Stevens Group

martens consulting engineers

Preliminary Geotechnical and Acid Sulfate Soil Assessment: Mardi Old Farm, 414 Old Maitland Road, Mardi, NSW

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

P1706264JR03V03

March 2021

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

Contents

1 Proposed Development and Investigation Scope

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

Table 1: Summary of proposed development and investigation scope.

Item	Details
Property Address	414 Old Maitland Road, Mardi, NSW
Legal Identifier	Lot 1 in DP 120512, Lot A in DP 396415, Lot 1 in DP 554423, Lot 101 in DP 604655 Lot 1 in DP 229970, Lot 1 in DP 229971, Lot 41 in DP 123953 and Lot 36 in DP755249.
Investigation Area (the Site)	Lot A in DP 396415, and central and northern portions of Lot 1 in DP 554423 and Lot 1 in DP 120512, respectively - Refer Figure 2, Attachment A.
LGA	Central Coast Council ('Council')
Proposed Development	We understand from the concept proposal plans (Northrop, 2021a) and client provided information that the development will include subdivision of the site into 246 residential allotments under two Community Title schemes and construction of associated internal access roads. The residential subdivision will be completed in five stages. The subdivision process involves the following: o Consolidation of eight existing lots into two Torrens Title lots. The first Torrens Title lot will comprise all of the land zoned R5 Large Lot Residential and E3 Environmental Management. The second Torrens Title lot will consist all of the land zoned E2 Environmental Conservation. The E2 zoned land is to be the subject of a Biodiversity Stewardship Agreement under the Biodiversity Conservation Act. o The R5 and E3 zoned land will further be subdivided with all of the E3 zoned land to be contained within Community Association Property as Lot 1 of a Community Scheme and six residential development lots. Five of the residential development lots will be stages in the first Community Scheme and the sixth lot will be the subject of a subsequent Neighbourhood Scheme with its own Neighbourhood Association Property. Filling up to approximately 4.75 m above existing ground level is expected to be required to reach the design earthworks platform. Filling will predominantly be carried out in the north eastern, central and south western portions of the site. Limited cutting up to approximately 2.7 metres below ground level (mbgl), particularly along the eastern, southern and western site boundaries will likely be required as part of proposed construction (Northrop, 2021b). Refer Figure 3, Attachment A for the proposed cut / fill plan.
Assessment Purpose	Preliminary geotechnical and acid sulfate soil (ASS) assessment, including preliminary pavement thickness design, to support a development application (DA) for the proposed subdivision.
Previous Assessment	A detailed contamination assessment was previously conducted by Martens and Associates (MA) to support the DA. Results of the contamination assessment are presented in MA's report referenced P1706264JR01V01, dated June 2018 (MA, 2018).
Other Assessment	A remedial action plan (RAP) was also prepared by Martens and Associates (MA) in conjunction with the preliminary geotechnical and ASS assessment. The RAP is presented in MA's report referenced P1706264JR02V01, dated December 2020 (MA, 2020).

Item	Details
Investigation Scope of Work	Field investigations conducted on 3rd, 4th and 17th November 2020 comprised: o Review of DBYD survey plans and underground services search. o General site walkover to gain an appreciation of the site. o Drilling of eighteen boreholes (BH302 to BH315 and BH322 to BH325) up to 9.0 mbgl (refer Attachment A for geotechnical investigation plan and Attachment B for borehole logs. Borehole explanatory notes is presented in Attachment G). o Collection of soil samples from boreholes for laboratory testing and for future reference. o Undertaking nine dynamic cone penetrometer (DCP) tests (DCP301 to DCP309) to 3.05 mbgl (refer Attachment C for DCP test results). We note that field investigations were undertaken following a period of heavy rainfall. Drilling of the initially proposed BH301 and BH316 to BH321 were not undertaken due to drilling rig access restrictions resulting from soft ground.
Laboratory Testing	Laboratory testing carried out by National Association of Testing Authorities (NATA) accredited laboratories included: o California Bearing Ratio (CBR) testing on five bulk soil samples, Atterberg limits and linear shrinkage testing on eight soil samples by Resource Laboratories. o Field screening of forty three soil samples and chromium suite testing on twenty five soil samples by Envirolab Services. Laboratory test certificates are provided in Attachment D.

2 General Site Conditions and Investigation Findings

2.1 General Site Details

General site details based on desktop review, site walkover and site investigations are summarised in Table 2.

Table 2: Summary of general site details.

Item	Comment
Topography	Within highly undulating terrain at the north eastern confluence of two adjacent northeast-southwest aligned ridges. The site covers the base of a northeast-southwest aligned valley between the ridges and toes of adjacent ridges to the north, west and south. Deep Creek, a tributary of Wyong River extend diagonally from the northeast corner towards the southwest corner through the base of the valley. The north eastern, central and south western portions of the site are located at the base of the valley within the Deep Creek floodplain.
Typical slopes, aspect, elevation	The north eastern, central and south western portions of the site (across the base of the valley) have gentle slopes with grades of less than approximately 5 % towards the north east. The northern, western, south eastern and southern portions of the site near the ridges toes have steeper slopes with grades of between approximately 15 % and 25 % towards Deep Creek. Site elevation ranges between approximately 3.0 mAHD in the north eastern corner at the base of the valley and 30.0 mAHD in the south eastern corner at the toe of the southern ridge (Northrop, 2019).
Expected geology	The site is underlain by two geological formations (*Gosford-Lake Macquarie Special 1:100 000 Geological Sheet 9131 & part sheet 9231*, 1st Edition): o Quaternary deposits comprising gravel and sand in the central and north eastern portions of the site (i.e. across the Deep Creek floodplain). o Patonga Claystone comprising red-brown claystone and siltstone, light green-grey fine-grained sandstone in areas near the ridge toes along the northern, western and southern site boundaries.
Soil landscape	The NSW Office of Environment and Heritage's (OEH) information system (eSPADE) indicates the site as being part of the Yarramalong (ya), Woodburys Bridge (wo) and Gorokan (gk) soil landscapes. They comprise the following: o The north eastern, central and south western portions of the site is underlain by Yarramalong soil landscape consisting of deep (> 200 cm) alluvial soils. This soil landscape is well known for flooding, foundation hazard and seasonal water logging. o A small area across the south eastern portion of the site is underlain by Gorokan soil landscape consisting of moderately deep (50–150 cm) soloths, yellow and grey-brown podzolic soils. This soil landscape often associated with very high erosion hazard, seasonal water logging, strongly acid and plastic. o The areas near the ridge toes along the northern, western and southern site boundaries is underlain by Woodburys Bridge consisting of shallow to moderately deep (50–150 cm) yellow podzolic soils on sandstone bedrock. This soil landscape is well known for extreme erosion hazard, seasonal water logging (localised) and acid soils.
Surrounding land uses	The site was bordered by Mardi Dam and bushland to the south, rural residential properties and agricultural land to the north, Old Maitland Road and rural residential properties to the east with bushland to the west.

Item	Comment
Vegetation	The majority of the site is covered by grass (particularly across the base of the valley) with dense mature trees along the toes of the ridges.
Drainage	Via overland flow towards to northeast into Deep Creek.

2.2 Sub-surface Conditions

Based on the observed variation in conditions, the site (i.e. investigation area) has been divided into two generalised zones: Zone A (north eastern, central and south western portions of the site) – underlain by quaternary alluvium and Zone B (southern and western portions of the site) – underlain by a residual soil profile of the Patonga Claystone geology (refer Figure 4, Attachment A). However a thin layer (thickness between 0.4 m and 1.0 m) of alluvium overlying residual soil profile was encountered in some boreholes (i.e. BH302, BH304, BH323 and BH324) across Zone B. Investigation revealed the following generalised subsurface units likely underlie the site:

Unit A: Topsoil comprising silty sand / sandy silt and silty clay / clayey silt, encountered up to approximately 0.3 mbgl.

Unit B: Alluvial soil comprising:

Unit B1: Generally loose clayey sand / silty sand up to between approximately 0.7 mbgl (BH311) and 2.3 mbgl (BH310).

Unit B2: Soft to firm clay / silty clay, up to between approximately 0.6 mbgl (BH324) and 7.95 mbgl (investigation termination depth of BH315). Soft clay layer was encountered at isolated locations across Zone A, particularly in the north eastern portion of the site, where thickest bulk filling is proposed.

Unit B3: Interbedded medium dense and dense clayey sand / silty sand, and clay / silty clay with consistencies varying between stiff and hard, up to maximum investigation termination depth of 9.0 mbgl (BH308).

Unit C: Residual soil comprising typically medium dense to dense silty sand, and / or silty clay / sandy clay with consistencies varying between stiff and hard, encountered up to V-bit refusal depths of between 1.5 mbgl (BH304) and 3.1 mbgl (BH324) and investigation termination depth of 4.5 mbgl. Unit C was not encountered across Zone A except in BH309.

2.3 Groundwater

Groundwater inflow was encountered during drilling of all boreholes except for BH302 to BH304, BH306, BH312 and BH314. A summary of groundwater inflow level observed during drilling of boreholes is provided in Table 3.

Table 3: Summary of groundwater levels.

Location	Geology	Surface Level (mAHD)	Depth of Groundwater inflow (mbgl)	Groundwater Inflow Level (mAHD)	Date
BH305	Quaternary	10.3	3.2	7.1	04.11.2020
BH307	Quaternary	16.1	5.5	10.6	17.11.2020
BH308	Quaternary	10.1	0.5 3.8 [1]	9.6 6.3	17.11.2020
BH309	Quaternary	16.6	0.3	16.3	17.11.2020
BH310	Quaternary	15.2	0.2 1.0	15.0 14.2	04.11.2020
BH311	Quaternary	14.6	0.4	14.2	04.11.2020
BH313	Quaternary	8.2	0.9	7.3	17.11.2020
BH315	Quaternary	4.9	4.3	0.6	04.11.2020
BH322	Quaternary	14.1	0.4	13.7	03.11.2020
BH323	Quaternary	22.6	0.5	22.1	03.11.2020
BH324	Quaternary	14.6	0.4	14.2	03.11.2020
BH325	Quaternary	12.1	0.3	11.8	03.11.2020

Notes:

1. Depth of groundwater measured at 2.7 mbgl (RL 7.4 mAHD) following completion of drilling.

Based on our observation of groundwater inflow we conclude the following:

- Shallow groundwater inflow in BH308 to BH311 and BH322 to BH325 was likely to be perched ground water as a result of recent heavy rainfall.
- Permeant groundwater levels are likely to be in the range of 2 – 5 m below grade in the lower portion of the site (Zone A).
- Minor groundwater / ephemeral perched groundwater seepage may be encountered for the proposed cut across the site,

particularly in Zone A following prolonged or heavy rainfall events. The inflow rate into excavations, however, is expected to be low.

- Groundwater level may vary in the long term depending on seasonal / climate conditions and variations in creek water levels. We recommend that long term groundwater conditions across the site, particularly across Zone A are established by additional investigation (i.e. installation of groundwater monitoring wells and long term monitoring).

