Green Valley Islamic College Limited
C/- Midson Group Pty Ltd

Geotechnical Assessment: Minarah College – 268 & 278 Catherine Fields Road, Catherine Field, NSW

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT
MANAGEMENT

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Head Office
Suite 201, 20 George St
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

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Author(s)	Reviewer(s)	Project Manager	Signature
Maheer Hasan	Surendran Karasu	Terry Harvey	

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

Contents

Abbreviations

ABC – Allowable bearing capacity

BH – Borehole

CBR – California Bearing Ratio

DBYD – Dial before you dig

DCP – Dynamic cone penetrometer

DP – Deposited plan

ESA – Equivalent standard axles

HVAG – Heavy vehicle axle groups

kN – kilo Newtons

kN/m^3 – kilo Newtons per cubic metre

kPa – kilo Pascal

LGA – Local government area

MA – Martens & Associates Pty Ltd

mAHD – metres Australian height datum

mbgl – metres below ground level

MDD – Maximum dry density

MPa – Mega pascal

OMC – Optimum moisture content

1 Proposed Development

Proposed development details are summarised in Table 1.

Table 1: Summary of proposed development.

Item	Details
Property Address	268 & 278 Catherine Fields Road, Catherine Field, NSW 2557 ('the site').
Lot / DP	Lot 11 in DP 833983 and Lot 12 in DP 833784 (CMS, 2021).
Site Area	45,000 m^2 (CMS, 2021).
LGA	Camden Council ('Council').
Proposed Development	We understand from the concept proposal plans (TZG Architects, 2021) and client provided information that the development will include the construction of a new Green Islamic Valley College campus, hereafter referred to as 'Minarah College'. It is understood the construction of Minarah College will be delivered in four (4) major stages, with Stage 1 works comprising: o Demolition of the existing development on the site. o Construction of a two-storey building at the front of the property (i.e. the western portion), dedicated as a start-up school for up to 350 students. o Construction of new internal roads and parking areas. Stage 1 construction works for Minarah College will likely require bulk excavation to a depth of approximately 0.3 metres below ground level (mbgl).
Assessment Purpose	A geotechnical assessment to support the detailed design for the proposed construction of Minarah College.
Investigation Scope of Work	Field investigations conducted on 25 November 2021 included: o A general site walkover inspection. o Review of DBYD plans and underground service location. o Drilling of fourteen boreholes (BH101 to BH114) up to a maximum depth of approximately 2.0 mbgl. o Fourteen Dynamic Cone Penetrometer (DCP) tests (DCP101 to DCP114) up to a maximum depth of 1.85 mbgl. o Collection of bulk soil samples for California Bearing Ratio (CBR) testing at five locations (CBR1 to CBR 5). o Collection of soil samples for laboratory testing and future reference. Investigation locations are shown in Figure 1, Attachment A.
Laboratory Testing	Testing carried out by National Association of Testing Authorities (NATA) accredited laboratories included: o Soil aggressivity on five soil samples by Envirolab Services. o Atterberg limits and linear shrinkage testing on four soil samples, shrink-swell testing on four soil samples and CBR testing on five bulk soil samples by Resource Laboratories.

2 General Site Details and Investigation Findings

2.1 General Site Details

General site details are summarised in Table 2.

Table 2: Summary of general site details.

Item	Comment
Topography	The NSW Office of Environment and Heritage's (eSPADE) information system indicates the site topography to comprise: o Gently undulating rises on Wianamatta Group shales. o Local relief to 30 m, slopes usually > 5 %; however, occasionally up to 10 %.
Typical Slopes	Approximately 5 % -10 % across the site.
Site Aspect	South west.
Site Elevation	Site elevation ranges between approximately 74.5 mAHD in the north west corner to 84.5 mAHD in the south east corner of the site (CMS, 2021).
Expected geology	The geological map indicates the site is underlain by Bringelly Shale comprising shale, carbonaceous claystone, claystone, laminite, fine to medium grained lithic sandstone and rare coal and tuff (Clark, 1991).
Expected soil landscape	The NSW Office of Environment and Heritage's (OEH) information system (eSPADE) indicates the site to be located in the Blacktown (bt) soil landscape, with shallow to moderately deep (>100cm) hard setting mottled texture contrast soils, red and brown podzolic soils on crests grading to yellow podzolic soils on lower slopes and in drainage lines. This soil landscape often associated with localised seasonal waterlogging, localised water erosion hazard, moderately reactive highly plastic subsoil and localised surface movement potential.
Existing development	The northern lot is occupied by a dwelling in the western portion of the lot and two sheds in the central portion of the lot. The southern lot is occupied by a dwelling and three sheds near the western portion of the lot. One farm dam and one silted in / vegetated farm dam were present near the central portion of the site. The remainder of the site consists of overgrown grass covered land.
Vegetation	Grass, shrubs and some mature trees.
Neighbouring environment	At the time of the geotechnical investigation, the site was surrounded by residential land use to the north and south, vegetated bushland to the east and Catherine Fields Road to the west.
Drainage	Via overland flow towards the south.

2.2 Subsurface Conditions

Investigation revealed the following generalised subsurface units likely underlie the site below ground surface level:

Unit A: Topsoil: silty clay, encountered up to a maximum depth of 0.3 mbgl (BH105).

Unit B: Fill: silty clay, encountered up to 0.7 mbgl (BH107) in the southern lot (Lot 11 in DP833983) adjacent to the garage shed in the central portion of the property. Fill was observed to comprise unsuitable material (e.g. plastic pieces) and is inferred to have been placed under uncontrolled conditions. The presence of potential asbestos containing material was observed in this existing fill. This unit was not encountered in other boreholes drilled at the site.

Unit C: Residual soil comprising:

Unit C1: Silty clay: firm, encountered up to between 0.5 mbgl (BH101) and 1.1 mbgl (BH111).

Unit C2: Silty clay: stiff to very stiff, encountered up to between 0.8 mbgl (BH101) and 1.6 mbgl (BH107).

Unit D: Shale: highly weathered, inferred very low to low strength encountered below Unit C up to TC-bit refusal depth of 2.0 mbgl (BH105).

2.3 Groundwater Conditions

Groundwater inflow was observed in the southern lot in BH107 at 0.5 mbgl. Based on our observation, groundwater inflow is considered likely to have originated from the previous dam located in the central portion of the southern lot.

Groundwater inflow was not observed in all other boreholes conducted in the southern lot during borehole auger drilling up to 1.6 mbgl (BH114). Groundwater inflow was not observed in the northern lot (Lot 12 in DP 833784) during borehole auger drilling up to 2.0 mbgl (BH105).

However, ephemeral perched groundwater may be encountered within the soil profile and / or at the soil / rock interface originating from infiltration of surface water during prolonged or intense rainfall events.

3 Geotechnical Assessment

3.1 Laboratory Test Results

3.1.1 Soil Aggressivity Testing

Laboratory test results for soil aggressivity testing are summarised in Table 3 (refer to Attachment D for soil aggressivity test certificate).

Table 3: Soil aggressivity test results.

Sample ID[1]	Material	EC_e (dS/m)[2]	Resistivity (ohm.cm)[3]	pH	Chloride (Cl) (mg/kg)	Sulphate (SO_4) (mg/kg)	Exposure Classification		
							AS 2159[4]	AS 2159[5]	AS 3600[6]
BH101/ 0.2-0.3	Silty CLAY	0.29	210	6.6	25	10	Non-aggressive	Moderate	A1
BH106/ 0.7-0.8	Silty CLAY	0.25	240	6.7	10	10	Non-aggressive	Moderate	A1
BH107/ 0.7-1.0	Silty CLAY	0.49	120	6.6	38	33	Non-aggressive	Moderate	A2
BH110/ 1.2-1.4	Silty CLAY	2.58	23	5.2	610	190	Mild	Moderate	A2
BH111/ 0.6-1.1	Silty CLAY	3.00	20	5.5	740	180	Mild	Moderate	A2

Notes:

1. Borehole#/Depth (mbgl).
2. Based on EC to EC_e multiplication factors from Table 6.1 in *Site Investigations for Urban Salinity* (2002) guidelines.
3. Resistivity in soil.
4. Exposure classification for concrete piles in soil based on Table 6.4.2(C) of AS 2159 (2009).
5. Exposure classification for steel piles in soil based on Table 6.5.2(C) of AS 2159 (2009).
6. Exposure classification for buried reinforced concrete based on Tables 4.8.1 and 4.8.2 of AS 3600 (2009).

In accordance with AS3600 (2018), an exposure classification of 'A2' should be adopted for shallow reinforced concrete footings founding in residual soil. In accordance with AS 2159 (2009), an exposure classification of 'Mild' and 'Moderate' may be adopted for preliminary design of buried concrete and steel piles, respectively.

3.1.2 Atterberg Limits Testing

A summary of Atterberg limits test results are presented in Table 5 (refer to Attachment D for Atterberg limits test certificate).

Table 4: Summary of laboratory Atterberg limits test results.

Sample ID [1]	Soil Type	Atterberg Limits (%)			Linear Shrinkage	Plasticity Classification	Potential Volume Change [3]
		LL[2]	PL[2]	PI[2]			
BH102/ 0.9-1.0	Silty CLAY	72	21	51	14.5	High	Medium to high
BH104/ 0.5-0.7	Silty CLAY	55	17	38	15.0	High	Medium
BH106/ 0.2-0.5	Silty CLAY	71	19	52	12.0	High	Medium to high
BH111/ 0.2-0.6	Silty CLAY	66	18	48	16.5	High	Medium

Notes:

1. Borehole#/Depth (mbgl).
2. LL = Liquid limit, PL= Plastic limit, PI=Plasticity index.
3. Based on Hazelton and Murphy, 2016.

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

3.1.3 California Bearing Ratio (CBR) Testing

Laboratory CBR test results are summarised in Table 5 (refer to Attachment D for CBR test certificate).

Table 5: CBR test results.

CBR Number	Sample Depth (mbgl)	Soil Type	CBR Value [1] (%)
CBR1	0.2-0.5	Silty CLAY	2.0
CBR2	0.2-0.5	Silty CLAY	3.5
CBR3	0.3-0.6	Silty CLAY	7.0
CBR4	0.3-0.6	Silty CLAY	2.5
CBR5	0.2-0.5	Silty CLAY	4.5

Notes:

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

3.1.4 Shrink Swell Index

A summary of shrink / swell index test results is presented in Table 5.

Table 5: Summary of laboratory shrink / swell index test results.

