <10 | <10 | 0 | 112 | 101 |
| Emerson Aggregate Test | - | 0 | Ext-037 | [NT] | 24 | 3a | [NT] | | [NT] | [NT] |

| QUALITY CONTROL: Misc Inorg - Soil | | | | | Duplicate | | | | Spike Recovery % | |
|---|---|---|---|---|---|---|---|---|---|---|
| Test Description | Units | PQL | Method | Blank | # | Base | Dup. | RPD | LCS-2 | 218046-25 |
| Date prepared | - | | | [NT] | 13 | 23/05/2019 | 23/05/2019 | | 24/05/2019 | 24/05/2019 |
| Date analysed | - | | | [NT] | 13 | 23/05/2019 | 23/05/2019 | | 24/05/2019 | 24/05/2019 |
| pH 1:5 soil:water | pH Units | | Inorg-001 | [NT] | 13 | 6.5 | 6.4 | 2 | 102 | [NT] |
| Electrical Conductivity 1:5 soil:water | µS/cm | 1 | Inorg-002 | [NT] | 13 | 31 | 31 | 0 | 101 | [NT] |
| Sulphate, SO4 1:5 soil:water | mg/kg | 10 | Inorg-081 | [NT] | 13 | <10 | <10 | 0 | 102 | 97 |

| QUALITY CONTROL: Misc Inorg - Soil | | | | | Duplicate | | | | Spike Recovery % | |
|---|---|---|---|---|---|---|---|---|---|---|
| Test Description | Units | PQL | Method | Blank | # | Base | Dup. | RPD | [NT] | [NT] |
| Date prepared | - | | | [NT] | 21 | 23/05/2019 | 23/05/2019 | | [NT] | [NT] |
| Date analysed | - | | | [NT] | 21 | 23/05/2019 | 23/05/2019 | | [NT] | [NT] |
| pH 1:5 soil:water | pH Units | | Inorg-001 | [NT] | 21 | 6.9 | 7.0 | 1 | [NT] | [NT] |
| Electrical Conductivity 1:5 soil:water | µS/cm | 1 | Inorg-002 | [NT] | 21 | 26 | 26 | 0 | [NT] | [NT] |
| Sulphate, SO4 1:5 soil:water | mg/kg | 10 | Inorg-081 | [NT] | 21 | 10 | 10 | 0 | [NT] | [NT] |

| QUALITY CONTROL: Misc Inorg - Soil | | | | | Duplicate | | | | Spike Recovery % | |
|---|---|---|---|---|---|---|---|---|---|---|
| Test Description | Units | PQL | Method | Blank | # | Base | Dup. | RPD | [NT] | [NT] |
| Date prepared | - | | | [NT] | 24 | 23/05/2019 | [NT] | | [NT] | [NT] |
| Date analysed | - | | | [NT] | 24 | 23/05/2019 | [NT] | | [NT] | [NT] |
| pH 1:5 soil:water | pH Units | | Inorg-001 | [NT] | 24 | 7.0 | [NT] | | [NT] | [NT] |
| Electrical Conductivity 1:5 soil:water | µS/cm | 1 | Inorg-002 | [NT] | 24 | 28 | [NT] | | [NT] | [NT] |
| Sulphate, SO4 1:5 soil:water | mg/kg | 10 | Inorg-081 | [NT] | 24 | 10 | [NT] | | [NT] | [NT] |

| QUALITY CONTROL: ESP/CEC | | | | | Duplicate | | | | Spike Recovery % | |
|---|---|---|---|---|---|---|---|---|---|---|
| Test Description | Units | PQL | Method | Blank | # | Base | Dup. | RPD | LCS-1 | [NT] |
| Date prepared | - | | | 24/05/2019 | 24 | 24/05/2019 | 24/05/2019 | | 24/05/2019 | [NT] |
| Date analysed | - | | | 24/05/2019 | 24 | 24/05/2019 | 24/05/2019 | | 24/05/2019 | [NT] |
| Exchangeable Ca | meq/100g | 0.1 | Metals-009 | <0.1 | 24 | 4.7 | 4.9 | 4 | 96 | [NT] |
| Exchangeable K | meq/100g | 0.1 | Metals-009 | <0.1 | 24 | 0.2 | 0.2 | 0 | 99 | [NT] |
| Exchangeable Mg | meq/100g | 0.1 | Metals-009 | <0.1 | 24 | 2.1 | 2.2 | 5 | 96 | [NT] |
| Exchangeable Na | meq/100g | 0.1 | Metals-009 | <0.1 | 24 | <0.1 | <0.1 | 0 | 91 | [NT] |
| ESP | % | 1 | Metals-009 | <1 | 24 | [NT] | [NT] | | [NT] | [NT] |