3 Acid Sulfate Soil (ASS) Assessment

3.1 Guidelines

This ASS assessment was undertaken in general accordance with the following guidelines:

- Acid Sulfate Soil Management Advisory Committee (1998), Acid Sulfate Soil Manual, referred to as ASSMAC (1998).
- Qld Natural Resources, Mines and Energy (2004) Acid Sulfate Soil Laboratory Methods Guidelines.

3.2 Acid Sulfate Soil Risk Map Classification

The Wyong LEP (2013) ASS planning map indicates that the north eastern portion of the site is Class 4 land, the central, south eastern and north western portions are Class 5 land as shown in Figure 1 (Attachment A). ASSMAC (1998) indicates that development on Class 4 land has the potential to pose an environmental risk, if works extend 2 m below the natural ground surface and are likely to lower the water table more than 2 m below the natural ground surface. Class 5 land has the potential to pose an environmental risk, if works are within 500 metres of adjacent Class 1, 2, 3, or 4 land and are likely to lower the water table below 1 mAHD on the adjacent land. Therefore a preliminary geomorphic ASS assessment was undertaken.

3.3 Geomorphic Setting

The likelihood of ASS occurrence at a site is a function of various geomorphic parameters, in particular those listed in Table 3 as derived from ASSMAC (1998). Each is an indicator that ASS may be present onsite.

Table 3: Site geomorphic features indicative of ASS.

Geomorphic Feature	Present On Site?
Holocene sediments	Yes
Soil horizons less than 5 mAHD	No
Marine / estuarine sediments or tidal lakes	No
Coastal wetland; backwater swamps; waterlogged or scalded areas; inter-dune swales or coastal sand dunes (i.e. deep excavation is required)	No
Dominant vegetation is mangroves, reeds, rushes and other swamp or marine tolerant species.	Possible, adjacent to creek
Geologies containing sulfide bearing material / coal deposits or former marine shales/sediments	No
Deep older (Holocene or Pleistocene) estuarine sediments > 10 mbgl (if deep excavation or drainage is proposed)	Not known

Some of the geomorphic features listed are present on-site in Zone A. Therefore, the geomorphic setting of Zone A indicates that ASS may be present and intrusive investigation, with laboratory testing of soils, should be carried out in this area.

3.4 ASS Field Screening

3.4.1 Criteria

Initial screening was undertaken to assess the field pH (pH_f) and oxidised pH (pH_{fox}) against the following ASSMAC (1998) criteria:

- An initial soil pH (pH_f) $\leq$ 4.0 is indicative of actual acid sulfate soil (AASS).
- An oxidised soil pH (pH_{fox}) < 3.5 is indicative of potential acid sulfate soil (PASS).
- Where $pH_f - pH_{fox} > 1$ and:
  - pH_{fox} is 3.5 - 4, the soil is likely PASS.
  - pH_{fox} of 4 - 5 is neither a positive or negative indicator of potential PASS.
  - pH_{fox} > 5, with little to no drop in pH, is indicative of little net acid generation ability and unlikely PASS.

3.4.2 Samples for Field Screening

Forty three soil samples, considered to be representative of the subsurface soil profile in Zone A, were selected and submitted to

Envirolab Services for pH screening (pH_f and pH_{fox}). Table 4 below provides a summary of samples selected for such screening along with their depth and elevation.

Table 4: Summary of samples selected for pH screening.

Borehole ID	Approximate Surface Elevation (mAHD)	Sample Depth (mbgl)	Material	Approximate Sample Elevation (mAHD)
BH305	10.3	0.5 - 0.6	Sandy CLAY	9.8 - 9.7
		1.0 - 1.1	Silty CLAY	9.3 - 9.2
		1.5 - 1.6	Silty CLAY	8.8 - 8.7
		2.0 - 2.1	Silty CLAY	8.3 - 8.2
		2.5 - 2.6	Silty CLAY	7.8 - 7.7
		3.0 - 3.1	Silty CLAY	7.3 - 7.2
		3.5 - 3.6	Clayey SAND	6.8 - 6.7
		4.0 - 4.1	Clayey SAND	6.3 - 6.2
BH311	14.6	0.5 - 0.6	Silty SAND	14.1 - 14.0
		1.0 - 1.1	Sandy CLAY	13.6 - 13.5
		1.5 - 1.6	Sandy CLAY	13.1 - 13.0
BH311	14.6	2.0 - 2.1	CLAY	12.6 - 12.5
		2.5 - 2.6	CLAY	12.1 - 12.0
		3.0 - 3.1	CLAY	11.6 - 11.5
		3.5 - 3.6	CLAY	11.1 - 11.0
		4.0 - 4.1	CLAY	10.6 - 10.5
		4.5 - 4.6	CLAY	10.1 - 10.0
BH312	6.9	0.5 - 0.6	CLAY	6.4 - 6.3
		1.0 - 1.1	CLAY	5.9 - 5.8
		1.5 - 1.6	CLAY	5.4 - 5.3
		2.0 - 2.1	CLAY	4.9 - 4.8
		2.5 - 2.6	CLAY	4.4 - 4.3
		3.0 - 3.1	CLAY	3.9 - 3.8
		3.5 - 3.6	CLAY	3.4 - 3.3
		4.0 - 4.1	CLAY	2.9 - 2.8
BH322	14.1	0.5 - 0.6	Silty CLAY	13.6 - 13.5
		1.0 - 1.1	Silty CLAY	13.1 - 13.0
		1.5 - 1.6	Silty CLAY	12.6 - 12.5
		2.0 - 2.1	Silty CLAY	12.1 - 12.0
		2.5 - 2.6	Silty CLAY	11.6 - 11.5

Borehole ID	Approximate Surface Elevation (mAHD)	Sample Depth (mbgl)	Material	Approximate Sample Elevation (mAHD)
BH322	14.1	3.0 - 3.1	Silty CLAY	11.1 - 11.0
		3.5 - 3.6	Sandy CLAY	10.6 - 10.5
		4.0 - 4.1	Silty SAND	10.1 - 10.0
BH325	12.1	0.5 - 0.6	Clayey SILT	11.6 - 11.5
		1.0 - 1.1	Sandy CLAY	11.1 - 11.0
		1.5-1.6	Sandy CLAY	10.6 - 10.5
		2.0 - 2.1	Sandy CLAY	10.1 - 10.0
		2.5 - 2.6	Sandy CLAY	9.6 - 9.5
		3.0 - 3.1	Sandy CLAY	9.1 - 9.0
		3.5 - 3.6	Sandy CLAY	8.6 - 8.5
		4.0 - 4.1	Silty SAND	8.1 - 8.0
		4.5 - 4.6	Silty SAND	7.6 - 7.5
		5.5	Silty SAND	6.6

3.4.3 Results

Laboratory analytical results are summarised in Table 5 with the complete laboratory report provided as Attachment E.

Table 5: Field ASS test results.

BH/Sample Depth (mbgl)	Sample Depth (mbgl)	Material	pH_f	pH_{fox}	ΔpH	Potential Classification
Criteria			**≤4.0**	**<3.5**	**>1 pH unit decrease**	
BH305	0.5 - 0.6	Sandy CLAY	5.6	**3.1**	**2.5**	PASS
	1.0 - 1.1	Silty CLAY	5.6	**2.9**	**2.7**	PASS
	1.5 - 1.6		6.7	6.0	0.7	Not PASS
	2.0 - 2.1		7.2	6.0	**1.2**	Unlikely PASS
	2.5 - 2.6		7.3	6.3	1.0	Not PASS
	3.0 - 3.1		6.9	5.7	**1.2**	Unlikely PASS
	3.5 - 3.6	Clayey SAND	6.8	5.9	0.9	Not PASS
	4.0 - 4.1		7.1	5.8	**1.3**	Unlikely PASS
BH311	0.5 - 0.6	Silty SAND	5.6	4.0	**1.6**	Potential PASS
	1.0 - 1.1	Sandy CLAY	5.8	4.6	**1.2**	Potential PASS
	1.5 - 1.6		5.5	4.5	1.0	Not PASS
	2.0 - 2.1	CLAY	5.6	4.3	**1.3**	Potential PASS

BH/Sample Depth (mbgl)	Sample Depth (mbgl)	Material	pH_f	pH_{fox}	ΔpH	Potential Classification
BH311	2.5 - 2.6	CLAY	5.4	3.9	**1.5**	Likely PASS
	3.0 - 3.1		5.4	3.9	**1.5**	Likely PASS
	3.5 - 3.6		5.6	4.5	**1.1**	Potential PASS
	4.0 - 4.1		5.6	4.9	0.7	Not PASS
	4.5 - 4.6		5.5	4.5	1.0	Not PASS
BH312	0.5 - 0.6	CLAY	5.1	**3.3**	**1.8**	PASS
	1.0 - 1.1		4.9	3.6	**1.3**	Likely PASS
	1.5 - 1.6		4.6	3.5	**1.1**	Likely PASS
	2.0 - 2.1		5.1	3.7	**1.4**	Likely PASS
	2.5 - 2.6		5.2	3.9	**1.3**	Likely PASS
	3.0 - 3.1		5.4	4.3	**1.1**	Potential PASS
	3.5 - 3.6		6.2	5.8	0.4	Not PASS
	4.0 - 4.1		6.4	5.9	0.5	Not PASS
BH322	0.5 - 0.6	Silty CLAY	5.4	**2.2**	**3.2**	PASS
	1.0 - 1.1		5.7	**3.1**	**2.6**	PASS
	1.5 - 1.6		5.9	3.6	**2.3**	Likely PASS
	2.0 - 2.1		5.6	5.2	0.4	Not PASS
	2.5 - 2.6		6.0	4.8	**1.2**	Potential PASS
	3.0 - 3.1		5.7	3.6	**2.1**	Likely PASS
	3.5 - 3.6	Sandy CLAY	6.2	5.0	**1.2**	Potential PASS
	4.0 - 4.1	Silty SAND	6.3	4.4	**1.9**	Potential PASS
CH325	0.5 - 0.6	Clayey SILT	5.7	**2.7**	**3.0**	PASS
	1.0 - 1.1	Sandy CLAY	5.5	**2.7**	**2.8**	PASS
	1.5 - 1.6		5.7	4.2	**1.5**	Potential PASS
	2.0 - 2.1		5.9	3.9	**2.0**	Likely PASS
	2.5 - 2.6		6.8	5.6	**1.2**	Unlikely PASS
	3.0 - 3.1		6.9	5.7	**1.2**	Unlikely PASS
	3.5 - 3.6		7.0	4.8	**2.2**	Potential PASS
	4.0 - 4.1	Silty SAND	6.9	4.9	**2.0**	Potential PASS
	4.5 - 4.6		6.7	4.9	**1.8**	Potential PASS
	5.5		6.9	4.8	**2.1**	Potential PASS

The following are the key summarises of the laboratory pH Screening test results:

- None of the analysed samples are 'AASS'.
- Samples taken from 0.5 m - 0.6 m depth in BH305, BH312, BH322 and BH325, and 1.0 m - 1.1 m depth in BH305, BH322 and BH325 are potentially classified as 'PASS'.
- The majority of the remaining samples have a potential classification of 'potential PASS' or 'likely PASS'.