Sample ID [1]	Soil Type	Shrink / Swell Index (%)
CBR1/0.2-0.5	Silty CLAY	3.3
CBR2/0.2-0.5	Silty CLAY	2.6
BH103/0.3-0.5	Silty CLAY	3.7
BH109/0.3-0.5	Silty CLAY	3.5

Notes:

1. Borehole#/Depth (mbgl).

A shrink / swell index greater than 2.5 % indicates that the clayey soils are considered expansive (i.e. high swell potential). Due to the soils tendency to swell and shrink, these soils are considered likely to cause damage to structures and pavements.

3.2 Preliminary Material Properties

Material properties inferred from observations during borehole drilling, such as auger penetration resistance, DCP and laboratory test results as well as engineering judgement are summarised in Table 6.

Table 6: Soil and rock strength properties.

Layer	$\gamma_{in\text{-}situ}$ [1] (kN/m^3)	Cu [2] (kPa)	C ′ [3] (kPa)	Ø′ [4] (deg)	E′ [5] (MPa)
Unit A – TOPSOIL: Silty CLAY	16	NA [6]	NA [6]	NA [6]	NA [6]
Unit B – FILL: Silty CLAY	17	NA [6]	NA [6]	NA [6]	NA [6]
UNIT C1 – RESIDUAL : Silty CLAY (firm)	18	40	2	26	10
UNIT C2 – RESIDUAL : Silty CLAY (stiff to very stiff)	19	100	5	28	25
Unit D – WEATHERED ROCK: SHALE (very low to low strength)	22	NA [6]	50	28	75

Notes:

1. Material in-situ unit weight, based on visual assessment (±10 %).
2. Average undrained shear strength estimate assuming normally consolidated clay.
3. Average drained cohesion estimate.
4. Effective internal friction angle (± 2 ˚) estimate, assuming drained conditions; may be dependent on rock defect conditions.
5. Average effective elastic modulus (± 10 %) estimate, that should be adopted to calculate lateral deflection of pile under serviceability loading.
6. Not applicable.

3.3 Risk of Slope Instability

No evidence of former or current slope movement was observed at the site. We consider the risk to property and loss of life by potential slope instability, such as landslide or soil creep, to be low subject to the recommendations in this report and adoption of relevant engineering standards and guidelines. A detailed slope risk assessment in accordance with Australian Geomechanics Society's Landslide Risk Management Guidelines (2007) was not undertaken.

Recommendations presented in this report are provided to mitigate risks associated with potential excavation instability during construction.

4 Pavement Thickness Design

4.1 Overview

Flexible and rigid pavement thicknesses design for the proposed access road and parking / service yard areas were undertaken in accordance with Camden Council Engineering Design Specification's (CC, 2009) and Austroads - Guide to Pavement Technology Part 2 : Pavement Structural Design (Austroads, 2017).

4.2 Design Parameters

4.2.1 Equivalent Standard Axles (ESA) and Heavy Vehicle Axle Groups (HVAG)

Flexible Pavement

A traffic loading of 5 x 10^5 Equivalent Standard Axles (ESA) was adopted in accordance CC, 2009.

Rigid Pavement

An axle loading of 2.0 x 10^5 HVAG was adopted in accordance with Austroads, 2017.

4.2.2 Pavement Design Life

A design life of 20 years and 30 years was adopted in the design of flexible and rigid pavements, respectively, based on Austroads, 2017.

4.2.3 Concrete Flexural Strength and Load Safety Factor for Rigid Pavement

A minimum concrete flexural strength of 4.0 MPa was adopted in the design. Considering a project reliability of 80%, a load safety factor of 1.05 was adopted in accordance with Austroads, 2017.

4.2.4 Design CBR

Test results returned CBR values ranging between 2.0 % and 7.0 % for the residual soil. The variability in CBR values is likely due to variable soil consistency and the presence of sand, silt and gravel in the soil.

A subgrade CBR of 3.0 % has been adopted to represent encountered site conditions, provided subgrade improvement / replacement is carried out.

4.2.5 Subgrade Treatment

We recommend the following subgrade treatment options are adopted (following stripping of topsoil to expose subgrade materials) to improve subgrade conditions for long term general use:

- Remove the top 0.5 m of the exposed subgrade layer and replace with granular material / engineered fill.
- Stabilise the exposed subgrade layer up to depth of at least 0.5 m by mixing the soil with gypsum / lime or similar binding agent.

4.3 Pavement Thickness Design

Assuming adequate subgrade treatment to achieve a minimum design CBR of 3 %, the pavement thickness design was carried out using Austroads (2017).

Flexible Pavement

Table 7 presents recommended pavement materials and material thicknesses for the flexible pavement.

Table 7: Pavement material thickness based on design CBR of 3 %.

Layer	Thickness (mm)	Total Thickness (mm)	Materials
Wearing Course	50	475	Two layers of AC10 with a total minimum thickness of 50 mm
Base	175 [1]		DGB20
Sub-base	250 [1]		DGS20 or DGS40

Notes:

1. Based on Figure 8.4 of Austroads, 2017.

Rigid Pavement

Based on the above (Section 4.2) design parameters, we recommend the following pavement materials and material thicknesses for rigid pavement.

- Thickness of subbase = 125 mm (DGS 20 or DGS40).
- Thickness of concrete base = 160 mm (based on Figure 12.13, Austroads, 2017).
- Minimum steel reinforcing fabric size = SL 92.

We note that the recommended pavement thicknesses design may need to be revised depending on the treatment method, resulting CBR following subgrade treatment and development of the final rigid pavement jointing details.

If the treated subgrade returned CBR value > 3 % following verification during construction by a geotechnical engineer and further on-site / laboratory testing, pavement thickness design may be revised with new CBR of treated subgrade.

4.4 Earthworks

4.4.1 Subgrade Preparation

Prior to subgrade treatment, the subgrade is to be trimmed and compacted, following the removal of topsoil and other unsuitable materials such as root containing soils. Minimum relative density of subgrade shall be 100 % Maximum Dry Density (MDD) at a standard compactive effort within -3 % of optimum moisture content (OMC).

Prior to placement of pavement material, the treated subgrade shall be proof rolled and approved by a geotechnical engineer. If soft localised spots are encountered, they can be treated by one of the following methods subject to final design and adopted subgrade treatment option:

- Removal and replacement with approved fill under geotechnical engineer's direction.
- Further *in-situ* stabilisation with cement / lime or similar binding agent.

Use of stabilisation method and extent will depend on the condition of material to be stabilised.

4.4.2 Subsoil Drainage

Surface and sub-soil drainage is to be provided in accordance with Council requirements. Typically, subsurface drains are installed on the upslope side of all internal roads or on both sides where adjacent to vegetated areas, and generally extend 600 mm below pavement level. Austroads advises against extending subsurface drainage into highly reactive soils beneath the pavement.

4.4.3 Placement and Testing of Pavement Material

Pavement materials shall be placed in layers (when compacted) not thicker than 300 mm or less than 100 mm. Pavement base (for flexible pavement) and sub-base shall be compacted to a minimum of 98 % MDD at modified compactive effort within -3 % of optimum moisture content (OMC).

Compaction testing shall be undertaken by a NATA accredited laboratory in accordance with AS1289. Each pavement layer shall be proof rolled under an experienced geotechnical engineers' supervision. Subsequent pavement layers shall not be placed prior to approval of underlying layer by the geotechnical engineer.

4.4.4 Fill Placement

Should filling be required to raise subgrade levels, site-won excavated fill and residual soils are considered not suitable for re-use as structural fill due to their moderate to high reactivity to soil moisture variation and associated difficulties in placement.

Suitable low plasticity clay from an approved borrow source or granular fill, approved for use by a Geotechnical Engineer should be adopted. Proof rolling to be witnessed by the project geotechnical engineer to detect localised soft or unstable areas which should be removed and replaced with engineered fill or alternatively stabilised or bridged. An earthworks specification is to be prepared by the supervising engineer and be implemented by the contractor.

4.4.5 Other Recommendations

Transitioning of existing and new pavement sections, if required, needs to be included in detailed design. The transition zone is to be keyed and adequately offset from wheel paths.

5 Geotechnical Recommendations

5.1 Geotechnical Constraints and Risks

The proposed development is inferred to be impacted by the following geotechnical constraints:

- High shrink /swell potential due to soil moisture changes.
- Localised contaminated material comprising potential asbestos in the central portion of the southern lot (Lot 11 in DP833983), near the existing garage shed.
- Water logged soils within the vicinity of the previous dam.

The above geotechnical constraints could be mitigated by adopting the following recommendations outlined below. Further general geotechnical recommendations are provided in Attachment E.

5.2 Site Preparation and Earthworks

All earthworks shall be carried out in accordance with AS3798 (2007) and Council earthworks specification. Site specific recommendations for site preparation and earthworks are as follows:

- Strip and remove all vegetation and unsuitable materials such as topsoil and root affected soils from the development area up to a depth of approximately 0.3 mbgl.
- The existing fill in the central portion of the southern lot (Lot 11 in DP833983), near the existing garage shed comprising unsuitable material (e.g. plastic pieces, potential asbestos containing material etc.) should be removed from the site. The actual extent and depth of removal will be subject to additional investigations and /or actual site conditions.
- Fill material shall be placed in horizontal layers of generally not more than 300 mm in loose thickness and with a mixture of materials as uniform as possible from an approved borrow source.
- Subgrade to be proof rolled with a 8 tonne smooth drum roller with a minimum of 6 passes in accordance with Clause 5.5 of AS3798 (2007). If soft spots are identified, these shall be treated until conditions are assessed by the geotechnical engineer to be suitable.

- Fill material shall be moisture conditioned and compacted to a minimum 98 % density ratio (DR) or 75 % density index (DI) for granular fill at a standard compactive effort within ± 2 % of OMC. The upper 300 mm of fill material shall be compacted to a DR of 100 % or DI of 80 % at a standard compactive effort within ± 2 % of OMC.

- Smooth drum vibratory rollers are considered as suitable plant in accordance with AS2187.2 (2006). If vibrating rollers are adopted, resultant ground vibration should be assessed and monitored in accordance with AS 2187.2 (2006) to ensure no adverse impacts on nearby structures.

Further geotechnical advice can be provided by MA related to earthworks requirements, dependent on final design and proposed construction methodologies.