## Result Definitions

| | |
|---|---|
| **NT** | Not tested |
| **NA** | Test not required |
| **INS** | Insufficient sample for this test |
| **PQL** | Practical Quantitation Limit |
| **<** | Less than |
| **>** | Greater than |
| **RPD** | Relative Percent Difference |
| **LCS** | Laboratory Control Sample |
| **NS** | Not specified |
| **NEPM** | National Environmental Protection Measure |
| **NR** | Not Reported |

## Quality Control Definitions

| | |
|---|---|
| **Blank** | This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples. |
| **Duplicate** | This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable. |
| **Matrix Spike** | A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist. |
| **LCS (Laboratory Control Sample)** | This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample. |
| **Surrogate Spike** | Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples. |

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

## Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

## Report Comments

ESP: Where the exchangeable Sodium is less than the PQL and CEC is less than 10meq/100g, the ESP cannot be calculated.

Emerson class analysed by EastWest report EW190966

# 12 Attachment E – General Geotechnical Recommendations

*These general geotechnical recommendations have been prepared by Martens to help you deliver a safe work site, to comply with your obligations, and to deliver your project. Not all are necessarily relevant to this report but are included as general reference. Any specific recommendations made in the report will override these recommendations.*

## Batter Slopes

Excavations in soil and extremely low to very low strength rock exceeding 0.75 m depth should be battered back at grades of no greater than 1 Vertical (V) : 2 Horizontal (H) for temporary slopes (unsupported for less than 1 month) and 1 V : 3 H for longer term unsupported slopes.

Vertical excavation may be carried out in medium or higher strength rock, where encountered, subject to inspection and confirmation by a geotechnical engineer. Long term and short term unsupported batters should be protected against erosion and rock weathering due to, for example, stormwater run-off.

Batter angles may need to be revised depending on the presence of bedding partings or adversely oriented joints in the exposed rock, and are subject to on-site inspection and confirmation by a geotechnical engineer. Unsupported excavations deeper than 1.0 m should be assessed by a geotechnical engineer for slope instability risk.

Any excavated rock faces should be inspected during construction by a geotechnical engineer to determine whether any additional support, such as rock bolts or shotcrete, is required.

## Earthworks

Earthworks should be carried out following removal of any unsuitable materials and in accordance with AS3798 (2007). A qualified geotechnical engineer should inspect the condition of prepared surfaces to assess suitability as foundation for future fill placement or load application.

Earthworks inspections and compliance testing should be carried out in accordance with Sections 5 and 8 of AS3798 (2007), with testing to be carried out by a National Association of Testing Authorities (NATA) accredited testing laboratory.

## Excavations

All excavation work should be completed with reference to the *Work Health and Safety (Excavation Work) Code of Practice (2015)*, by Safe Work Australia. Excavations into rock may be undertaken as follows:

1. Extremely low to low strength rock - conventional hydraulic earthmoving equipment.
2. Medium strength or stronger rock - hydraulic earthmoving equipment with rock hammer or ripping tyne attachment.

Exposed rock faces and loose boulders should be monitored to assess risk of block / boulder movement, particularly as a result of excavation vibrations.

## Fill

Subject to any specific recommendations provided in this report, any fill imported to site is to comprise approved material with maximum particle size of two thirds the final layer thickness. Fill should be placed in horizontal layers of not more than 300 mm loose thickness, however, the layer thickness should be appropriate for the adopted compaction plant.

## Foundations

All exposed foundations should be inspected by a geotechnical engineer prior to footing construction to confirm encountered conditions satisfy design assumptions and that the base of all excavations is free from loose or softened material and water. Water that has ponded in the base of excavations and any resultant softened material is to be removed prior to footing construction.

Footings should be constructed with minimal delay following excavation. If a delay in construction is anticipated, we recommend placing a concrete blinding layer of at least 50 mm thickness in shallow footings or mass concrete in piers / piles to protect exposed foundations.

A geotechnical engineer should confirm any design bearing capacity values, by further assessment during construction, as necessary.

## Shoring - Anchors

Where there is a requirement for either soil or rock anchors, or soil nailing, and these structures penetrate past a property boundary, appropriate permission from the adjoining land owner must be obtained prior to the installation of these structures.

## Shoring - Permanent

Permanent shoring techniques may be used as an alternative to temporary shoring. The design of such structures should be in accordance with the findings of this report and any further testing recommended by this report. Permanent shoring may include [but not be limited to] reinforced block work walls, contiguous and semi contiguous pile walls, secant pile walls and soldier pile walls with or without reinforced shotcrete infill panels. The choice of shoring system will depend on the type of structure, project budget and site specific geotechnical conditions.