3.5 Chromium Suite Assessment

3.5.1 Methodology

Based on the results of the field screening assessment, twenty five samples (Table 6) were submitted for further chromium suite laboratory testing to determine the presence of ASS material.

Table 6: Summary of samples selected for chromium suite assessment.

Borehole ID	Approximate Surface Elevation (mAHD)	Sample Depth (mbgl)	Material	Approximate Sample Elevation (mAHD)
BH305	10.3	0.5 - 0.6	Sandy CLAY	9.8 - 9.7
		1.0 - 1.1	Silty CLAY	9.3 - 9.2
		2.0 - 2.1	Silty CLAY	8.3 - 8.2
		2.5 - 2.6	Silty CLAY	7.8 - 7.7
		3.0 - 3.1	Silty CLAY	7.3 - 7.2
BH311	14.6	0.5 - 0.6	Silty SAND	14.1 - 14.0
		1.0 - 1.1	Sandy CLAY	13.6 - 13.5
		1.5 - 1.6	Sandy CLAY	13.1 - 13.0
		2.0 - 2.1	CLAY	12.6 - 12.5
		2.5 - 2.6	CLAY	12.1 - 12.0
		3.0 - 3.1	CLAY	11.6 - 11.5
		3.5 - 3.6	CLAY	11.1 - 11.0
BH312	6.9	0.5 - 0.6	CLAY	6.4 - 6.3
		1.0 - 1.1	CLAY	5.9 - 5.8
		1.5 - 1.6	CLAY	5.4 - 5.3
		2.0 - 2.1	CLAY	4.9 - 4.8
		2.5 - 2.6	CLAY	4.4 - 4.3
		3.0 - 3.1	CLAY	3.9 - 3.8

Borehole ID	Approximate Surface Elevation (mAHD)	Sample Depth (mbgl)	Material	Approximate Sample Elevation (mAHD)
BH322	14.1	0.5 - 0.6	Silty CLAY	13.6 - 13.5
		1.0 - 1.1	Silty CLAY	13.1 - 13.0
		1.5 - 1.6	Silty CLAY	12.6 - 12.5
		3.0 - 3.1	Silty CLAY	11.1 - 11.0
BH325	12.1	0.5 - 0.6	Clayey SILT	11.6 - 11.5
		1.0 - 1.1	Sandy CLAY	11.1 - 11.0
		2.0 - 2.1	Sandy CLAY	10.1 - 10.0

3.5.2 ASS Action Criteria

It is estimated that more than 1000 tonnes of soil will be disturbed as part of the development works in Zone A. The ASSMAC (1998) indicates that an ASS management plan (ASSMP) will be required if the criteria in Table 7 are exceeded.

Table 7: Action criteria based on ASS soil analysis for > 1000 tonnes soil disturbance.

Texture	Sulfur Trail (S_{cr}) (%)	Acid Trail (Net Acidity) (mol H+/tonne)
Coarse	0.03	18
Medium		
Fine		

3.5.3 Results

A summary of laboratory chromium suite analytical results is provided in Attachment D with the complete laboratory report provided as Attachment E.

No samples exceed the sulfur trail action criteria. Under acid trail, the net acidity is elevated in majority of the tested soil samples, which indicates other acid generating mechanism apart from sulfidic soils that are present at the site. 8 out of the 14 samples that exceeded the acid trail action criteria were from shallow depth (from ground surface to 1.6 mbgl).

3.6 Discussion / Conclusion

Laboratory chromium reducible sulfur suite analytical results indicate that no tested soil samples are either AASS or PASS, however they are acidic soil originated from other mechanism (possibly organic acid). Therefore, the soils at the site should not be regulated as ASS, however it is prudent that the soils are appropriately managed to prevent causing any environmental impacts from acid generation when disturbed. We recommend preparation of a management plan to address risk associated with potential acid generation, subject to further ASS assessment particularly within the proposed cut area across Zone A. The further assessment will confirm / revise preliminary findings of this report in relation to ASS and to delineate ASS conditions across the site considering final development details.

4 Geotechnical Assessment

4.1 Laboratory Test Results

The following sections summarise the laboratory testing results completed to date.

4.1.1 Atterberg Limits Testing

A summary of Atterberg limits test results are presented in Table 8 (refer Attachment D for Atterberg limits test certificate).

Table 8: Summary of laboratory soil reactivity test results.

Borehole No.	Depth (mbgl)	Soil Type	Atterberg Limits (%)				Plasticity Classification	Potential Volume Change [2]
			LL [1]	PL [1]	PI [1]	LS [1]		
BH302	1.8-2.2	Silty CLAY	43	15	28	13.0	Medium	Medium to high
BH310	0.3-1.0	Sandy Silty CLAY	27	16	11	6.5	Low	Low
BH310	1.0-2.0	Clayey SAND	22	15	7	3.0	Low	Low
BH323	1.0-1.5	Silty CLAY, with sand	30	13	17	5.5	Low	Low to medium
BH323	2.0-2.5	Silty CLAY, with sand	28	13	15	5.5	Low	Low to medium
BH313	0.3-0.8	Clayey SAND	23	17	6	2.5	Low	Low
BH315	0.5-1.0	Silty CLAY	57	18	39	10.0	High	High
BH307	0.5-1.0	Silty CLAY	52	19	33	13.5	High	High

Notes:

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

Laboratory test results indicate that the plasticity of tested soil samples ranges between low and high. Residual and alluvial silty clay at the site is expected to be medium to high plasticity. Plasticity of the site soils may result in ground movement varying between low and high due to soil moisture changes.

4.1.2 California Bearing Ratio (CBR) Testing

Laboratory CBR test results are summarised in Table 9 (refer Attachment D for CBR test certificate). All CBR tests were carried out on alluvial soil samples (from Zone A), except for the sample from BH324 which is of residual origin (from Zone B).

Table 9: CBR test results.

Borehole Number	Sample Depth (mbgl)	Material	CBR [1] Value (%)
BH304	0.3 – 0.8	Silty Clayey SAND	25
BH309	0.3 – 1.0	Silty Sandy CLAY	19
BH324	0.6 – 1.0	Silty CLAY	2.5
BH313	0.3 – 0.8	Clayey SAND	35
BH314	0.3 – 0.8	Silty Clayey SAND	25

Notes:

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

4.2 Preliminary Material Properties

Preliminary material properties inferred from observations during borehole drilling, such as auger penetration resistance and DCP test results as well as engineering judgement are summarised in Table 10.

Table 10: Preliminary estimates of soil strength properties.

Layer	$\gamma_{in\text{-}situ}$ [1] (kN/m³)	Cu [2] (kPa)	C' [3] (kPa)	Ø' [4] (deg)	E' [5] (MPa)
TOPSOIL: silty SAND / Sandy SILT / Silty CLAY / Clayey SILT (varying densities and consistencies, moist)	16	NA [6]	NA [6]	NA [6]	NA [6]
Silty SAND / Clayey SAND (loose to medium dense, moist and wet)	16 (moist) 18 (wet)	NA [6]	NA [6]	30	15
Silty SAND / Clayey SAND (medium dense to dense, moist and wet)	19 (moist) 21 (wet)	NA [6]	NA [6]	34	35
CLAY / Silty CLAY (soft to firm, moist and wet)	16 (moist) 18 (wet)	20	1	22	5
CLAY / Silty CLAY (stiff to very stiff, moist and wet)	18 (moist) 19 (wet)	75	4	26	20
CLAY / Silty CLAY (very stiff to hard, moist and wet)	19 (moist) 20 (wet)	150	6	28	40

Notes:

1. Material in-situ unit weight (inferred average for unit), based on visual assessment (±10 %).
2. Undrained shear strength estimate.
3. Drained (effective) cohesion estimate.
4. Effective internal friction angle estimate assuming drained conditions.
5. Effective elastic modulus (±10 %) estimate.
6. Not applicable.

4.3 Risk of Slope Instability

4.3.1 Site Observations

The ridge side slopes along the southern, western and northern boundaries of the site were visually assessed for evidence of historical slope movement. Site inspection revealed:

- Ridge sides along the site boundary was densely covered by vegetation and trees with slopes approximately between 20% and 40%.

- No evidence of former slope instability (landslip), e.g. soil creep, leaning trees and hummocky ground, was observed across the south eastern portion of the site and in the immediate vicinity of ridge toe.

- Evidence of isolated shallow former slope instability (landslip), e.g. soil creep, leaning trees, hummocky ground and displaced sandstone boulders was observed in the vicinity of the western portion of the site near ridge toe, approximately 150 m west from the western site boundary.

4.3.2 Preliminary Slope Instability Assessment

Considering the assessed geotechnical conditions at the site, the risk of landslide as a result of the proposed development or concerns on impacting the proposed development is expected to be low. The site is considered suitable for the proposed development, subject to the recommendations presented in this report and adoption of relevant Australian Standards and industry guidelines.

4.4 Geotechnical Constraints

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

- Loose alluvial clayey sand in Zone A up approximately 2.3 mbgl may lead to immediate foundation settlement under applied building loads, including loads from plant and machinery during construction.

- Thick (> 3 m) soft to firm clay encountered at deeper soil profile in the north eastern portion of Zone A. This material is susceptible to consolidation settlement in the long term, which could potentially cause damage to the new structures / infrastructures as well as slope instability during construction (filling to earthworks platform level). We note that soft to firm clay is expected to be encountered within the soil profile at depth in other locations across Zone A.

- Groundwater across Zone A is expected to be shallow and variable. Variation of groundwater levels as a result of weather and seasonal changes may impact foundation design and construction methodologies.

- Presence of acidic soils within subsurface profile, particularly across Zone A.

- Proposed cut along the toe of the ridge batters (i.e. across Zone B) for the perimeter road may induce slope instability. Proposed cut for the perimeter road across south eastern portion of the site may extends into rock.

5 Preliminary Pavement Thickness Design

5.1 Overview

Preliminary flexible pavement thicknesses design for the proposed internal access road were undertaken in accordance with Central Coast City Council's Civil Works Specification - Design Guideline (CCC, 2018a) and Austroads - Guide to Pavement Technology Part 2 : Pavement Structural Design (Austroads, 2017).

5.2 Design Parameters

5.2.1 Equivalent Standard Axles (ESA)

A traffic loading of 3×10^5 Equivalent Standard Axles (ESA) was adopted in accordance CCC, 2018a.

5.2.2 Pavement Design Life

A design life of 40 years was adopted in accordance CCC, 2018a.

5.2.3 Design CBR

<u>Zone A</u>

Test results returned CBR values between 19 % and 35 % for the alluvial soils in Zone A. Given the limited laboratory testing, DCP-CBR correlations were carried out using Austroads (2017), returning CBR values of typically between 2.5 % and 7 %. We note that medium to high plasticity silty clay was encountered at some locations within the subgrade area, which has likely lower CBR values. In addition, the CBR testing results may not be applicable for final subdivision road design in Zone A which based on a plan provided by Northrop proposes significant earthworks involving cut and fill. Considering the CBR test results, CBR values interpreted from DCP tests and the likely variable cut and fill requirements across the site, we have adopted a CBR value of 7 for preliminary design purposes, subject to the following:

- Further laboratory CBR assessment following completion of proposed earthworks.