5.3 Excavatability

It is envisaged that only minimal requirement of excavation (i.e. < 0.5 m) is required across the site. However, if required, soils and weathered rock should be readily excavated to a maximum depth of 2.0 m using conventional earthmoving equipment. Low strength rock may require a 'toothed' bucket or ripping tyne (or similar).

All excavation work should be completed with reference to the most recent version of Code of Practice 'Excavation Work' by Safe Work Australia.

5.4 Batters Slopes

Batter slopes of 1V:2H should be adopted for temporary slopes (unsupported for less than 1 month) and 1V:3H for longer term unsupported slopes, subject to inspection and approval by a qualified and experienced geotechnical engineer on site.

Sufficient setback for batter slopes should be achievable, subject to adjacent structures and / or infrastructure remaining outside the zone of influence. Excavation in soil / weathered rock, exceeding 1.0 m depth must be temporarily and permanently battered back / supported / retained to maintain slope stability.

5.5 Temporary Shoring and Retaining Walls

Contiguous piles may be adopted for areas within the zone of influence of adjacent structures. For shoring outside the zone of influence of adjacent structures, soldier pile walls such as timber panels with steel posts may be adopted. The design parameters for excavation support are provided in Section 5.11 (Table 8).

Retaining structures should consider additional surcharge loading from live loads, new structures, construction equipment, compacted backfill compaction and static water pressures unless drainage such as subsoil drains, weepholes or horizontal drains is provided behind retaining walls.

5.6 Re-use of Site Soils

Since the residual clay underlying the site comprise high plasticity clays, this material is considered not suitable for re-use as fill placement. However if the material is mixed with lime / gypsum to improve its properties / characteristics, the material may be re-used, subject to further laboratory testing on selected soil samples and advise by an experienced geotechnical engineer.

Alternatively, suitable engineered or granular fill from a borrow source, approved for use by a qualified and experienced geotechnical engineer may be adopted.

The residual reactive silty clay underlying the site is likely to be affected by shrinkage and swelling movement due to soil moisture changes. In order to minimise shrink-swell movement due to soil moisture changes, we recommend undertaking lime / gypsum stabilisation of the top 0.5 m of residual soil within the footprint of buildings and structures. Appropriate surface and sub-surface drainage shall be provided to divert overland flows and potential perched groundwater, away from excavations, retaining walls or foundations.

5.7 Groundwater / Drainage Requirements

Excavation near the southern lot may encounter groundwater seepage in the soil profile, particularly in close proximity to existing dam and overland drainage channel. Seepage inflow is expected to be low and should be managed by sump and pump methods.

Appropriate surface and sub-surface drainage should be provided to divert overland flows and limit ponding of water near footings and foundations.

5.8 Soil Erosion Control

Removal of soil overburden should be performed in a manner that reduces the risk of sedimentation occurring in the Council stormwater system and on neighbouring lands. 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.

5.9 Foundation Recommendations

5.9.1 Shallow Foundations

Shallow footings such as pad or strip footings and slab on ground are considered suitable for retaining walls and buildings. All footings should be founded on at least the stiff to very stiff residual clay or engineered fill or bedrock. Footings should be founded on consistent material to limit the potential of long term differential settlement. We do not consider firm clay as suitable foundation stratum due to the potential for long-term differential settlement and low bearing capacity.

The preliminary design parameters for shallow foundations are provided in Section 5.11 (Table 8).

5.9.2 Pile Foundations

Pile foundations such as bored cast in situ piles may be adopted where greater structural loads are required to be supported. We recommend that all piles are inspected by an experienced geotechnical engineer to check adequacy of cleanliness of pile base and to confirm pile socket depth into design strata during pile construction. We do not recommend adopting screw piles as foundation support as these piles would not be able to penetrate into the very stiff to hard residual soil encountered at shallow depths of less than 1m. From our experience, screw piles are generally more suitable in areas of granular soils comprising medium to dense sands.

The preliminary design parameters for pile foundations are provided in Section 5.11 (Table 8).

5.10 Site Classification

The site is classified as a Class "H1" in accordance with AS 2870 (2011) for design of shallow footings founding on residual soil. The central portion of the southern lot is classified as a Class 'P' due to the presence of uncontrolled fill up to approximately 0.7 mbgl.

The site classification is subject to the recommendations presented in this report and footings unlikely being impacted by the presence of environments that could lead to exceptional foundation material movements, such as existing or future trees or surface / subsurface water accumulation.

5.11 Geotechnical Design Parameters

Preliminary design parameters for foundations including earth pressure coefficients for retaining wall design are presented in Table 8. The design parameters assume the base of excavation of exposed shallow footing and base of bored piles / piers are free of loose / soft soils or debris and reasonably dry prior to placement of concrete and approved following inspection by an experienced and qualified geotechnical engineer.

Table 8: Geotechnical design parameters for shallow footings and piles / piers.

Layer	Shallow Footings	Piles / Piers [1]		Retaining Structures		
	ABC [2, 4]	AEBC [2, 5]	ASF [3, 5]	K_a [5]	K_p [5]	K_0 [5]
Engineered FILL:	100	NA [7]	NA [7]	0.39	2.56	0.56
Unit A – TOPSOIL: Silty CLAY	NA [7]	NA [7]	NA [7]	0.42	2.37	0.59
Unit B – FILL: Silty CLAY	NA [7]	NA [7]	NA [7]	0.42	2.37	0.59
UNIT C1 – RESIDUAL : Silty CLAY (firm)	NA [7]	NA [7]	5	0.39	2.56	0.56
UNIT C2 – RESIDUAL : Silty CLAY (stiff to very stiff)	100	NA [7]	10	0.36	2.76	0.53
Unit D – WEATHERED ROCK: SHALE (very low to low strength)	NA [7]	500	20	NA [7]	NA [7]	NA [7]

Notes:

1. Assuming bored cast in-situ pile.
2. Allowable end bearing capacity (kPa) for shallow footings embedded at least 0.3 m and piles embedded at least 0.5 m or 1 pile diameter, whichever is greater, subject to confirmation on site by a geotechnical engineer of inferred foundation conditions.
3. Allowable skin friction (kPa) below 1 m depth for bored pile in compression, assuming intimate contact between pile and foundation material. For up lift resistance, we recommend reducing ASF by 50% and checking against 'piston' and 'cone' pull-out mechanisms in accordance with AS2159 (2009).
4. ABC and ASF are recommended based on adopting a reduction factor of Øg = 0.4 in accordance with AS2159 (2009), to limit settlement to 10 mm or 1 % of the pile diameter, whichever is lesser.
5. k_a = Coefficient of active earth pressure; k_p = Coefficient of passive earth pressure; k_0 = Coefficient of earth pressure at rest.
6. Not applicable or side adhesion not recommended either due to shallow depth or potential internal settlement of materials.

6 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 detailed design by a senior geotechnical engineer to confirm adequate consideration of the geotechnical risks and adoption of the recommendations provided in this report.
2. If higher end bearing pressures are required, we recommend to carry out rock coring and point load testing of collected rock samples to assess rock strength.
3. Further investigations comprising test pits is required to determine the actual extent and depth of contaminated / unsuitable materials close to the existing shed (BH107). The services of an environmental scientist should be sought to determine the protocols of removal of the contaminated material.

6.1 Construction Monitoring and Inspections

We recommend the following is inspected and monitored during construction phase of the project (Table 9).

Table 9: Recommended inspection / monitoring requirements during site works.

Scope of Works	Frequency/Duration	Who to Complete
Inspect excavation retention (shoring, retaining wall) installations and monitor associated performance to assess need for additional support requirements.	Daily / As required	Builder / MA [1]
Inspect batters and associated performance, if applicable.	As required	MA [1]
Proof rolling of exposed subgrade by a geotechnical engineer prior to fill placement	As required [2] / prior to certification	Builder / MA [1]
Audit of fill materials and placement.	As required during earthworks	MA [1]
Inspect exposed material at foundation / subgrade level to verify suitability as foundation / lateral support / subgrade.	Prior to reinforcement set-up and concrete placement	MA [1]
Monitor sedimentation downslope of excavated areas.	During and after rainfall events	Builder
Monitor sediment and erosion control structures to assess adequacy and for removal of built up spoil.	After rainfall events	Builder
Removal of contaminated and / or asbestos containing material in the site footprint.	As required	MA [1]

Notes:

1. MA = Martens and Associates engineer

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8 Attachment A – Geotechnical Testing Plan

1:1000 @ A3

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Project No: P2108320 Map Set: MS02-R01 EPSG: 28356

Map Title / Figure:

Geotechnical Testing Plan - Minarah College

Map 01	Map
268 and 278 Catherine Fields Road, Catherine Fields, NSW.	Site
Geotechnical Investigations and Consultancy Services	Project
Geotechnical Investigation	Sub-Project
Green Valley Islamic College Limited C/- Midson Group Pty Ltd	Client
24/12/2021	Date

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9 Attachment B – Test Borehole Logs

CLIENT	Green Valley Islamic College Limited	COMMENCED	22/11/2021	COMPLETED	22/11/2021	**REF BH101**
PROJECT	Geotechnical Investigation	LOGGED	MH	CHECKED	WB/SK	Sheet 1 OF 1
SITE	268 & 278 Catherine Fields Road, Catherine Field	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P2108320
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE	150.759463	RL SURFACE	76.5 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 0.90 m depth	LATITUDE	-33.984991	ASPECT	West	SLOPE 5%

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		76.50				CI-CH	TOPSOIL: Silty CLAY; medium to high plasticity; brown and black; with rootlets and organics.	M		TOPSOIL
	L-M		0.2	0.20 76.30	0.2-0.3/S/1 D 0.20-0.30 m	■		CH	Silty CLAY; high plasticity; dark brown, dark grey and reddish brown.	M (<PL)	F	RESIDUAL SOIL
			0.4								St	
	M		0.6	0.70 75.80					0.7 m: Becoming olive brown and brown.		VSt	
	H		0.8	0.80 75.70	0.8-0.9/S/1 D 0.80-0.90 m	■		CI-CH	Silty CLAY (extremely weathered rock); medium to high plasticity; olive brown and brown.		H	
				0.90					Hole Terminated at 0.90 m (Target depth reached)			0.90: V-bit refusal on inferred very low to low strength shale / siltstone.
			1.0									
			1.2									
			1.4									
			1.6									
			1.8									
			2.0									
			2.2									
			2.4									