Permanent shoring systems are to be engineer designed and backfilled with suitable granular material and free-draining drainage material. Backfill should be placed in maximum 100 mm thick layers compacted using a hand operated compactor. Care should be taken to ensure excessive compaction stresses are not transferred to retaining walls.

Shoring design should consider any surcharge loading from sloping / raised ground behind shoring structures, live loads, new structures, construction equipment, backfill compaction and static water pressures. All shoring systems shall be provided with adequate foundation designs.

Suitable drainage measures, such as geotextile enclosed 100 mm agricultural pipes embedded in free-draining gravel, should be included to redirect water that may collect behind the shoring structure to a suitable discharge point.

### Shoring - Temporary

In the absence of providing acceptable excavation batters, excavations should be supported by suitably designed and installed temporary shoring / retaining structures to limit lateral deflection of excavation faces and associated ground surface settlements.

### Soil Erosion Control

Removal of any soil overburden should be performed in a manner that reduces the risk of sedimentation occurring in any formal stormwater drainage system, on neighbouring land and in receiving waters. Where possible, this may be achieved by one or more of the following means:

1. Maintain vegetation where possible
2. Disturb minimal areas during excavation
3. Revegetate disturbed areas if possible

All spoil on site should be properly controlled by erosion control measures to prevent transportation of sediments off-site. Appropriate soil erosion control methods in accordance with Landcom (2004) shall be required.

### Trafficability and Access

Consideration should be given to the impact of the proposed works and site subsurface conditions on trafficability within the site e.g. wet clay soils will lead to poor trafficability by tyred plant or vehicles.

Where site access is likely to be affected by any site works, construction staging should be organised such that any impacts on adequate access are minimised as best as possible.

### Vibration Management

Where excavation is to be extended into medium or higher strength rock, care will be required when using a rock hammer to limit potential structural distress from excavation-induced vibrations where nearby structures may be affected by the works. To limit vibrations, we recommend limiting rock hammer size and set frequency, and setting the hammer parallel to bedding planes and along defect planes, where possible, or as advised by a geotechnical engineer. We recommend limiting vibration peak particle velocities (PPV) caused by construction equipment or resulting from excavation at the site to 5 mm/s (AS 2187.2, 2006, Appendix J).

### Waste – Spoil and Water

Soil to be disposed off-site should be classified in accordance with the relevant State Authority guidelines and requirements.

Any collected waste stormwater or groundwater should also be tested prior to discharge to ensure contaminant levels (where applicable) are appropriate for the nominated discharge location.

MA can complete the necessary classification and testing if required. Time allowance should be made for such testing in the construction program.

### Water Management - Groundwater

If the proposed works are likely to intersect ephemeral or permanent groundwater levels, the management of any potential acid soil drainage should be considered. If groundwater tables are likely to be lowered, this should be further discussed with the relevant State Government Agency.

### Water Management – Surface Water

All surface runoff should be diverted away from excavation areas during construction works and prevented from accumulating in areas surrounding any retaining structures, footings or the base of excavations.

Any collected surface water should be discharged into a suitable Council approved drainage system and not adversely impact downslope surface and subsurface conditions.

All site discharges should be passed through a filter material prior to release. Sump and pump methods will generally be suitable for collection and removal of accumulated surface water within any excavations.

### Contingency Plan

In the event that proposed development works cause an adverse impact on geotechnical hazards, overall site stability or adjacent properties, the following actions are to be undertaken:

1. Works shall cease immediately.
2. The nature of the impact shall be documented and the reason(s) for the adverse impact investigated.
3. A qualified geotechnical engineer should be consulted to provide further advice in relation to the issue.

# 13 Attachment F – Notes About This Report

# Information

## 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:

- o 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.

## 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.

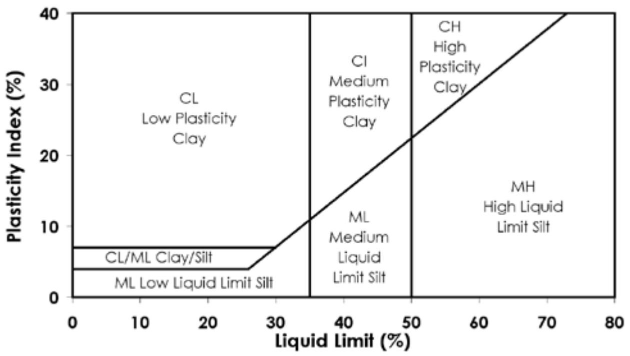
## Particle Size

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 %<br>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 %<br>Fine grained soils: 15 – 30 % |