- If material of inferior quality (i.e. CBR < 7 %) is uncovered during excavation, subgrade improvement (e.g. lime stabilisation) will be required to achieve a CBR of 7 %. Alternatively, a lower CBR value should be adopted and pavement thickness design may need to be revised.

Zone B

Test results returned a CBR value of 2.5 % for the residual silty clay in Zone B. This CBR value is typical for residual soils derived from Patonga Claystone. Considering this, a subgrade CBR of 2.5 % has been adopted to represent encountered site conditions in Zone B. Therefore subgrade improvement / replacement will be required. We recommend one of the following subgrade treatment option is adopted (following stripping of topsoil to expose subgrade materials) to improve subgrade conditions for long term general use:

- Remove and replace with engineered fill up to 0.3 m depth of the poor subgrade material.
- Alternatively, stabilise the exposed subgrade layer up to at least 0.3 m depth from the top with cement / lime or similar binding agent or install geofabric / geogrid reinforcement in a high strength aggregate layer above subgrade level.

5.3 Preliminary Pavement Thickness

Table 11 presents recommended pavement materials and material thicknesses for the proposed flexible pavement in Zone A and Zone B.

Table 11: Preliminary pavement thickness design for Zone A and Zone B.

Layer	Thickness (mm)	Total Thickness (mm)	Materials
CBR 7 % (Zone A)			
Wearing Course	40	310 [3]	Single coat 10 mm seal + 30 mm AC10
Base	120 [1, 2]		DGB20
Sub-base	150 [1, 2]		DGS20 or DGS40
CBR 3 % (Zone B)			
Wearing Course	40	460 [4]	Single coat 10 mm seal + 30 mm AC10
Base	120 [1, 2]		DGB20
Sub-base	300 [1, 2]		DGS20 or DGS40

Notes:

1. Based on Figure 8.4 of Austroads, 2017.
2. Minimum based on CCC, 2018b.
3. Assume subgrade improvement where CBR < 7 %.
4. Assume subgrade improvement where CBR < 3 %.

5.4 Earthworks for Road Construction

5.4.1 Subgrade Preparation

The subgrade is to be trimmed and compacted, following the removal of topsoil / silt deposits and other unsuitable materials such as root containing soils and soft to firm clays. Minimum relative density of subgrade shall be 100 % Maximum Dry Density (MDD) at a standard compactive effort within - 2 % 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 localised soft 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.

5.4.2 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.

5.4.3 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 materials shall be compacted to the following condition:

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

- Base - Minimum 95% MDD at modified compactive effort (± 2 % OMC).

Compaction testing shall be undertaken by a NATA accredited laboratory in accordance with procedures as outlined in CCC, 2018b. 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.

5.4.4 Fill Placement

Should filling be required to raise subgrade levels, approved site-won material or imported fill (granular or low plasticity clay) should be used. 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. An earthworks specification is to be prepared by the supervising engineer and be implemented by the contractor.

5.4.5 Other Recommendations

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

Consideration should be given to the provision of appropriate cross drainage structures (e.g. bridges / culverts) across the creek to connect different portions of the proposed development.

6 Geotechnical Recommendations

6.1 General Geotechnical Recommendations

Geotechnical recommendations for site development are provided below. Further general geotechnical recommendations are provided in Attachment F.

6.1.1 Excavations

Soils and weathered rock should be readily excavated using conventional earthmoving equipment. Excavation into low strength rock may require a 'toothed' bucket or a ripping tyne (or similar). Further investigation, including rock coring is recommended to better define rock conditions at the site, particularly in Zone B, for developing appropriate construction methodologies.

6.1.2 Excavation Support

Excavation in soil exceeding 1.0 m depth must be temporarily and permanently battered back / supported / retained to maintain slope stability. The following maximum batter grades are recommended, subject to inspection and approval by a geotechnical engineer on site.

- Temporary slope (unsupported for less than 1 month): 1V:2H.
- Permanent slope: 1V:3H.

In cut areas where there are space restrictions, steeper batters could be adopted by installation of soil nails with shotcrete over the batter surface or construction of a mid- height retaining wall. Retained heights are generally not more than 4 m and retaining wall options that could be adopted include free draining gabion baskets, sandstone block walls or free cantilevered reinforced concrete walls.

6.1.3 Site Preparation and Earthworks

6.1.3.1 General Recommendations

We recommend carry out the following site preparation and earthworks:

- The subgrade is to be proof rolled using a 8 tonne smooth drum roller with a minimum of 6 passes, following the removal of topsoil and other unsuitable materials such as root containing soils and soft to firm clay up to a depth of 1 m. We recommend all excavated material should be stockpiled and undergo formal waste classification (following lime treatment in accordance with ASS management plan, where necessary) in accordance with NSW EPA (2014) Waste Classification Guidelines prior to on-site re-use (where possible) or off-site disposal to a suitable location in accordance with NSW Waste Classification Guidelines.

- A qualified geotechnical engineer should inspect the condition of the exposed subgrade, to assess suitability of the subgrade for fill placement.
- Inspection of the subgrade during proof roll should be carried out by a geotechnical engineer to assess if localised weak subgrade material need to be removed and replaced with approved fill.
- Fill material should be placed in horizontal layers, generally not more than 300 mm in loose thickness. Compact newly place fill in accordance with AS3798 (2007). Site-won excavated alluvial and residual soils may be re-used for general / engineered fill, subject to compliance with AS3798 (2007) and further assessment of soil plasticity to determine if any treatment is required prior to placement. Alternatively, imported fill (granular or low plasticity clay) should be adopted.

  Should the unsuitable material such as non-organic soil and / or soft to firm clay be considered for re-use, mixing with suitable imported material (e.g. bottom ash) may be considered, subject to the following:

  1. Inspection and approval by the onsite geotechnical engineer and compliance with AS3798-2007.
  2. Assessment of material quality, particle size distribution and capability to comply with compaction requirement.
  3. Assessment of environmental impacts.

- Filling should be carried out in stages. Maximum fill batter should not exceed a grade of 1V:3H, with a maximum lift of 1 m in height at each stage. Appropriate berm to provide lateral restraint and as a counter weight to the fill batter may also be constructed to minimise slope instability risk during construction.
- Contractor should submit their earthworks construction methodology for earthworks to a senior geotechnical engineer for review and approval.

All earthworks should be carried out under Level 1: Inspection and Testing as defined in Section 8 of AS3798 (2007) and council's requirements under the guidance of a geotechnical engineer.

6.1.3.2 Ground Treatment for Filling over Soft Soils

In order to accelerate the primary consolidation settlement of the soft to firm alluvial clay within the soil profile across Zone A, the following two ground treatment methods are recommended:

- In areas underlain by soft to firm alluvial clays to say 2 - 3 m depth from existing ground surface, we recommend to partially remove the underlying clays to a depth of 1 m and replace with engineered fill or granular material. Subsequently, surcharge should be placed over the area to accelerate the consolidation process.
- In areas underlain by deeper soft to firm alluvial clays (> 3 m) as encountered in BH315, we recommend to install prefabricated vertical drains (PVD) and surcharge the area to accelerate the consolidation process by provision of horizontal drainage.

We note that considerable consolidation settlement is expected to occur where fill depth exceeds 0.5 m overlying the soft alluvial clay. Depending on the soil properties, thickness of soft to firm clay and drainage characteristics, the time taken to achieve required degree of consolidation may typically range between 3 and 6 months. Further field investigations and laboratory testing on selected soil samples should be undertaken to evaluate the time required for achieving a target degree of consolidation.

6.1.3.3 Settlement Monitoring

Monitoring of primary consolidation settlement behaviour needs to be carried out on-site to determine the actual settlement performance under fill loads, particularly in areas underlain by soft to firm clays > 1 m depth across Zone A. Monitoring should include site surveying, settlement plates and ground settlement markers installed on the ground surface.

6.1.4 Earth Pressure Coefficients

Where the depth of excavation exceeds 1 m, excavation support (temporary shoring) or retaining wall design, may adopt preliminary earth pressure coefficients presented in Table 12.

Table 12: Preliminary earth pressure coefficients.

Material	K_0 [1]	K_a [1]	K_p [1]
Soft to firm clay / silt	0.63	0.46	2.20
Loose to medium dense sand	0.50	0.33	3.00
Stiff to very stiff clay / silt	0.56	0.39	2.56

Notes:

1. K_0 = Earth pressure coefficient at rest, K_a = active earth pressure coefficient and K_p = passive earth pressure coefficient.

6.1.5 Site Classification

The area of the site across Zone A is classified as a class 'P' site in accordance with AS 2870 (2011) due to presence of loose and / or soft soil within the soil profile. The area of the site across Zone B is classified as a class 'H1' site in accordance with AS 2870 (2011) for design of lightly loaded shallow footing founding in at least medium dense sand / stiff clay.

Future residential lots across Zone A may be reclassified as class 'H1' following ground treatment and placement of granular or site won material. This reclassification is subject to the recommendations presented in this report, design of footings in accordance with the relevant Australian Standards and the following conditions:

- Construction of foundations following occurrence of acceptable degree of primary consolidation settlement of soft to firm clay across proposed fill areas after ground treatment.

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

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

6.1.6 Groundwater / Drainage Requirements

It is unlikely that the proposed cutting will intercept the groundwater table across Zone B. Ephemeral and potential groundwater seepage may be encountered across Zone A, particularly after rainfall events. Significant excavation in Zone A is mainly proposed for water quality / quantity statements and impacts of groundwater on these locations are subject to additional groundwater assessment results.

Appropriate surface and sub-surface site drainage should be provided to intercept and divert overland flows, perched and permanent groundwater, away from road pavements, excavations or structures and discharge into Council approved discharge points. Site drainage may include sub soil drains below pavements, strip drains and horizontal drains along cut slopes, concrete V drains at the crest and toe of fill embankments and weep holes at locations of concrete retaining walls. A maintenance regime, particularly for the horizontal drains and weep holes should be undertaken periodically to ensure that they are not clogged and in good working condition for its intended use.

7 Proposed Additional Works

7.1 Works Prior to Construction

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

1. Additional borehole investigations, particularly across the proposed cut area in Zone A to better define the risk of acidic alluvial soils.

2. Additional intrusive (borehole or cone penetration testing) investigation below current investigation termination depth to identify the extent and thickness of soft clay across Zone A of the site (particularly where filling is proposed).

3. Laboratory testing of soft to firm clayey soil present within the soil profile across Zone A for more accurate prediction of the settlement and the rate of consolidation.

4. More detailed CBR testing across pavement areas following completion of cut and fill design works.

5. Installation of groundwater monitoring well(s) and monitoring with continuous data loggers, particularly across Zone A, to assess permanent groundwater levels at site.

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

7.2 Construction Monitoring and Inspections

We recommend the following is inspected and monitored during construction phase of the project (Table 13).

Table 13: Recommended inspection / monitoring requirements during site works.