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Engineering Log - BOREHOLE

CLIENT	Green Valley Islamic College Limited	COMMENCED	22/11/2021	COMPLETED	22/11/2021	**REF BH102**
PROJECT	Geotechnical Investigation	LOGGED	MH	CHECKED	WB/SK	Sheet 1 OF 1
SITE	268 & 278 Catherine Fields Road, Catherine Field	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P2108320
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE	150.759539	RL SURFACE	76.3 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.60 m depth	LATITUDE	-33.985188	ASPECT	West	SLOPE 5%

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		76.30	0.1-0.3/S/1 D 0.10-0.30 m	■		CI-CH	TOPSOIL: Silty CLAY; medium to high plasticity; brown and black; with rootlets and organics.	M		TOPSOIL
			0.2									
				0.30 76.00				CH	Silty CLAY; high plasticity; dark brown, dark grey and reddish brown.			RESIDUAL SOIL
			0.4									
			0.6	0.60 75.70					0.6 m: Becoming light grey with red mottles.		F	
			0.8									
					0.9-1.0/S/1 D 0.90-1.00 m	■				M (<PL)		
	M		1.0									
											St	
	H		1.2									
					1.3-1.4/S/1 D 1.30-1.40 m	■					VSt	
			1.4									
				1.50 74.80				CI-CH	Silty CLAY (extremely weathered rock); medium to high plasticity; grey with red mottles.		H	
			1.6	1.60					Hole Terminated at 1.60 m (Target depth reached)			1.60: V-bit refusal on inferred very low to low strength shale.
			1.8									
			2.0									
			2.2									
			2.4									

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CLIENT	Green Valley Islamic College Limited	COMMENCED	22/11/2021	COMPLETED	22/11/2021	**REF BH103**	
PROJECT	Geotechnical Investigation	LOGGED	MH	CHECKED	WB/SK	Sheet	1 OF 1
SITE	268 & 278 Catherine Fields Road, Catherine Field	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P2108320	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE	150.75952	RL SURFACE	77 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.30 m depth	LATITUDE	-33.985374	ASPECT	West	SLOPE	5%

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		77.00				CI-CH	TOPSOIL: Silty CLAY; medium to high plasticity; brown and black; with rootlets and organics.	M		TOPSOIL
			0.2		0.2-0.6/S/1 D 0.20-0.60 m							
				0.30 76.70				CH	Silty CLAY; high plasticity; dark brown, dark grey and reddish brown.		St	RESIDUAL SOIL
			0.4									
	M-H		0.6	0.60 76.40					0.6 m: Becoming brown with red mottles.			
					0.7-1.2/S/1 D 0.70-1.20 m							
			0.8							M (<PL)	VSt	
			1.0									
	H		1.2	1.20 75.80				CI-CH	Silty CLAY (extremely weathered rock); medium to high plasticity; brown with red mottles.		H	
				1.30					Hole Terminated at 1.30 m (Target depth reached)			1.30: V-bit refusal on inferred very low to low strength shale / siltstone.
			1.4									
			1.6									
			1.8									
			2.0									
			2.2									
			2.4									

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CLIENT	Green Valley Islamic College Limited	COMMENCED	22/11/2021	COMPLETED	22/11/2021	**REF BH104**	
PROJECT	Geotechnical Investigation	LOGGED	MH	CHECKED	WB/SK	Sheet 1 OF 1	
SITE	268 & 278 Catherine Fields Road, Catherine Field	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P2108320	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE	150.759974	RL SURFACE	79.9 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 0.90 m depth	LATITUDE	-33.984894	ASPECT	West	SLOPE	7%

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	0.2	79.90	0.1-0.2/S/1 D 0.10-0.20 m			CI-CH	TOPSOIL: Silty CLAY; medium to high plasticity; brown and black; with rootlets and organics.	M		TOPSOIL
			0.4	*0.30* 79.60	0.4-0.5/S/1 D 0.40-0.50 m			CH	Silty CLAY; high plasticity; dark brown, dark grey and reddish brown.		F	RESIDUAL SOIL
	M		0.6	*0.50* 79.40	0.5-0.7/S/1 D 0.50-0.70 m				0.5 m: Becoming light brown and reddish brown.	M (<PL)	St	
	H		0.8	*0.80* 79.10	0.8-0.9/S/1 D 0.80-0.90 m			CI-CH	Silty CLAY (extremely weathered rock); medium to high plasticity; brown with red mottles.		H	WEATHERED ROCK
				0.90					Hole Terminated at 0.90 m (Target depth reached)			0.90: V-bit refusal on inferred very low to low strength shale.
			1.0									
			1.2									
			1.4									
			1.6									
			1.8									
			2.0									
			2.2									
			2.4									

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PROJECT	Geotechnical Investigation	LOGGED	MH	CHECKED	WB/SK	Sheet 1 OF 1
SITE	268 & 278 Catherine Fields Road, Catherine Field	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P2108320
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE	150.760031	RL SURFACE	79.7 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 2.00 m depth	LATITUDE	-33.985102	ASPECT	West	SLOPE 7%

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		79.70	0.1-0.2/S/1 D 0.10-0.20 m			CI-CH	TOPSOIL: Silty CLAY; medium to high plasticity; brown and black; with rootlets and organics.	M		TOPSOIL
	L-M		0.2	0.20 79.50	0.2-0.5/S/1 D 0.20-0.50 m			CH	Silty CLAY; high plasticity; dark brown, dark grey and reddish brown.		F	RESIDUAL SOIL
			0.4									
	M		0.6	0.50 79.20	0.5-0.9/S/1 D 0.50-0.90 m				0.5 m: Becoming light brown and reddish brown.		St	
	H		0.8								VSt	
AD/T	M-H		1.0	0.90 78.80	0.9-1.2/S/1 D 0.90-1.20 m				SHALE; brown with red mottles; highly weathered; inferred very low to low strength.	M (<PL)	H	WEATHERED ROCK 0.90: V-bit refusal.
			1.2									
			1.4									
	H		1.6	1.50 78.20					1.5 m: Inferred low strength.			
			1.8		1.7-2.0/S/1 D 1.70-2.00 m							
			2.0	2.00					Hole Terminated at 2.00 m (Target depth reached)			2.00: Tc-bit refusal on inferred low to medium strength shale / siltstone.
			2.2									
			2.4									

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PROJECT	Geotechnical Investigation	LOGGED	MH	CHECKED	WB/SK	Sheet 1 OF 1
SITE	268 & 278 Catherine Fields Road, Catherine Field	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P2108320
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE	150.7602	RL SURFACE	79 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.20 m depth	LATITUDE	-33.985474	ASPECT	West	SLOPE 5%

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		79.00	0.0-0.1/S/1 D 0.00-0.10 m			CI-CH	TOPSOIL: Silty CLAY; medium to high plasticity; brown and black; with rootlets and organics.	M		TOPSOIL
	L-M		0.2	0.20 78.80	0.2-0.5/S/1 D 0.20-0.50 m			CH	Silty CLAY; high plasticity; dark brown, dark grey and reddish brown.	M (<PL)	F	RESIDUAL SOIL
			0.4									
	M		0.6									
					0.7-0.8/S/1 D 0.70-0.80 m						St	
			0.8	0.80 78.20					0.8 m: Becoming dark brown.			
											VSt	
	H		1.0	1.00 78.00	1.0-1.2/S/1 D 1.00-1.20 m			CI-CH	Silty CLAY (extremely weathered rock); medium to high plasticity; pale brown, grey and reddish brown.			
											H	
			1.2	1.20					Hole Terminated at 1.20 m (Target depth reached)			1.20: V-bit refusal on inferred very low to low strength shale / siltstone
			1.4									
			1.6									
			1.8									
			2.0									
			2.2									
			2.4									

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Engineering Log - BOREHOLE

CLIENT	Green Valley Islamic College Limited	COMMENCED	22/11/2021	COMPLETED	22/11/2021	**REF BH107**
PROJECT	Geotechnical Investigation	LOGGED	MH	CHECKED	WB/SK	Sheet 1 OF 1
SITE	268 & 278 Catherine Fields Road, Catherine Field	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P2108320
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE	150.760541	RL SURFACE	79.8 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.80 m depth	LATITUDE	-33.985386	ASPECT	West	SLOPE 5%

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	▽ Inflow.	0.2 0.4 0.6	79.80	0.0-0.2/S/1 D 0.00-0.20 m	■		CH	FILL: Silty CLAY; high plasticity; pale brown and brown.	W		FILL 0.10: Potential asbestos containing material encountered. 0.40: Pieces of rope and anthropogenic material encountered.
	L-M		0.8 1.0 1.2 1.4	0.70 79.10	0.7-1.0/S/1 D 0.70-1.00 m	■		CH	Silty CLAY; high plasticity; light brown and reddish brown.	M (<PL)	F St VSt	RESIDUAL SOIL
	H		1.6	1.65 78.15	1.6-1.8/S/1 D 1.60-1.80 m	■		CI-CH	Silty CLAY (extremely weathered rock); medium to high plasticity; pale brown, grey and reddish brown.		H	
			1.8 2.0 2.2 2.4	1.80					Hole Terminated at 1.80 m (Target depth reached)			1.80: V-bit refusal on inferred very low to low strength shale / siltstone.

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Engineering Log - BOREHOLE

CLIENT	Green Valley Islamic College Limited	COMMENCED	22/11/2021	COMPLETED	22/11/2021	**REF BH108**
PROJECT	Geotechnical Investigation	LOGGED	MH	CHECKED	WB/SK	Sheet 1 OF 1
SITE	268 & 278 Catherine Fields Road, Catherine Field	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P2108320
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE	150.760737	RL SURFACE	81.6 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.50 m depth	LATITUDE	-33.984995	ASPECT	West	SLOPE 5%

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	0.0	81.60	0.1-0.2/S/1 D 0.10-0.20 m			CI-CH	TOPSOIL: Silty CLAY; medium to high plasticity; brown and black; with rootlets and organics.	M		TOPSOIL
	M		0.2	0.20 81.40	0.2-0.5/S/1 D 0.20-0.50 m 0.5-0.9/S/1 D 0.50-0.90 m			CH	Silty CLAY; high plasticity; dark brown, dark grey and reddish brown.	M (<PL)	F	RESIDUAL SOIL
			0.6	0.60 81.00					0.6 m: Becoming light brown.		St	
	H		1.1		1.1-1.2/S/1 D 1.10-1.20 m 1.3-1.5/S/1 D 1.30-1.50 m						VSt	
			1.4	1.40 80.20				CI-CH	Silty CLAY (extremely weathered rock); medium to high plasticity; light brown, grey and reddish brown.		H	
			1.5	1.50					Hole Terminated at 1.50 m (Target depth reached)			1.50: V-bit refusal on inferred very low to low strength shale / siltstone.