# Soil Data

## Explanation of Terms (2 of 3)

### Symbols for Soils and Other

| **SOILS** | | | | **OTHER** | |
|---|---|---|---|---|---|
| ▨ | COBBLES/BOULDERS | ▨ | SILT (ML OR MH) | ▨ | FILL |
| ▨ | GRAVEL (GP OR GW) | ▨ | ORGANIC SILT (OH) | ▨ | TALUS |
| ▨ | SILTY GRAVEL (GM) | ▨ | CLAY (CL, CI OR CH) | ■ | ASPHALT |
| ▨ | CLAYEY GRAVEL (GC) | ▨ | SILTY CLAY | ▨ | CONCRETE |
| ▨ | SAND (SP OR SW) | ▨ | SANDY CLAY | | |
| ▨ | SILTY SAND (SM) | ▨ | PEAT | | |
| ▨ | CLAYEY SAND (SC) | ▨ | TOPSOIL | | |

### Unified Soil Classification Scheme (USCS)

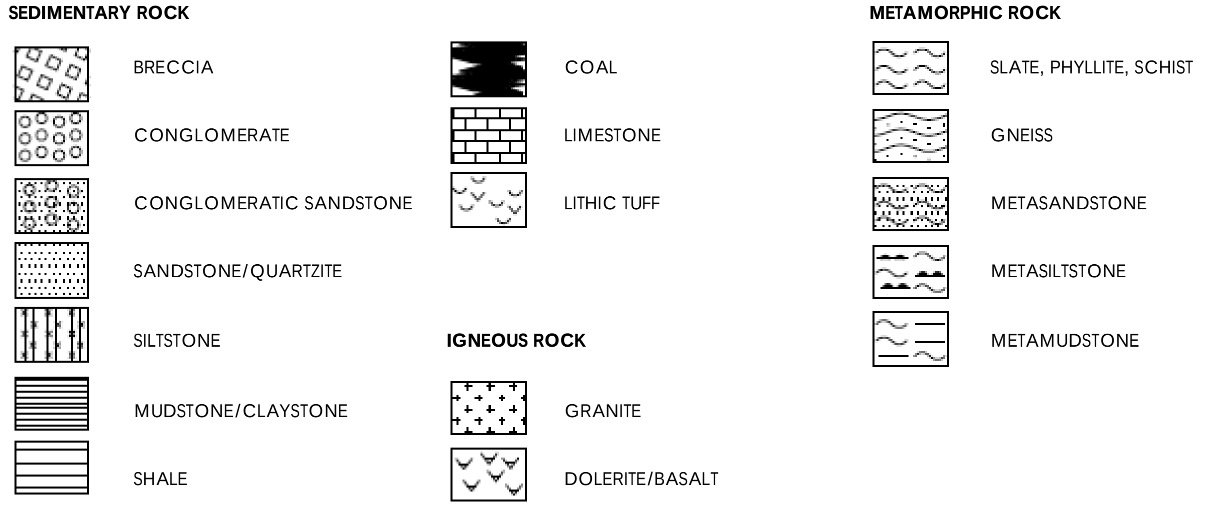
<table>
<tr><td colspan="6"><b>FIELD IDENTIFICATION PROCEDURES</b><br>(Excluding particles larger than 63 mm and basing fractions on estimated mass)</td><td><b>USCS</b></td><td><b>Primary Name</b></td></tr>
<tr><td rowspan="8">COARSE GRAINED SOILS<br>More than 50 % of material less than 63 mm is larger 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<br>More than half of coarse fraction is larger than 2.0 mm.</td><td rowspan="2">CLEAN GRAVELS<br>(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<br>(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<br>More than half of coarse fraction is smaller than 2.0 mm</td><td rowspan="2">CLEAN SANDS<br>(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<br>(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<br>More than 50 % of material less than 63 mm is smaller than 0.075 mm</td><td colspan="6"><b>IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 MM</b></td></tr>
<tr><td><b>DRY STRENGTH (Crushing Characteristics)</b></td><td><b>DILATANCY</b></td><td><b>TOUGHNESS</b></td><td><b>DESCRIPTION</b></td><td><b>USCS</b></td><td><b>Primary Name</b></td></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], gravelly 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"><b>Notes:</b><br>1. Low Plasticity – Liquid Limit $W_L$ < 35 % Medium Plasticity – Liquid limit $W_L$ 35 to 60 % High Plasticity - Liquid limit $W_L$ > 60 %.<br>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 |

## 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 Rs and EW material is described using soil descriptive terms.

2. The term "Distinctly Weathered" (DW) may be used to cover the range of substance weathering between EW and SW

## 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 |

## 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.<br>'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 | | |