Scope of Works	Frequency/Duration	Who to Complete
Inspect batters and associated performance, if applicable.	As required	MA [1]
Monitor proof rolling of exposed subgrade by a geotechnical engineer prior to pavement material placement.	As required [2] / prior to pavement material placement	Civil contractor / MA [1]
Audit of fill materials and placement.	As required during earthworks	MA [1]
Monitor primary consolidation settlement.	As required during earthworks	Builder
Review initial consolidation settlement data and assess need for additional surcharge.	As required during earthworks	MA [1]
Inspect excavation retention (retaining wall) installations and monitor associated performance, if applicable, to assess need for additional support requirements.	Daily / As required [2]	Builder / MA [1]
Monitor groundwater seepage from excavation faces, if encountered, to assess stability of exposed materials and need for additional drainage requirements.	When encountered	Builder / 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

Notes:

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

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Wyong Local Environmental Plan (2013) *Acid Sulfate Soils Map - Sheet ASS_007.*

9 Attachment A – Figures

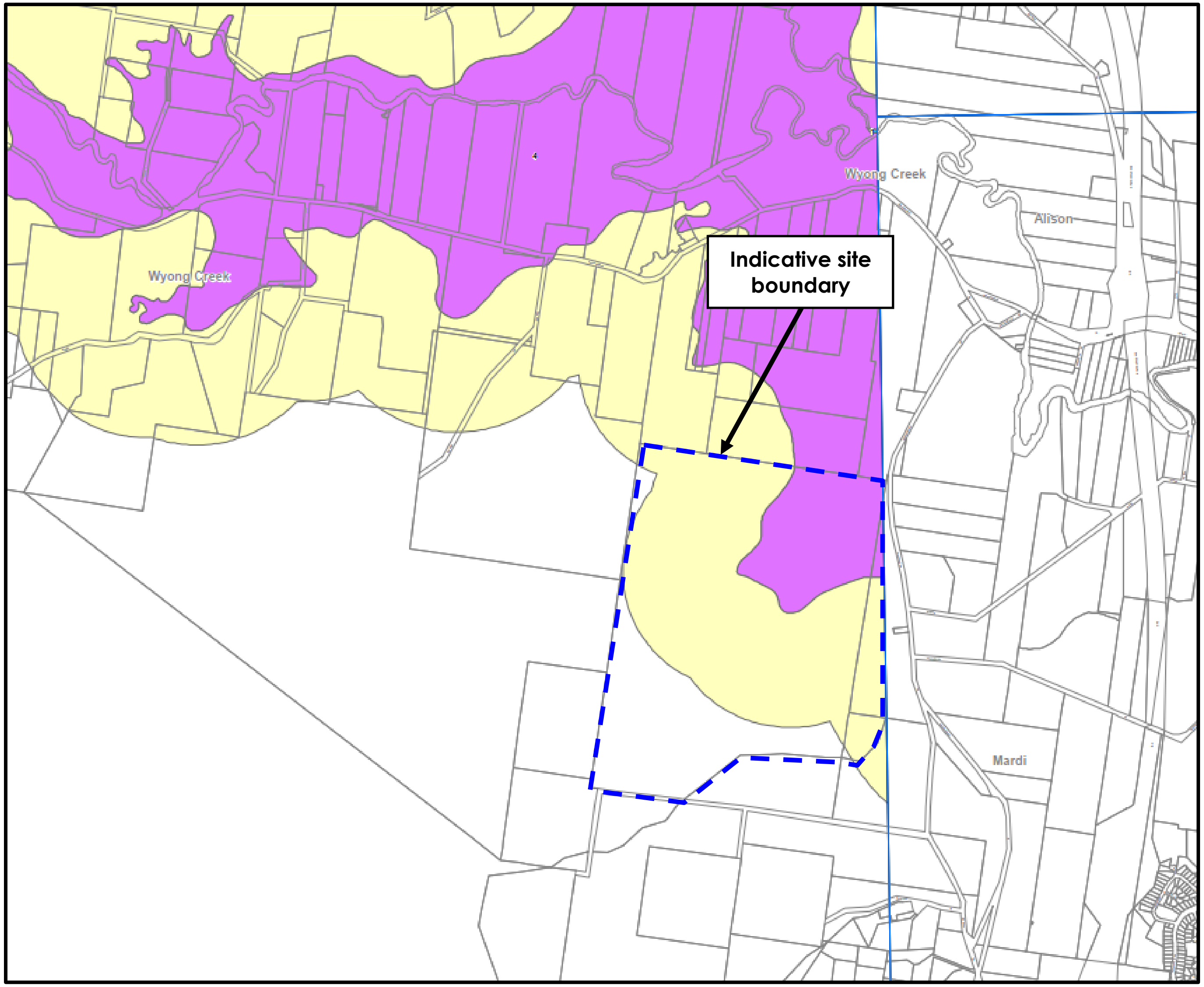
N

Wyong Local Environmental Plan 2013

Acid Sulfate Soils Map - Sheet ASS_007

Acid Sulfate Soils

1	Class 1
2	Class 2
3	Class 3
4	Class 4
5	Class 5



martens

Martens & Associates Pty Ltd ABN 85 070 240 890		Environment | Water | Wastewater | Geotechnical | Civil | Management	
Drawn:	WB	SITE LOCATION RELATIVE TO ASS RISK CLASSES Mardi Old Farm, 414 Old Maitland Road, Mardi, NSW (Source: Wyong LEP, 2013)	Drawing: FIGURE 1
Approved:	SK		
Date:	07.01.2021		
Scale:	NA		Job No: P1706264JR03V03

0 60 120 180 240 300 m

1:5000 @ A3

Viewport A

Map Title / Figure:

Figure 2: Geotechnical Investigation Plan

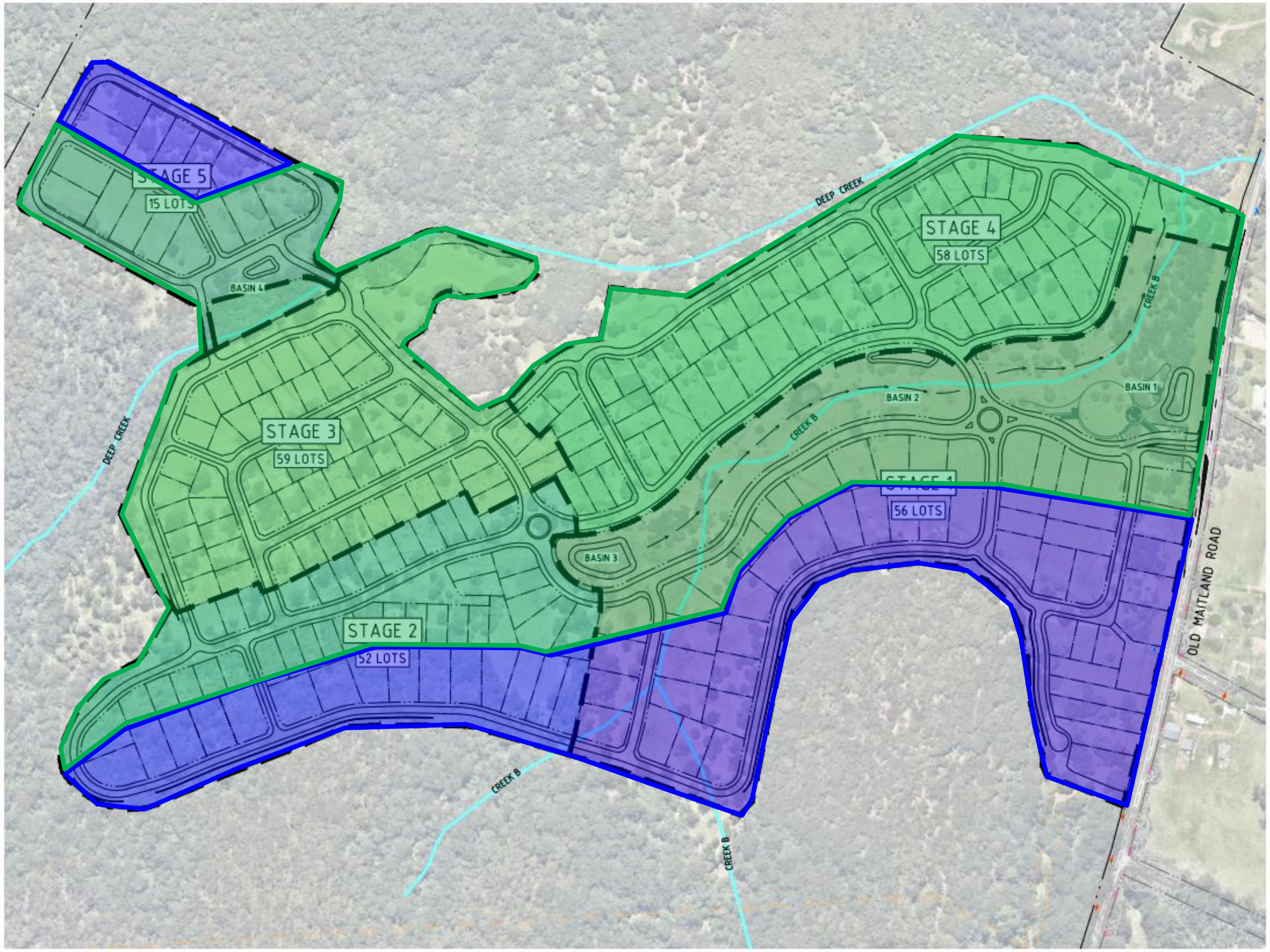
GE01	Map
Old Maitland Road, Mardi	Site
Subdivision	Project
Preliminary Geotechnical & Ass Assessment	Sub-Project
Stevens Holdings Pty Ltd	Client
08/01/2021	Date

martens
Environment | Water | Geotechnics | Civil | Projects

Project No: P1706264 Map Set: MS02-R02 EPSG: 28356

martens

Martens & Associates Pty Ltd ABN 85 070 240 890		Environment | Water | Wastewater | Geotechnical | Civil | Management	
Drawn:	WB	**CUT / FILL PLAN** **Mardi Old Farm, 414 Old Maitland Road, Mardi, NSW** (Source: Northrop, 2021)	Drawing: **FIGURE 3**
Approved:	SK		
Date:	23.03.2021		
Scale:	NA		Job No.: P1706264JR03V03



Zone A: Indicative area underlain by alluvial soils (Unit B)

Zone B: Indicative area underlain by residual soils (Unit C)

martens

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	WB	**GEOTECHNICAL INVESTIGATION LAYOUT PLAN** **Mardi Old Farm, 414 Old Maitland Road, Mardi, NSW** (Source: Northrop, 2021a)	Drawing: **FIGURE 4**
Approved:	SK		
Date:	23.03.2021		
Scale:	NA		Job No.: P1706264JR03V03

10 Attachment B – Borehole Logs

CLIENT	Stevens Group	COMMENCED	04/11/2020	COMPLETED	04/11/2020	REF BH302
PROJECT	Geotechnical Assessment	LOGGED	SVK	CHECKED	WB/SK	Sheet 1 OF 1
SITE	414 Old Maitland Road, Mardi, NSW	GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P1706264
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.3936	RL SURFACE	21.7 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 4.50 m depth	NORTHING	-33.2874	ASPECT	Northeast	SLOPE 7%