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CLIENT	Green Valley Islamic College Limited	COMMENCED	22/11/2021	COMPLETED	22/11/2021	**REF BH109**
PROJECT	Geotechnical Investigation	LOGGED	MH	CHECKED	WB/SK	Sheet 1 OF 1
SITE	268 & 278 Catherine Fields Road, Catherine Field	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P2108320
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE	150.760709	RL SURFACE	81.2 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.70 m depth	LATITUDE	-33.984646	ASPECT	West	SLOPE 5%

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		81.20			▨	CI-CH	TOPSOIL: Silty CLAY; medium to high plasticity ; brown and black; with rootlets and organics.	M		TOPSOIL
	L-M		0.2 0.4 0.6	0.10 81.10	0.1-0.15/S/1 D 0.10-0.15 m 0.2-0.7/S/1 D 0.20-0.70 m	■	▤	CH	Silty CLAY; high plasticity; dark brown, dark grey and reddish brown.	M (>PL)	St	RESIDUAL SOIL
	M		0.8 1.0 1.2				▤			M (<PL)	St VSt	
	H		1.4 1.6	1.40 79.80	1.5-1.7/S/1 D 1.50-1.70 m	■		CI-CH	Silty CLAY (extremely weathered rock); medium to high plasticity; light brown, grey and reddish brown.		H	
			1.8 2.0 2.2 2.4	1.70					Hole Terminated at 1.70 m (Target depth reached)			1.70: V-bit refusal on inferred very low to low strength shale / siltstone.

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

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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	Green Valley Islamic College Limited	COMMENCED	22/11/2021	COMPLETED	22/11/2021	**REF BH110**
PROJECT	Geotechnical Investigation	LOGGED	MH	CHECKED	WB/SK	Sheet 1 OF 1
SITE	268 & 278 Catherine Fields Road, Catherine Field	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P2108320
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE	150.761116	RL SURFACE	82.1 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.60 m depth	LATITUDE	-33.984903	ASPECT	West	SLOPE 5%

Drilling					Sampling	Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	L	Not Encountered	0.0	82.10	0.0-0.15/S/1 D 0.00-0.15 m	CI-CH	TOPSOIL: Silty CLAY; medium to high plasticity; brown and black; with rootlets and organics.	M		TOPSOIL
			0.2	0.20 81.90	0.2-0.6/S/1 D 0.20-0.60 m	CH	Silty CLAY; high plasticity; dark brown, dark grey and reddish brown.	M (>PL)	F St	RESIDUAL SOIL
	M		1.0	1.05 81.05	1.3-1.4/S/1 D 1.30-1.40 m 1.5-1.6/S/1 D 1.50-1.60 m	CI-CH	Silty CLAY (extremely weathered rock); medium to high plasticity; light brown, grey and reddish brown.	M (<PL)	H VSt H	
	H									
			1.6	1.60			Hole Terminated at 1.60 m (Target depth reached)			1.60: V-bit refusal on inferred very low to low strength shale / siltstone.

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

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Engineering Log - BOREHOLE

CLIENT	Green Valley Islamic College Limited	COMMENCED	22/11/2021	COMPLETED	22/11/2021	**REF BH111**	
PROJECT	Geotechnical Investigation	LOGGED	MH	CHECKED	WB/SK	Sheet 1 OF 1	
SITE	268 & 278 Catherine Fields Road, Catherine Field	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P2108320	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE	150.761087	RL SURFACE	81.2 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.50 m depth	LATITUDE	-33.985239	ASPECT	West	SLOPE	5%

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		81.20	0.0-0.2/S/1 D 0.00-0.20 m			CI-CH	TOPSOIL: Silty CLAY; medium to high plasticity; brown and black; with rootlets and organics.	M		TOPSOIL
			0.2	0.20 81.00	0.2-0.4/S/1 D 0.20-0.40 m			CH	Silty CLAY; high plasticity; dark brown, dark grey and reddish brown.			RESIDUAL SOIL
			0.4									
			0.6		0.6-0.8/S/1 D 0.60-0.80 m						F	
			0.8							M (<PL)		
			1.0									
	M			1.10 80.10					1.1 m: Becoming olive and brown		St	
			1.2		1.2-1.5/S/1 D 1.20-1.50 m							
	H										VSt	
			1.4	1.40 79.80				CI-CH	Silty CLAY (extremely weathered rock); medium to high plasticity; pale olive and brown.		H	
				1.50					Hole Terminated at 1.50 m (Target depth reached)			1.50: V-bit refusal on inferred very low to low strength shale / siltstone.
			1.6									
			1.8									
			2.0									
			2.2									
			2.4									

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Engineering Log - BOREHOLE

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CLIENT	Green Valley Islamic College Limited	COMMENCED	22/11/2021	COMPLETED	22/11/2021	**REF BH112**	
PROJECT	Geotechnical Investigation	LOGGED	MH	CHECKED	WB/SK	Sheet 1 OF 1	
SITE	268 & 278 Catherine Fields Road, Catherine Field	GEOLOGY	Bringelly Shale	VEGETATION	Long Grass	PROJECT NO. P2108320	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE	150.761121	RL SURFACE	80 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 0.90 m depth	LATITUDE	-33.985527	ASPECT	West	SLOPE	5%

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
HA	L	Not Encountered		80.00 *0.10*				CI-CH	TOPSOIL: Silty CLAY; medium to high plasticity; brown and black; with rootlets and organics.	M		TOPSOIL
	L-M M		0.2 0.4 0.6 0.8	79.90 *0.90*				CH	Silty CLAY; high plasticity; dark brown, dark grey and reddish brown.	M (<PL)	F St	RESIDUAL SOIL
			1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4						Hole Terminated at 0.90 m (Target depth reached)			0.90: Hand auger refusal.

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

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Engineering Log - BOREHOLE

CLIENT	Green Valley Islamic College Limited	COMMENCED	22/11/2021	COMPLETED	22/11/2021	**REF BH113**	
PROJECT	Geotechnical Investigation	LOGGED	MH	CHECKED	WB/SK	Sheet	1 OF 1
SITE	268 & 278 Catherine Fields Road, Catherine Field	GEOLOGY	Bringelly Shale	VEGETATION	Grass	PROJECT NO. P2108320	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE	150.761454	RL SURFACE	82.5 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 0.90 m depth	LATITUDE	-33.984819	ASPECT	West	SLOPE	5%

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		82.50	0.1-0.2/S/1 D 0.10-0.20 m	■	▨	CI-CH	TOPSOIL: Silty CLAY; medium to high plasticity; brown and black; with rootlets and organics.	M		TOPSOIL
	L-M		0.2	*0.20* 82.30			☰	CH	Silty CLAY; high plasticity; brown reddish brown; trace shale gravels.	M (<PL)	F VSt	RESIDUAL SOIL
	M-H		0.6	*0.60* 81.90	0.6-0.8/S/1 D 0.60-0.80 m 0.8-0.9/S/1 D 0.80-0.90 m	■	☰	CH	Silty CLAY (extremely weathered rock); medium to high plasticity; light brown, grey and reddish brown.		H	
				0.90					Hole Terminated at 0.90 m (Target depth reached)			0.90: V-bit refusal on inferred very low to low strength shale / siltstone.

Depth scale: 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, 2.4

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

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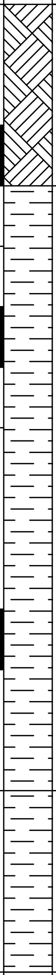
Engineering Log - BOREHOLE

CLIENT	Green Valley Islamic College Limited	COMMENCED	22/11/2021	COMPLETED	22/11/2021	**REF BH114**	
PROJECT	Geotechnical Investigation	LOGGED	MH	CHECKED	WB/SK	Sheet 1 OF 1	
SITE	268 & 278 Catherine Fields Road, Catherine Field	GEOLOGY	Bringelly Shale	VEGETATION	Long Grass	PROJECT NO. P2108320	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE	150.761922	RL SURFACE	83.1 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.60 m depth	LATITUDE	-33.485188	ASPECT	West	SLOPE	5%



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	0.2	83.10 *0.30*	0.2-0.4/S/1 D 0.20-0.40 m			CI-CH	TOPSOIL: Silty CLAY; medium to high plasticity; brown and black; with rootlets and organics.	M		TOPSOIL
			0.4 0.6 0.8	82.80	0.5-0.7/S/1 D 0.50-0.70 m			CH	Silty CLAY; high plasticity; dark brown, dark grey and reddish brown.	M	F	RESIDUAL SOIL
	M		1.0 1.2	*1.30*	1.0-1.3/S/1 D 1.00-1.30 m					M (<PL)	St VSt	
	H		1.4	81.80 *1.60*				CI-CH	Silty CLAY (extremely weathered rock); medium to high plasticity; light brown, grey and reddish brown.		H	
			1.6 1.8 2.0 2.2 2.4						Hole Terminated at 1.60 m (Target depth reached)			1.60: V-bit refusal on inferred very low to low strength shale / siltstone.

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Engineering Log - BOREHOLE

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10 Attachment C – DCP 'N' Counts

Dynamic Cone Penetrometer Test Log Summary

Site	Minarah College: 268 & 278 Catherine Fields Road, Catherine Field	**DCP Group Reference**	P2108320JS01V01
Client	Green Valley Islamic College Limited	**Log Date**	22.11.2021
Logged by	MH		
Checked by	SK		
Comments	DCPs commenced at 50 mm BGL.		

TEST DATA

Depth Interval (m)	DCP101	DCP102	DCP103	DCP104	DCP105	DCP106	DCP107	DCP108
0.15	2	3	4	2	2	2	3	1
0.30	3	3	4	3	3	4	4	3
0.45	5	3	6	3	3	3	HW [4]	5
0.60	10	4	9	8	5	4	HW [4]	6
0.75	10	3	20	8	10	5	7	5
0.90	30	3	10	4	20	8	3	3
1.05	Terminated @ 0.95 mbgl. DB [2]	4	13	Terminated @ 1.0 mbgl. DB [2]	Terminated @ 1.1 mbgl. DB [2]	13	6	5
1.20		8	30			30	6	17
1.35		11	Terminated @ 1.3 mbgl. DB [2]			Terminated @ 1.3 mbgl. HC [3]	5	35
1.50		15					13	Terminated @ 1.4 mbgl. DB [2]
1.65		Terminated @ 1.65 mbgl. DB [2]					30	
1.80							Terminated @ 1.75 mbgl. HC [3]	
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					Notes: 1. TDR = Target depth reached. 2. DB = Double bouncing. 3. HC = High blow count. 4. HW = Hammer weight.			
5.25								
5.40								
5.55								
5.70								
5.85								

Dynamic Cone Penetrometer Test Log Summary

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Site	Minarah College: 268 & 278 Catherine Fields Road, Catherine Field	**DCP Group Reference**	P2108320JS01V01
Client	Green Valley Islamic College Limited	**Log Date**	22.11.2021
Logged by	MH		
Checked by	SK		
Comments	DCPs commenced at 50 mm BGL.		