METHOD	PENETRATION RESISTANCE	WATER	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	0.15 / 21.55		SM	TOPSOIL: Silty SAND; fine to medium; dark grey to dark olive; with clay.	M	L	TOPSOIL
AD/V	L	Not Encountered	1.20 / 20.50	0.3-1.0/S/1 D 0.30-1.00 m	SM	Silty SAND; fine to medium; grey to olive; trace clay.	M	MD	ALLUVIUM
AD/V	M	Not Encountered	1.60 / 20.10		SM	Silty SAND; fine to course; brown; with silt and gravel.	M	MD - D	
AD/V	M	Not Encountered	3.80 / 17.90	1.5-2.2/S/1 D 1.50-2.20 m	CI	Silty CLAY; medium plasticity; reddish brown; trace sand.	M (<PL)	VSt	RESIDUAL SOIL
AD/V	H	Not Encountered	4.50		CL-CI	Silty CLAY; low to medium plasticity; reddish brown; with sand.	M (<PL)	VSt - H	

Hole Terminated at 4.50 m
(Target depth reached)

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

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Engineering Log - BOREHOLE

CLIENT	Stevens Group	COMMENCED	04/11/2020	COMPLETED	04/11/2020	REF **BH303**	
PROJECT	Geotechnical Assessment	LOGGED	SVK	CHECKED	WB/SK	Sheet 1 OF 1	
SITE	414 Old Maitland Road, Mardi, NSW	GEOLOGY	Patonga Claystone	VEGETATION	Grass	PROJECT NO. P1706264	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.3914	RL SURFACE	18.5 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 4.50 m depth	NORTHING	-33.2869	ASPECT	Northwest	SLOPE	15%

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		Not Encountered		18.50				SM	TOPSOIL: Silty SAND; fine to medium; dark grey to olive; with clay.		L - MD	TOPSOIL
	M		1	0.30 18.20	0.3-1.0/S/1 D 0.30-1.00 m			SM	Silty SAND; fine to medium; brown; trace clay.	M	MD - D	RESIDUAL SOIL
	H		2 3 4	1.80 16.70	2.0-2.5/S/1 D 2.00-2.50 m			ML	Sandy SILT; low plasticity; brown to reddish brown; with clay layers.	M (<<PL)	VSt - H	
				3.40 15.10	3.5-4.0/S/1 D 3.50-4.00 m				Becoming red at 3.4m.			
				4.50								
			5 6 7 8 9						Hole Terminated at 4.50 m (Target depth reached)			

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Engineering Log - BOREHOLE

CLIENT	Stevens Group	COMMENCED	04/11/2020	COMPLETED	04/11/2020	**REF BH304**
PROJECT	Geotechnical Assessment	LOGGED	SVK	CHECKED	WB/SK	Sheet 1 OF 1
SITE	414 Old Maitland Road, Mardi, NSW	GEOLOGY	Patonga Claystone	VEGETATION	Grass	PROJECT NO. P1706264
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.3894	RL SURFACE	14.7 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.50 m depth	NORTHING	-33.2895	ASPECT	North	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		14.70 0.20				ML	TOPSOIL: Sandy SILT; low plasticity; dark grey; with clay.	M (<PL)	S - F	TOPSOIL
	M			14.50	0.3-0.5/CBR/1 CBR 0.30-0.80 m			SC	Silty Clayey SAND; fine to medium; dark grey.	M	L - MD	ALLUVIUM 0.60: Hydrogen sulfide odour.
	H		1	0.80 13.90	1.1-1.2/S/1 D 1.10-1.20 m			CL	Sandy CLAY; low plasticity; grey; with silt.	M (<PL)	VSt H	ALLUVIUM / RESIDUAL SOIL
				1.50					Hole Terminated at 1.50 m (Target depth reached)			1.50: V-bit refusal @ 1.5 m.
			2									
			3									
			4									
			5									
			6									
			7									
			8									
			9									

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CLIENT	Stevens Group	COMMENCED	04/11/2020	COMPLETED	04/11/2020	REF BH305
PROJECT	Geotechnical Assessment	LOGGED	SVK	CHECKED	WB/SK	Sheet 1 OF 1
SITE	414 Old Maitland Road, Mardi, NSW	GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P1706264
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.3887	RL SURFACE	10.3 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 4.10 m depth	NORTHING	-33.2874	ASPECT	Southeast	SLOPE <5%

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		0.00–0.30	10.30 / 0.30		SM	TOPSOIL: Silty SAND; fine; dark grey to dark olive; with clay.	M	MD-D	TOPSOIL
AD/V	L		0.30–0.90	10.00 / 0.90	0.5-0.6/S/1 D 0.50-0.60 m	CL	Sandy CLAY; low plasticity; dark grey to dark olive; with silt.	M (<PL)	St	ALLUVIUM
AD/V	M / H		0.90–3.20	9.40 / 3.20	1.0-1.1/S/1 D 1.00-1.10 m; 1.5-1.6/S/1 D 1.50-1.60 m; 2.0-2.1/S/1 D 2.00-2.10 m; 2.5-2.6/S/1 D 2.50-2.60 m; 3.0-3.1/S/1 D 3.00-3.10 m	CI	Silty CLAY; medium plasticity; brown and grey to olive; with sand.	M (>PL)	VSt / H	
AD/V	L-M	Seepage at 3.2m.	3.20–4.10	7.10 / 4.10	3.5-3.6/S/1 D 3.50-3.60 m; 4.0-4.1/S/1 D 4.00-4.10 m	SC	Clayey SAND; fine; grey; with silt; inferred dense.	W	D	
			4.10				Hole Terminated at 4.10 m (Target depth reached)			

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CLIENT	Stevens Group	COMMENCED	04/11/2020	COMPLETED	04/11/2020	REF BH306
PROJECT	Geotechnical Assessment	LOGGED	SVK	CHECKED	WB/SK	Sheet 1 OF 1
SITE	414 Old Maitland Road, Mardi, NSW	GEOLOGY	Patonga Claystone	VEGETATION	None	PROJECT NO. P1706264
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.3861	RL SURFACE	25.6 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.70 m depth	NORTHING	-33.29	ASPECT	Northwest	SLOPE 22%

METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH / RL	SAMPLE OR FIELD TEST	RECOVERED	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	M	Not Encountered		0.15 / 25.45			SM	TOPSOIL: Silty SAND; fine to medium; dark grey to olive; trace clay.	M	D	TOPSOIL
			1		0.3-1.0/S/1 D 0.30-1.00 m		CL	Sandy CLAY; low plasticity; grey to brown.	M (<PL)	St - VSt	RESIDUAL SOIL
	H			1.30 / 24.30	1.5-1.7/S/1 D 1.50-1.70 m		SM	Silty SAND; fine to medium; brown; with clay.	M	D - VD	
				1.70				Hole Terminated at 1.70 m (Target depth reached)			1.70: V-bit refusal on inferred very low strength sandstone.
			2								
			3								
			4								
			5								
			6								
			7								
			8								
			9								

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CLIENT	Stevens Group	COMMENCED	17/11/2020	COMPLETED	17/11/2020	**REF BH307**	
PROJECT	Geotechnical Assessment	LOGGED	SVK	CHECKED	WB/SK	Sheet 1 OF 1	
SITE	414 Old Maitland Road, Mardi, NSW	GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P1706264	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.3837	RL SURFACE	16.1 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 7.95 m depth	NORTHING	-33.2903	ASPECT	Northeast	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			16.10 / 0.20		CI	TOPSOIL: Silty CLAY; medium plasticity; grey to olive; with sand.	M (<PL)	F	TOPSOIL
			0.20–2.20	15.90	SPT 1.00-1.45 m 4,4,5 N=9 1.0-1.45/S/1 D 1.00-1.45 m	CH	Silty CLAY; high plasticity; grey and brown.		F - St St	ALLUVIUM
			2.20–2.90	2.20 / 13.90	SPT 2.50-2.95 m 3,7,8 N=15 2.5-2.95/S/1 D 2.50-2.50 m	CI	Sandy CLAY; medium plasticity; grey and brown; with silt.		St - VSt	
	M	Seepage @ 5.5 m	2.90–7.95	2.90 / 13.20	SPT 4.00-4.45 m 4,4,9 N=13 4.0-4.45/S/1 D 4.00-4.45 m SPT 5.50-5.95 m 4,5,6 N=11 5.5-5.95/S/1 D 5.50-5.95 m SPT 7.50-7.95 m 4,6,11 N=17 7.5-7.95/s/1 D 7.50-7.95 m	CI	Silty CLAY; medium plasticity; brown to orange; with trace sand; trace ironstone elements.	M (<PL), then M (>PL) from about 5.5 m	St VSt	
			7.95	7.95			Hole Terminated at 7.95 m (Target depth reached)			

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CLIENT	Stevens Group	COMMENCED	17/11/2020	COMPLETED	17/11/2020	REF	BH308
PROJECT	Geotechnical Assessment	LOGGED	SVK	CHECKED	WB/SK	Sheet	1 OF 1
SITE	414 Old Maitland Road, Mardi, NSW	GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P1706264	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.3882	RL SURFACE	10.1 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 9.00 m depth	NORTHING	-33.2858	ASPECT	Southeast	SLOPE	<5%

Drilling | **Sampling** | **Field Material Description**

Method: AD/V. Penetration resistance: L.

Water: Seepage at 0.5m; 2.7 mbgl, 17/11/20; Seepage at 3.8m

DEPTH (m)	RL	SAMPLE OR FIELD TEST	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
0.20	10.10		SM	TOPSOIL; Silty SAND; fine; brown; trace clay.			TOPSOIL
1.30	9.90	0.5-1/S/1 D 0.50-1.00 m; SPT 1.15-1.60 m 0,3,3 N=6 1.15-1.6/S/1 D 1.15-1.60 m	SC	Clayey SAND; fine; brown and pale brown; with silt.	M / W	L	ALLUVIUM
3.80	8.80	SPT 2.50-2.95 m 2,3,4 N=7 2.5-2.95/s/1 D 2.50-2.95 m	CI-CH	CLAY; medium to high plasticity; brown and grey; trace silt.	M (<PL)	F	
5.50	6.30	SPT 4.00-4.45 m 5,8,10 N=18 4.0-4.45/S/1 D 4.00-4.45 m	SP	SAND (running sand); fine; pale grey; with silt; trace clay.	W	MD	
9.00	4.60	SPT 5.50-5.95 m 10,15,17 N=32 5.5-5.95/S/1 D 5.50-5.95 m		With sandy clay layers (very stiff); approximately 300mm thick.	W	D	7.00: Hole collapsed to 2 m.
				Hole Terminated at 9.00 m (Target depth reached)			

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Engineering Log - BOREHOLE

CLIENT	Stevens Group	COMMENCED	03/11/2020	COMPLETED	03/11/2020	REF BH309
PROJECT	Geotechnical Assessment	LOGGED	SVK	CHECKED	WB/SK	Sheet 1 OF 1
SITE	414 Old Maitland Road, Mardi, NSW	GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P1706264
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.3835	RL SURFACE	16.6 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 4.50 m depth	NORTHING	-33.2883	ASPECT	Northeast	SLOPE <5%

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	Seepage at 0.3 m		16.60 0.20 16.40				ML	TOPSOIL: Sandy SILT; low plasticity; dark grey to dark olive; with clay.	M (<PL)		TOPSOIL
			1	1.20	0.3-0.7/CBR/1 CBR 0.30-1.00 m			CL	Silty Sandy CLAY; low plasticity; dark grey to dark olive.			ALLUVIUM
	M		2	15.40 2.50				ML	Sandy SILT; low plasticity; brown; with clay.	W	F	
	L		3	14.10 3.60				SM	Silty SAND; fine to medium; brown; with clay.		MD - D	RESIDUAL SOIL
	M / H		4	13.00 4.50				CI	Silty CLAY; medium plasticity; grey and brown; trace sand.	M (<PL)	VSt / H	
			5 6 7 8 9						Hole Terminated at 4.50 m (Target depth reached)			

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Engineering Log - BOREHOLE

CLIENT	Stevens Group	COMMENCED	04/11/2020	COMPLETED	04/11/2020	**REF BH310**	
PROJECT	Geotechnical Assessment	LOGGED	SVK	CHECKED	WB/SK	Sheet 1 OF 1	
SITE	414 Old Maitland Road, Mardi, NSW	GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P1706264	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.3848	RL SURFACE	15.2 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 4.50 m depth	NORTHING	-33.2882	ASPECT	Southeast	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	Seepage at 0.2 m		15.20 / 0.20 / 15.00				ML	TOPSOIL: Sandy SILT; low plasticty; dark grey to dark olive; with clay.	M (<PL)	S and F	TOPSOIL
								CL	Sandy Silty CLAY; low plasticity; dark grey to dark olive.	W / M (<PL)	F	ALLUVIUM
	M	Seepage at 1.0 m	1	1.00 / 14.20	SPT 1.00-1.45 m 2,3,3 N=6 1.0-1.45/s/1 D 1.00-1.45 m			SC	Clayey SAND; fine; brown; trace fine silt.	W	L	
			2	2.30 / 12.90	SPT 2.50-2.95 m 4,6,9 N=15 2.5-2.95/s/1 D 2.50-2.95 m			CI	Silty CLAY; medium plasticity; brown and grey.	M (<PL)	St - VSt	
			3									
			4	4.50	SPT 4.00-4.45 m 4,3,5 N=8 4.0-4.45/s/1 D 4.00-4.45 m						St	
			5						Hole Terminated at 4.50 m (Target depth reached)			
			6									
			7									
			8									
			9									

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

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CLIENT	Stevens Group	COMMENCED	04/11/2020	COMPLETED	04/11/2020	REF BH311
PROJECT	Geotechnical Assessment	LOGGED	SVK	CHECKED	WB/SK	Sheet 1 OF 1
SITE	414 Old Maitland Road, Mardi, NSW	GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P1706264
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.3857	RL SURFACE	14.6 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 4.60 m depth	NORTHING	-33.2881	ASPECT	Southeast	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	Seepage at 0.4 m		14.60 / 0.20		ML	TOPSOIL: Sandy SILT; low plasticity; grey to dark olive, with clay.	M	S - F	TOPSOIL
				14.40	0.3-0.6/S/1 D 0.30-0.60 m	SM	Silty SAND; fine to medium; grey to brown; with clay.	W	L - MD	ALLUVIUM
			1	0.70 / 13.90	1.0-1.1/S/1 D 1.00-1.10 m; 1.5-1.6/S/1 D 1.50-1.60 m	CL	Sandy CLAY; low plasticity; brown to orange; with silt.	M (>PL)	F - St	
	M		2, 3, 4	1.70 / 12.90	2.0-2.1/S/1 D 2.00-2.10 m; 2.5-2.6/S/1 D 2.50-2.60 m; 3.0-3.1/S/1 D 3.00-3.10 m; 3.5-3.6/S/1 D 3.50-3.60 m; 4.0-4.1/S/1 D 4.00-4.10 m; 4.5-4.6/S/1 D 4.50-4.60 m	CI-CH	CLAY; medium to high plasticity; grey and brown.	M (<PL)	VSt; H	
				4.60			Hole Terminated at 4.60 m (Target depth reached)			

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CLIENT	Stevens Group	COMMENCED	17/11/2020	COMPLETED	17/11/2020	REF BH312
PROJECT	Geotechnical Assessment	LOGGED	SVK	CHECKED	WB/SK	Sheet 1 OF 1
SITE	414 Old Maitland Road, Mardi, NSW	GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P1706264
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.3913	RL SURFACE	6.9 m	DATUM: AHD
EXCAVATION DIMENSIONS	Ø100 mm x 4.10 m depth	NORTHING	-33.2852	ASPECT	Northwest	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		6.90				CI	TOPSOIL: Silty CLAY; medium plasticity; dark grey to dark olive; trace sand.	M (<PL)	F	TOPSOIL
				0.20 / 6.70				CI	CLAY; medium plasticity; brown; with silt.		St	ALLUVIUM
					0.5-0.6/S/1 D 0.50-0.60 m							
			1		1.0-1.1/S/1 D 1.00-1.10 m						VSt	
	M			1.50 / 5.40	1.5-1.6/S/1 D 1.50-1.60 m				Becoming grey.			
			2		2.0-2.1/S/1 D 2.00-2.10 m							
					2.5-2.6/S/1 D 2.50-2.60 m						H	
			3		3.0-3.1/S/1 D 3.00-3.10 m							
					3.5-3.6/S/1 D 3.50-3.60 m							
			4	4.10	4.0-4.1/S/1 D 4.00-4.10 m							
									Hole Terminated at 4.10 m (Target depth reached)			
			5									
			6									
			7									
			8									
			9									

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

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Engineering Log - BOREHOLE

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P1706264BH302-BH325.GPJ <<DrawingFile>> 17/12/2020 12:46 8.30.004 Datgel Lab and In Situ Tool - DGD | Lib: Martens 2.00 2016-11-13 Prj: Martens 2.00 2016-11-13

CLIENT	Stevens Group	COMMENCED	17/11/2020	COMPLETED	17/11/2020	REF **BH313**
PROJECT	Geotechnical Assessment	LOGGED	SVK	CHECKED	WB/SK	Sheet 1 OF 1
SITE	414 Old Maitland Road, Mardi, NSW	GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P1706264
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.3904	RL SURFACE	8.2 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.50 m depth	NORTHING	-33.2844	ASPECT	Southeast	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			8.20 *0.20*				SM	TOPSOIL: Silty SAND; fine grained; dark grey to dark brown; with clay.	M	L	TOPSOIL
				8.00	0.3-0.8/CBR/1 CBR 0.30-0.80 m			SC	Clayey SAND; fine; pale grey and brown; trace silt.	M		ALLUVIUM
		Seepage at 0.9 m	1	*0.80* 7.40					Becoming grey.	W	L - MD	
				1.50							MD	
			2–9						Hole Terminated at 1.50 m (Target depth reached)			

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Engineering Log - BOREHOLE

CLIENT	Stevens Group	COMMENCED	17/11/2020	COMPLETED	17/11/2020	REF BH314
PROJECT	Geotechnical Assessment	LOGGED	SVK	CHECKED	WB/SK	Sheet 1 OF 1
SITE	414 Old Maitland Road, Mardi, NSW	GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P1706264
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.392	RL SURFACE	9.5 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.50 m depth	NORTHING	-33.2857	ASPECT	Northwest	SLOPE 8%

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		9.50				SM	TOPSOIL; Silty SAND; fine; dark grey to dark olive; with clay.		L - MD	TOPSOIL
				0.20 / 9.30	0.3-0.8/CBR/1 CBR 0.30-0.80 m			SC	Silty Clayey SAND; fine; dark grey.	M	MD	ALLUVIUM
			1	0.80 / 8.70				CH	CLAY; high plasticity; pale grey and pale brown; with silt.	M (<PL)	F - St	
				1.50					Hole Terminated at 1.50 m (Target depth reached)			

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Engineering Log - BOREHOLE

CLIENT	Stevens Group	COMMENCED	04/11/2020	COMPLETED	04/11/2020	**REF BH315**
PROJECT	Geotechnical Assessment	LOGGED	SVK	CHECKED	WB/SK	Sheet 1 OF 1
SITE	414 Old Maitland Road, Mardi, NSW	GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P1706264
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.3924	RL SURFACE	4.9 m	DATUM: AHD
EXCAVATION DIMENSIONS	Ø100 mm x 7.95 m depth	NORTHING	-33.2834	ASPECT	North	SLOPE: <5%

Drilling: METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH / RL	Sampling: SAMPLE OR FIELD TEST	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	L			4.90		MH	TOPSOIL: Clayey SILT; high plasticity; dark brown; trace sand.	M (<PL)		TOPSOIL
				0.30 / 4.60		CH	Silty CLAY; high plasticity; grey, brown and reddish brown.		F	ALLUVIUM
			1		SPT 1.00-1.45 m 4,5,6 N=11			M (=PL)		
				1.70 / 3.20		CH	CLAY; high plasticity; pale grey to grey; trace silt.			
			2							
			3		SPT 2.50-2.95 m 4,5,5 N=10 2.5-2.95/s/1 D 2.50-2.95 m			M (>PL)	St	
			4		SPT 4.00-4.45 m 3,4,6 N=10 4.0-4.45/s/1 D 4.00-4.45 m					
		Seepage at 4.3 m		4.30 / 0.60		CL-CI	Sandy CLAY; low to medium plasticity; pale grey to grey; with silt.	M (>>PL)		
			5	4.80 / 0.10		CH	CLAY; high plasticity; pale grey to grey; trace silt.	M (<PL)	S - F	
			6	5.70 / -0.80	SPT 5.50-5.95 m 1,2,2 N=4 5.5-5.95/S/1 D 5.50-5.95 m	CL	Sandy CLAY; low plasticity; pale grey to grey; with silt.			
			7					M (>>PL)	S	
			8	7.95	SPT 7.50-7.95 m 0,0,3 N=3 7.5-7.95/S/1 D 7.50-7.95 m		Hole Terminated at 7.95 m (Target depth reached)			
			9							

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Engineering Log - BOREHOLE

CLIENT	Stevens Group	COMMENCED	03/11/2020	COMPLETED	03/11/2020	REF BH322
PROJECT	Geotechnical Assessment	LOGGED	SVK	CHECKED	WB/SK	Sheet 1 OF 1
SITE	414 Old Maitland Road, Mardi, NSW	GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P1706264
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.3832	RL SURFACE	14.1 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 4.45 m depth	NORTHING	-33.2866	ASPECT	East	SLOPE <5%