TEST DATA

Depth Interval (m)	DCP109	DCP110	DCP111	DCP112	DCP113	DCP114		
0.15	2	3	1	3	2	1		
0.30	4	3	2	3	6	2		
0.45	4	5	2	2	13	3		
0.60	5	4	2	2	23	4		
0.75	4	5	3	3	25	4		
0.90	4	5	3	5	27	4		
1.05	4	18	4	5	20	6		
1.20	7	30	8	7	18	13		
1.35	17	10	17	8	35	35		
1.50	34	12	Terminated @ 1.5 mbgl. HC[3]	7	Terminated @ 1.45 mbgl. HC[3]	Terminated @ 1.5 mbgl. HC[3]		
1.65	32	22		6				
1.80	Terminated @ 1.7 mbgl. HC[3]	40		5				
1.95		Terminated @ 1.85 mbgl. HC[3]		7				
2.10				24				
2.25				Terminated @ 2.15 mbgl. HC[3]				
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								
5.55								
5.70								
5.85								

Notes:
1. TDR = Target depth reached.
2. DB = Double bouncing.
3. HC = High blow count.
4. HW = Hammer weight.

11 Attachment D – Laboratory Test Certificates

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 283831

Client Details

Client	Martens & Associates Pty Ltd
Attention	Maheer Hasan
Address	Suite 201, 20 George St, Hornsby, NSW, 2077

Sample Details

Your Reference	**P2108320COC01V01: 268 & 278 Catherine Fields**
Number of Samples	5 soil
Date samples received	25/11/2021
Date completed instructions received	25/11/2021

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	02/12/2021
Date of Issue	02/12/2021

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
Hannah Nguyen, Metals Supervisor
Manju Dewendrage, Prep Team Leader
Nick Sarlamis, Assistant Operation Manager

Authorised By

Nancy Zhang, Laboratory Manager

Misc Inorg - Soil						
Our Reference		283831-1	283831-2	283831-3	283831-4	283831-5
Your Reference	UNITS	8320/BH101/0.2-0.3	8320/BH106/0.7-0.8	8320/BH107/0.7-1.0	8320/BH110/1.2-1.4	8320/BH111/0.6-1.1
Date Sampled		22/11/2021	22/11/2021	22/11/2021	22/11/2021	22/11/2021
Type of sample		soil	soil	soil	soil	soil
Date prepared	-	30/11/2021	30/11/2021	30/11/2021	30/11/2021	30/11/2021
Date analysed	-	30/11/2021	30/11/2021	30/11/2021	30/11/2021	30/11/2021
pH 1:5 soil:water	pH Units	6.6	6.7	6.6	5.2	5.5
Electrical Conductivity 1:5 soil:water	µS/cm	48	41	81	430	500
Chloride, Cl 1:5 soil:water	mg/kg	25	10	38	610	740
Sulphate, SO4 1:5 soil:water	mg/kg	10	10	33	190	180
Resistivity in soil*	ohm cm	210	240	120	23	20

Acid Extractable Cations in Soil						
Our Reference		283831-1	283831-2	283831-3	283831-4	283831-5
Your Reference	UNITS	8320/BH101/0.2-0.3	8320/BH106/0.7-0.8	8320/BH107/0.7-1.0	8320/BH110/1.2-1.4	8320/BH111/0.6-1.1
Date Sampled		22/11/2021	22/11/2021	22/11/2021	22/11/2021	22/11/2021
Type of sample		soil	soil	soil	soil	soil
Date prepared	-	29/11/2021	29/11/2021	29/11/2021	29/11/2021	29/11/2021
Date analysed	-	30/11/2021	30/11/2021	30/11/2021	30/11/2021	30/11/2021
Magnesium	mg/kg	1,100	1,000	1,400	1,100	1,100

Moisture						
Our Reference		283831-1	283831-2	283831-3	283831-4	283831-5
Your Reference	UNITS	8320/BH101/0.2-0.3	8320/BH106/0.7-0.8	8320/BH107/0.7-1.0	8320/BH110/1.2-1.4	8320/BH111/0.6-1.1
Date Sampled		22/11/2021	22/11/2021	22/11/2021	22/11/2021	22/11/2021
Type of sample		soil	soil	soil	soil	soil
Date prepared	-	26/11/2021	26/11/2021	26/11/2021	26/11/2021	26/11/2021
Date analysed	-	29/11/2021	29/11/2021	29/11/2021	29/11/2021	29/11/2021
Moisture	%	20	19	22	14	19

Method ID	Methodology Summary
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-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA 22nd ED 2510 and Rayment & Lyons. Resistivity is calculated from Conductivity (non NATA). Resistivity (calculated) may not correlate with results otherwise obtained using Resistivity-Current method, depending on the nature of the soil being analysed.
Inorg-008	Moisture content determined by heating at 105+/-5 °C for a minimum of 12 hours.
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. Alternatively determined by colourimetry/turbidity using Discrete Analyser.
Metals-020	Determination of various metals by ICP-AES.

Client Reference: P2108320COC01V01: 268 & 278 Catherine Fields

QUALITY CONTROL: Misc Inorg - Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	283831-2
Date prepared	-			30/11/2021	1	30/11/2021	30/11/2021		30/11/2021	30/11/2021
Date analysed	-			30/11/2021	1	30/11/2021	30/11/2021		30/11/2021	30/11/2021
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	1	6.6	6.6	0	99	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	1	48	54	12	105	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	1	25	36	36	113	118
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	1	10	10	0	115	126
Resistivity in soil*	ohm cm	1	Inorg-002	<1	1	210	180	15	[NT]	[NT]

QUALITY CONTROL: Acid Extractable Cations in Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	283831-2
Date prepared	-			29/11/2021	1	29/11/2021	29/11/2021		29/11/2021	29/11/2021
Date analysed	-			30/11/2021	1	30/11/2021	30/11/2021		30/11/2021	30/11/2021
Magnesium	mg/kg	10	Metals-020	<10	1	1100	1200	9	97	#

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.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

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 (not SPOCAS); 60-140% for organics/SPOCAS (+/-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.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

Cations in soil - # Percent recovery is not applicable due to the high concentration of the element in the sample. However an acceptable recovery was obtained for the LCS.

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Test Report

Customer: Martens & Associates Pty Ltd
Job number: 21-0136
Project: P2108320
Report number: 1
Location: 268 and 278 Catherine Fields Road, Catherine Field, NSW 2557
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.	26204	26205		
Customer sample no.	8320/CBR1/ 0.2-0.5	8320/CBR2/ 0.2-0.5		
Date sampled	22/11/2021	22/11/2021		
Material description	silty CLAY, trace of gravel, brown/pale grey/red	silty CLAY, trace of gravel, red/brown		
Maximum dry density (t/m^3)	1.56	1.62		
Optimum moisture content (%)	23.3	21.1		
Field moisture content (%)	n/a	n/a		
Oversize retained on 19.0mm sieve (%)	0	0		
Minimum curing time (hours)	48	48		
Dry density before soak (t/m^3)	1.53	1.60		
Dry density after soak (t/m^3)	1.47	1.56		
Moisture content before soak (%)	23.1	21.0		
Moisture content after soak (%)	27.8	25.2		
Moisture content after test - top 30mm (%)	34.1	28.0		
Moisture content after test - remaining depth (%)	25.2	22.9		
Density ratio before soaking (%)	98.0	98.5		
Moisture ratio before soaking (%)	99.5	99.5		
Period of soaking (days)	4	4		
Compactive effort	Standard	Standard		
Mass of surcharge applied (kg)	4.5	4.5		
Swell after soaking (%)	4.0	2.5		
Penetration (mm)	2.5	2.5		
CBR Value (%)	**2.0**	**3.5**		

Notes: Specified LDR: 98 ±1%

Method of establishing plasticity level - Visual / tactile

Approved Signatory: C. Greely

Date: 15/12/2021

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Sydney: 12/1 Boden Road Seven Hills NSW 2147 | PO Box 45 Pendle Hill NSW 2145
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Test Report

Customer: Martens & Associates Pty Ltd
Job number: 21-0136
Project: P2108320
Report number: 4
Location: 268 and 278 Catherine Fields Road, Catherine Field, NSW 2557
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.	26208	26210		
Customer sample no.	8320/CBR3	8320/CBR5		
Date sampled	30/11/2021	30/11/2021		
Material description	silty CLAY, trace of gravel and sand, brown/red	silty CLAY, trace of gravel, brown/ red/grey		
Maximum dry density (t/m^3)	1.78	1.84		
Optimum moisture content (%)	16.9	15.1		
Field moisture content (%)	n/a	n/a		
Oversize retained on 19.0mm sieve (%)	0	0		
Minimum curing time (hours)	96	48		
Dry density before soak (t/m^3)	1.75	1.80		
Dry density after soak (t/m^3)	1.74	1.78		
Moisture content before soak (%)	16.7	14.9		
Moisture content after soak (%)	18.9	17.2		
Moisture content after test - top 30mm (%)	19.5	18.4		
Moisture content after test - remaining depth (%)	17.6	15.9		
Density ratio before soaking (%)	98.5	98.0		
Moisture ratio before soaking (%)	99.0	98.5		
Period of soaking (days)	4	4		
Compactive effort	Standard	Standard		
Mass of surcharge applied (kg)	4.5	4.5		
Swell after soaking (%)	0.5	1.5		
Penetration (mm)	2.5	2.5		
CBR Value (%)	**7**	**4.5**		

Notes: Specified LDR: 98 ±1%

Method of establishing plasticity level - Visual / tactile

Approved Signatory: C. Greely **Date:** 22/12/2021

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Ph: (02) 9674 7711 | **Fax:** (02) 9674 7755 | **Email:** info@resourcelab.com.au

Test Report

Customer: Martens & Associates Pty Ltd
Job number: 21-0136
Project: P2108320
Report number: 5
Location: 268 and 278 Catherine Fields Road, Catherine Field, NSW 2557
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.	26209			
Customer sample no.	8320/CBR4			
Date sampled	30/11/2021			
Material description	silty CLAY, trace of gravel, brown/red/grey			
Maximum dry density (t/m^3)	1.55			
Optimum moisture content (%)	24.8			
Field moisture content (%)	n/a			
Oversize retained on 19.0mm sieve (%)	0			
Minimum curing time (hours)	168			
Dry density before soak (t/m^3)	1.52			
Dry density after soak (t/m^3)	1.48			
Moisture content before soak (%)	24.9			
Moisture content after soak (%)	28.8			
Moisture content after test - top 30mm (%)	34.1			
Moisture content after test - remaining depth (%)	27.0			
Density ratio before soaking (%)	98.0			
Moisture ratio before soaking (%)	100.5			
Period of soaking (days)	4			
Compactive effort	Standard			
Mass of surcharge applied (kg)	4.5			
Swell after soaking (%)	3.0			
Penetration (mm)	2.5			
CBR Value (%)	**2.5**			

Notes: Specified LDR: 98 ±1%

Method of establishing plasticity level - Visual / tactile

Approved Signatory: L. Coleman **Date:** 18/01/2022

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Ph: (02) 9674 7711 | **Fax:** (02) 9674 7755 | **Email:** info@resourcelab.com.au

Test Report

Customer: Martens & Associates Pty Ltd
Project: P2108320
Location: 268 and 278 Catherine Fields Road, Catherine Field, NSW 2557

Job number: 21-0136
Report number: 2
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 .3.4.1

	Results				
Laboratory sample no.	26200	26201	26202	26203	
Customer sample no.	8320/BH102/ 0.9-1.0	8320/BH104/ 0.5-0.7	8320/BH106/ 0.2-0.5	8320/BH111/ 0.2-0.6	
Date sampled	22/11/2021	22/11/2021	22/11/2021	22/11/2021	
Material description	silty CLAY, red/pale grey/ brown	silty CLAY, red/brown	silty CLAY, red/brown	silty CLAY, red/brown	
Liquid limit (%)	72	55	71	66	
Plastic limit (%)	21	17	19	18	
Plasticity index (%)	51	38	52	48	
Linear shrinkage (%)	14.5	15.0	12.0	16.5	
Cracking / Curling / Crumbling	Curling	-	-	Curling	
Sample history	Air dried	Air dried	Air dried	Air dried	
Preparation	Dry sieved	Dry sieved	Dry sieved	Dry sieved	

Approved Signatory: C. Greely

Date: 20/12/2021

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Sydney: 12/1 Boden Road Seven Hills NSW 2147 | PO Box 45 Pendle Hill NSW 2145
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Test Report

Customer: Martens & Associates Pty Ltd
Project: P2108320
Location: 268 and 278 Catherine Fields Road, Catherine Field, NSW 2557

Job number: 21-0136
Report number: 3
Page: 1 of 1

Shrink Swell Index

Sampling method: Tested as received

Test method(s): AS 1289.1.1, 2.1.1, 5.1.1, 7.1.1

	Results				
Laboratory sample no.	26204	26205	26206	26207	
Customer sample no.	8320/CBR1/ 0.2-0.5	8320/CBR2/ 0.2-0.5	8320/BH103	8320/BH109	
Date sampled	22/11/2021	22/11/2021	30/11/2021	30/11/2021	
Material description	silty CLAY, trace of gravel, brown/pale grey/red	silty CLAY, trace of gravel, red/brown	silty CLAY, trace of gravel, brown/ red/dark brown	silty CLAY, trace of gravel, red/ brown/pale grey	
Shrink (%)	5.7	4.4	6.1	5.8	
Moisture content (%)	22.8	21.1	21.2	20.3	
Soil crumbling	No	No	No	No	
Extent of cracking	Open cracks	Open cracks	Fine cracks	Fine cracks	
Inert inclusions (%)	<5	<5	<5	<5	
Swell (%)	0.4	0.5	1.0	0.9	
Moisture content initial (%)	22.8	21.3	21.2	20.4	
Moisture content final (%)	24.4	21.9	22.9	22.0	
Shrink swell index (%)	**3.3**	**2.6**	**3.7**	**3.5**	

Notes: Specimens remoulded. Specified LDR: 98 ± 1%.

Approved Signatory: C. Greely

Date: 21/12/2021

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NATA Accredited Laboratory Number: **17062**

12 Attachment E – General Geotechnical Recommendations

Geotechnical Recommendations

Important Recommendations About Your Site (1 of 2)

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. <u>Extremely low to low strength rock</u> - conventional hydraulic earthmoving equipment.

2. <u>Medium strength or stronger rock</u> - 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

Important Information About Your Report (1 of 2)

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

Engineering Reports - Limitations

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

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

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

Engineering Reports – Project Specific Criteria

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

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

Engineering Reports – Recommendations

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

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

Engineering Reports – Use for Tendering Purposes

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

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

Engineering Reports – Data

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

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

Engineering Reports – Other Projects

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

Subsurface Conditions - General

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

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

- Changes in guidelines, standards and policy or interpretation of guidelines, standards and policy by statutory authorities.
- The actions of contractors responding to commercial pressures.
- Actual conditions differing somewhat from those inferred to exist, because no professional, no matter how qualified, can reveal precisely what is hidden by earth, rock and time.

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

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

Subsurface Conditions - Changes

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

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

Subsurface Conditions - Site Anomalies

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

Report Use by Other Design Professionals

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

Subsurface Conditions – Geo-environmental Issues

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

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

Responsibility

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

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

Site Inspections

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

Soil Data

Explanation of Terms (1 of 3)

Definitions

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

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

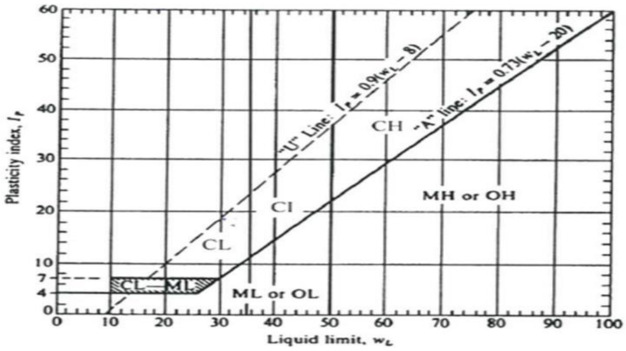
Particle Size

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		Particle Size (mm)
Oversized	BOULDERS		>200
	COBBLES		63 to 200
Coarse Grained Soil	GRAVEL	Coarse	19 to 63
		Medium	6.7 to 19
		Fine	2.36 to 6.7
	SAND	Coarse	0.6 to 2.36
		Medium	0.21 to 0.6
		Fine	0.075 to 0.21
Fine Grained Soil	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.



Soil Moisture Condition

Coarse Grained (Granular) Soil:

Dry (D):	Looks and feels dry. Cemented soils are hard, friable or powdery. Uncemented soils run freely through fingers.
Moist (M):	Feels cool and damp and is darkened in colour. Particles tend to cohere.
Wet (W):	As for moist but with free water forming on hands when handled.

Fine Grained (Cohesive) Soil:

Moist, dry of plastic limit[1] (w < PL):	Looks and feels dry. Hard, friable or powdery.
Moist, near plastic limit (w ≈ PL):	Can be moulded, feels cool and damp, is darkened in colour, at a moisture content approximately equal to the PL.
Moist, wet of plastic limit (w > PL):	Usually weakened and free water forms on hands when handled.
Wet, near liquid limit[2] (w ≈ LL)	
Wet, wet of liquid limit (w > LL)	

[1] Plastic Limit (PL): Moisture content at which soil becomes too dry to be in a plastic condition.

[2] Liquid Limit (LL): Moisture content at which soil passes from plastic to liquid state.

Consistency of Cohesive Soils

Cohesive soils refer to predominantly clay materials.
(Note: consistency is affected by soil moisture condition at time of measurement)

Term	C_u (kPa)	Field Guide
Very Soft (VS)	≤12	A finger can be pushed well into the soil with little effort. Sample exudes between fingers when squeezed in fist.
Soft (S)	>12 and ≤25	A finger can be pushed into the soil to about 25mm depth. Easily moulded by light finger pressures.
Firm (F)	>25 and ≤50	The soil can be indented about 5mm with the thumb, but not penetrated. Can be moulded by strong figure pressure.
Stiff (St)	>50 and ≤100	The surface of the soil can be indented with the thumb, but not penetrated. Cannot be moulded by fingers.
Very Stiff (VSt)	>100 and ≤200	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 (H)	> 200	The surface of the soil can only be marked with the thumbnail. Brittle. Tends to break into fragments.
Friable (Fr)	-	Crumbles or powders when scraped by thumbnail. Can easily be crumbled or broken into small pieces by hand.

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 and ≤35	5 - 10	2 - 5
Medium dense	>35 and ≤65	10 - 30	5 - 15
Dense	>65 and ≤85	30 - 50	15 - 25
Very dense	> 85	> 50	> 25

* Values may be subject to corrections for overburden pressures and equipment type and influenced by soil moisture condition at time of measurement.

Minor Components

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

Description of components	Proportion of component in:					
	coarse grained soil				fine grained soil	
	% Fines	Terminology	% Accessory coarse fraction	Terminology	% Sand/ gravel	Terminology
Minor	≤5	Trace clay / silt, as applicable	≤15	Trace sand / gravel, as applicable	≤15	Trace sand / gravel, as applicable
	>5,≤12	With clay / silt, as applicable	>15,≤30	With sand / gravel, as applicable	>5,≤30	With sand / gravel, as applicable
Secondary	>12	Prefix soil name as 'silty' or 'clayey', as applicable	>30	Prefix soil name as 'sandy' or 'gravelly', as applicable	>30	Prefix soil name as 'sandy' or 'gravelly', as applicable

Soil Data

Explanation of Terms (2 of 3)

Symbols for Soils and Other

SOILS

▨	COBBLES/BOULDERS
▨	GRAVEL (GP or GW)
▨	Silty GRAVEL (GM)
▨	Clayey GRAVEL (GC)
▨	SAND (SP or SW)
▨	Silty SAND (SM)
▨	Clayey SAND (SC)
▨	SILT (ML or MH)
▨	ORGANIC SILT or CLAY (OH or OL)
▨	CLAY (CL, CI or CH)
▨	Silty CLAY
▨	Sandy CLAY
▨	PEAT (Pt)
▨	Gravelly CLAY

OTHER

▨	FILL
▨	TALUS
■	ASPHALT
▨	CONCRETE
▨	TOPSOIL

Unified Soil Classification Scheme (USCS)

<table>
<tr><th colspan="6">FIELD IDENTIFICATION PROCEDURES
(Excluding particles larger than 63 mm and basing fractions on estimated mass)</th><th>USCS</th><th>Primary Name</th></tr>
<tr><td rowspan="8">COARSE GRAINED SOILS
More than 65 % of material less than 63 mm is larger than 0.075 mm</td><td rowspan="16">(A 0.075 mm particle is about the smallest particle visible to the naked eye)</td><td rowspan="4">GRAVELS
More than half of coarse fraction is larger than 2.36 mm.</td><td rowspan="2">GRAVEL and GRAVEL-SAND Mixtures (≤ 5% fines)</td><td colspan="2">Wide range in grain size and substantial amounts of all intermediate particle sizes; not enough fines to bind coarse grains; no dry strength</td><td>GW</td><td>GRAVEL</td></tr>
<tr><td colspan="2">Predominantly one size or a range of sizes with some intermediate sizes missing; not enough fines to bind coarse grains; no dry strength</td><td>GP</td><td>GRAVEL</td></tr>
<tr><td rowspan="2">GRAVEL-SILT and GRAVEL-SAND-SILT mixtures (≥12% fines) [1]</td><td colspan="2">With excess non-plastic fines (for identification procedures see ML below); zero to medium dry strength; may also contain sand</td><td>GM</td><td>Silty GRAVEL</td></tr>
<tr><td colspan="2">With excess plastic fines (for identification procedures see CL below); medium to high dry strength; may also contain sand</td><td>GC</td><td>Clayey GRAVEL</td></tr>
<tr><td rowspan="4">SANDS
More than half of coarse fraction is smaller than 2.36 mm</td><td rowspan="2">SAND and GRAVEL-SAND mixtures (≤5% fines)</td><td colspan="2">Wide range in grain sizes and substantial amounts of all intermediate sizes; not enough fines to bind coarse grains; no dry strength.</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; not enough fines to bind coarse grains; no dry strength</td><td>SP</td><td>SAND</td></tr>
<tr><td rowspan="2">SAND-SILT and SAND-CLAY mixtures (≥12% fines) [1]</td><td colspan="2">With excess non-plastic fines (for identification procedures see ML below); zero to medium dry strength;</td><td>SM</td><td>Silty SAND</td></tr>
<tr><td colspan="2">With excess plastic fines (for identification procedures see CL below); medium to high dry strength</td><td>SC</td><td>Clayey SAND</td></tr>
<tr><td rowspan="8">FINE GRAINED SOILS
More than 35 % of material less than 63 mm is smaller than 0.075 mm</td><td colspan="6">IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 MM</td></tr>
<tr><td>DRY STRENGTH (Crushing Characteristics)</td><td>DILATANCY</td><td>TOUGHNESS</td><td>DESCRIPTION</td><td>USCS</td><td>Primary Name</td></tr>
<tr><td>None to Low</td><td>Quick to Slow</td><td>Low</td><td>Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or silt with low plasticity [2]</td><td>ML</td><td>SILT [3]</td></tr>
<tr><td>Medium to High</td><td>None to Slow</td><td>Medium</td><td>Inorganic clays of low to medium plasticity, gravely clays, sandy clays, silty clays, lean clays</td><td>CL (or CI[4])</td><td>CLAY</td></tr>
<tr><td>Low to Medium</td><td>Slow</td><td>Low</td><td>Organic slits and organic silty clays of low plasticity</td><td>OL</td><td>Organic SILT or CLAY</td></tr>
<tr><td>Low to Medium</td><td>None to 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 [3]</td></tr>
<tr><td>High to Very 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 to Very Slow</td><td>Low to Medium</td><td>Organic clays of medium to high plasticity, organic silt of high plasticity</td><td>OH</td><td>Organic SILT or CLAY</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>
</table>

Notes:

1. Between 5% and 12% - dual classification, e.g. GP-GM.
2. Low Plasticity Clay – Liquid Limit W_L ≤35%; Medium Plasticity Clay – Liquid limit W_L >35%, ≤50%; High Plasticity Clay - Liquid limit W_L > 50%.
3. Low Plasticity Silt – Liquid Limit W_L ≤50%; High Plasticity Silt - Liquid limit W_L > 50%.
4. CI may be adopted for clay of medium plasticity to distinguish from clay of low plasticity.

Soil Agricultural Classification Scheme

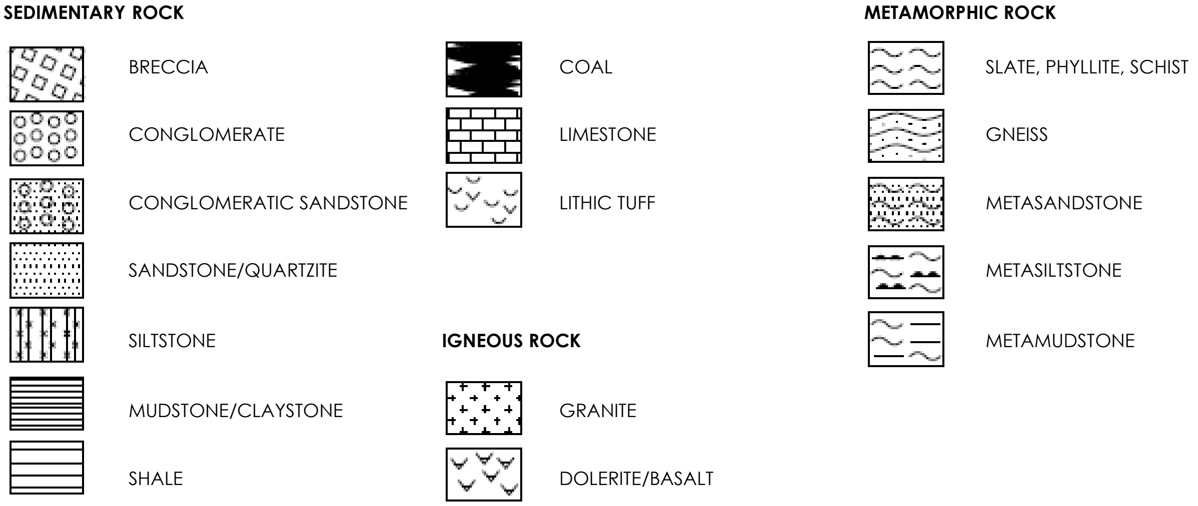
In some situations, such as where soils are to be used for effluent disposal purposes, soils are often more appropriately classified in terms of traditional agricultural classification schemes. Where a Martens report provides agricultural classifications, these are undertaken in accordance with descriptions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

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

Rock Data

Explanation of Terms (1 of 2)

Symbols for Rock



Definitions

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

Rock Material	The intact rock that is bounded by defects.
Rock Defect	Discontinuity, fracture, break or void in the material or minerals across which there is little or no tensile strength.
Rock Structure	The nature and configuration of the different defects within the rock mass and their relationship to each other.
Rock Mass	The entirety of the system formed by all of the rock material and all of the defects that are present.

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	Material is weathered to such an extent that it has soil properties. Mass structure, material texture, and fabric of original rock are no longer visible, but the soil has not been significantly transported.
Extremely weathered[1]	XW	Material is weathered to such an extent that it has soil properties - i.e. it can be remoulded and can be classified according to the Unified Classification System. Mass structure and material texture and fabric of original rock are still visible.
Highly weathered[2]	HW	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the original colour of the rock is not recognisable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Moderately weathered[2]	MW	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the rock is not recognisable. Rock strength shows little or no change from fresh rock.
Slightly weathered	SW	Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.
Fresh	FR	Rock substance unaffected by weathering. No sign of decomposition of individual materials or colour changes.

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 (Strength)	I_s (50) MPa	Uniaxial Compressive Strength MPa	Field Guide	Symbol
Very low	>0.03 ≤0.1	0.6 – 2	May be crumbled in the hand. Sandstone is 'sugary' and friable.	VL
Low	>0.1 ≤0.3	2 – 6	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	6 – 20	Core 150mm long x 50mm diameter can be broken by hand with considerable difficulty. Readily scored with a knife.	M
High	>1 ≤3	20 – 60	Core 150mm long x 50mm diameter cannot be broken by unaided hands, can be slightly scratched or scored with a knife. Breaks with single blow from pick.	H
Very high	>3 ≤10	60 – 200	Core 150mm long x 50mm diameter, broken readily with hand held hammer. Cannot be scratched with knife. Breaks after more than one pick strike.	VH
Extremely high	>10	>200	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

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

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)
●	Uniaxial compressive strength (UCS) (MPa)

Defect Type Abbreviations and Descriptions

Defect Type (with inclination given)

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

Planarity

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

Roughness

Pol	Polished
Sl	Slickensided
Sm	Smooth
Ro	Rough
VR	Very rough

Thickness

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

Coating or Filling

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

Inclination

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

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

Test, Drill and Excavation Methods

Explanation of Terms (1 of 3)

Sampling

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

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

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

Drilling / Excavation Methods

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

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

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

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

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

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

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

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

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

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

In-situ Testing and Interpretation

Cone Penetrometer Testing (CPT)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

as 4, 6, 7
N = 13

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

as 15, 30/40 mm.

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

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

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

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

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

$q_u = 2 \times C_u$.

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

Test Pit / Borehole Logs

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

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

Laboratory Testing

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

Ground Water

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

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

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

Test, Drill and Excavation Methods

Explanation of Terms (3 of 3)

DRILLING / EXCAVATION METHOD

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

SUPPORT

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

WATER

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

GROUNDWATER NOT OBSERVED (NO)	The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.
GROUNDWATER NOT ENCOUNTERED (NX)	The borehole/test pit was dry soon after excavation. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period.

PENETRATION / EXCAVATION RESISTANCE

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

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

SAMPLING

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

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

TESTING

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

Notes:

RW	Penetration occurred under rod weight only
HW	Penetration occurred under hammer and rod weight only
20/100mm	Where practical refusal or hammer double bouncing occurred, blows and penetration for that interval are reported (e.g. 20 blows for 100 mm penetration)

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		