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				14.10 0.20		ML	TOPSOIL: Clayey SILT; low plasticity; dark grey to dark brown; with sand.	M		TOPSOIL
	L	Seepage at 0.4 m		13.90	0.5-0.6/S/1 D 0.50-0.60 m	CL	Silty CLAY; low plasticity; dark grey to dark brown; with sand.	M (>PL) / W	S - F / F	ALLUVIUM
	M		1	0.90 13.20	SPT 1.00-1.45 m 2,4,5 N=9 1.0-1.45/s/1 D 1.00-1.45 m 1.5-1.6/S/1 D 1.50-1.60 m 2.0-2.1/S/1 D 2.00-2.10 m SPT 2.50-2.95 m 3,4,6 N=10 2.5-2.6/S/1 D 2.50-2.60 m 2.5-2.95/s/1 D 2.50-2.95 m	CL	Silty CLAY; low plasticity; grey and orange; with sand.	M (<PL)	St	
			3	3.10 11.00	3.0-3.1/S/1 D 3.00-3.10 m 3.5-3.6/S/1 D 3.50-3.60 m	CL	Sandy CLAY; low plasticity; pale brown to olive; with silt.			
	H		4	3.90 10.20	SPT 4.00-4.45 m 13,8,6 N=14 4.0-4.45/S/1 D 4.00-4.45 m	SM	Silty SAND; fine to medium; grey; trace clay with some indurated layers.	M	MD	
				4.45			Hole Terminated at 4.45 m (Target depth reached)			

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Engineering Log - BOREHOLE

CLIENT	Stevens Group	COMMENCED	03/11/2020	COMPLETED	03/11/2020	REF BH323
PROJECT	Geotechnical Assessment	LOGGED	SVK	CHECKED	WB/SK	Sheet 1 OF 1
SITE	414 Old Maitland Road, Mardi, NSW	GEOLOGY	Patonga Claystone	VEGETATION	Grass	PROJECT NO. P1706264
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.3815	RL SURFACE	22.6 m	DATUM: AHD
EXCAVATION DIMENSIONS	Ø100 mm x 4.45 m depth	NORTHING	-33.2858	ASPECT	Southeast	SLOPE: 10%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	L	Seepage at 0.5 m		22.60				ML	TOPSOIL: Sandy SILT; low plasticity; dark grey to dark olive; with clay.	M (>PL)	F	TOPSOIL
				0.20 22.40				ML	Sandy SILT; low plasticity; dark grey to dark brown; trace clay.	M (>PL)		ALLUVIUM
			1	0.80 21.80	SPT 1.00-1.45 m 2,3,4 N=7 1.0-1.45/s/1 D 1.00-1.45 m			CL	Silty CLAY; low plasticity; brown and orange; with sand.	M (<PL)	St	RESIDUAL SOIL
			2		2.0-2.5/S/1 D 2.00-2.50 m						St - VSt	
			3		SPT 2.50-2.95 m 5,7,8 N=15 2.5-2.95/s/1 D 2.50-2.95 m							
			4	4.45	SPT 4.00-4.45 m 5,6,7 N=13 4.0-4.45/s/1 D 4.00-4.45 m						St	
			5						Hole Terminated at 4.45 m (Target depth reached)			
			6									
			7									
			8									
			9									

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Engineering Log - BOREHOLE

CLIENT	Stevens Group	COMMENCED	03/11/2020	COMPLETED	03/11/2020	**REF BH324**	
PROJECT	Geotechnical Assessment	LOGGED	SVK	CHECKED	WB/SK	Sheet 1 OF 1	
SITE	414 Old Maitland Road, Mardi, NSW	GEOLOGY	Patonga Claystone	VEGETATION	Grass	PROJECT NO. P1706264	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.3839	RL SURFACE	14.6 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 3.10 m depth	NORTHING	-33.2855	ASPECT	Southeast	SLOPE	<5%

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	Seepage at 0.4 m		14.60 / 0.20 / 14.40				ML	TOPSOIL: Sandy SILT; low plasticity; dark grey to dark olive; with clay.	M (<PL)	S	TOPSOIL
				0.60 / 14.00				ML	Sandy SILT; low plasticity; dark grey; trace clay.	M (>PL)	F / S	ALLUVIUM
	M		1	1.40 / 13.20	0.6-1.0/CBR/1 CBR 0.60-1.00 m; SPT 1.00-1.45 m 4,7,12 N=19 1.0-1.45/s/1 D 1.00-1.45 m			CL	Silty CLAY; low plasticity; brown; trace sand.		St	RESIDUAL SOIL
	H		2						Grey mottled brown.	M (<PL)	VSt	
			3	3.10	SPT 2.50-2.95 m 7,14,16 N=30 2.5-2.95/s/1 D 2.50-2.95 m						H	
									Hole Terminated at 3.10 m (Target depth reached)			3.10: V-bit refusal @ 3.1 m.
			4									
			5									
			6									
			7									
			8									
			9									

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

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Engineering Log - BOREHOLE

CLIENT	Stevens Group	COMMENCED	03/11/2020	COMPLETED	03/11/2020	REF BH325
PROJECT	Geotechnical Assessment	LOGGED	SVK	CHECKED	WB/SK	Sheet 1 OF 1
SITE	414 Old Maitland Road, Mardi, NSW	GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P1706264
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.3855	RL SURFACE	12.1 m	DATUM: AHD
EXCAVATION DIMENSIONS	Ø100 mm x 5.50 m depth	NORTHING	-33.2858	ASPECT	Southeast	SLOPE: <5%

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	Seepage at 0.3 m		12.10 / 0.30		ML	TOPSOIL: Sandy SILT; low plasticity; dark grey to dark olive; with clay.	M	S and F	TOPSOIL
				11.80 / 1.00	0.5-0.6/S/1 D 0.50-0.60 m	ML	Clayey SILT; low plasticity; dark grey to dark olive; with sand.	W	F	ALLUVIUM
	M		1	11.10 / 2.80	1.0-1.1/S/1 D 1.00-1.10 m; 1.5-1.6/S/1 D 1.50-1.60 m; 2.0-2.1/S/1 D 2.00-2.10 m; 2.5-2.6/S/1 D 2.50-2.60 m	CL-CI	Sandy CLAY; low to medium plasticity; brown; with silt.	M (<PL)	St; VSt and H	
			3	9.30 / 3.80	3.0-3.1/S/1 D 3.00-3.10 m; 3.5-3.6/S/1 D 3.50-3.60 m		Becoming grey with mottled orange.		VSt	
		Seepage at 3.8 m	4, 5	8.30 / 5.50	4.0-4.1/S/1 D 4.00-4.10 m	SM	Silty SAND; fine to medium; grey to olive; with clay and thin silty clay layers; inferred dense.	W	D	
			6, 7, 8, 9				Hole Terminated at 5.50 m (Target depth reached)			

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Engineering Log - BOREHOLE

11 Attachment C – DCP Test Results

Dynamic Cone Penetrometer Test Log Summary

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Site	Mardi Old Farm, 414 Old Maitland Road, Mardi, NSW	**DCP Group Reference**	P1706264JS01V01
Client	Stevens Group	**Log Date**	3.11.2020 - 17.11.2020
Logged by	SvK	**Page**	1 of 2
Checked by	SK		
Comments	DCP commenced from 50 mm bgl.		

TEST DATA

Depth Interval (m)	DCP101	DCP102	DCP103	DCP104	DCP105	DCP106		
0.15	4	2	3	2	4	2		
0.30	6	1	2	2	5	1		
0.45	5	2	3	3	5	1		
0.60	5	3	5	3	5	2		
0.75	6	4	8	3	3	3		
0.90	8	6	10	4	4	5		
1.05	10	8	12	4	4	7		
1.20	9	8	18	3	8	14		
1.35	10		23	3	12	19		
1.50	11	Terminated @ 1.25 m	26	5	13	26		
1.65	12		31	8		22		
1.80	12			11	Terminated @ 1.55 m	17		
1.95	12		Terminated @ 1.7 m due to high 'N' counts	16		16		
2.10	15			19		16		
2.25	19			24		17		
2.40	21			27		19		
2.55	27			28		30 / 70 mm		
2.70	27			30 / 140 mm				
2.85	32					Terminated @ 2.52 m due to high 'N' counts		
3.00				Terminated @ 2.74 m due to high 'N' counts				
	Terminated @ 2.9 m due to high 'N' counts							

Dynamic Cone Penetrometer Test Log Summary

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Site	Mardi Old Farm, 414 Old Maitland Road, Mardi, NSW	DCP Group Reference	P1706264JS01V01
Client	Stevens Group	Log Date	3.11.2020 - 17.11.2020
Logged by	SvK	Page	2 of 2
Checked by	SK		
Comments	DCP commenced from 50 mm bgl.		

TEST DATA

Depth Interval (m)	DCP107	DCP108	DCP109					
0.15	2	1	1					
0.30	2	1	3					
0.45	3	3	1					
0.60	2	1	2					
0.75	5	4	3					
0.90	5	6	3					
1.05	9	8	3					
1.20	5	8	4					
1.35	10	10	5					
1.50	12	11	5					
1.65	14	9	2					
1.80	20	22	4					
1.95	19	21	8					
2.10	22	18	16					
2.25	21	18	16					
2.40	17	23	20					
2.55	24	24	21					
2.70	20	17	14					
2.85	23	30	14					
3.00	Terminated @ 2.9 m	Terminated @ 2.9 m	16					
3.15			Terminated @ 3.05 m					

12 Attachment D – Laboratory Summary Tables

ASS Laboratory Test Results Interpretation

Method based on Acid Sulfate Soil Manual (ASSMAC, 1998)
Method ST-50 V05 Revised 30.04.2018

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PROJECT DETAILS

Client	Stevens Group	Page	1 of 2
Project	Geotechnical and Acid Sulfate Soils Assessment	Date	04.12.2020
Sampling Site	Mardi Old Farm, 414 Old Maitland Road, Mardi, NSW	Job Number	P1706264
Sample History	03.11.2020 and 04.11.2020	Sampled By	SvK

SAMPLE DETAILS / TEST RESULTS

Sample ID	Sample Depth (m)	Material Type [1]	Net Acidity (mol H+/t)	TAA[2] (mol H+/t)	Scr [3] (%w/w S)	S_{NAS} [4] (%w/w S)	ANC (%w/w S)	Liming Rate (kg $CaCO_3$/t)[5]
6264/BH311/0.5-0.6	0.5-0.6	C	8.5	8	< 0.005	NT [6]	NT [6]	< 0.75
6264/BH311/1.0-1.1	1.0-1.1	F	11	10	< 0.005	NT [6]	NT [6]	0.80
6264/BH311/1.5-1.6	1.5-1.6	F	10	10	< 0.005	NT [6]	NT [6]	0.80
6264/BH311/2.0-2.1	2.0-2.1	F	9	9	< 0.005	NT [6]	NT [6]	< 0.75
6264/BH311/2.5-2.6	2.5-2.6	F	**53**	**49**	< 0.005	0.006	NT [6]	4.00
6264/BH311/3.0-3.1	3.0-3.1	F	**50**	**40**	< 0.005	0.013	NT [6]	4.00
6264/BH311/3.5-3.6	3.5-3.6	F	**23**	**18**	< 0.005	0.007	NT [6]	2.00
6264/BH322/0.5-0.6	0.5-0.6	F	**29**	**24**	< 0.005	0.007	NT [6]	2.00
6264/BH322/1.0-1.1	1.0-1.1	F	**26**	**21**	< 0.005	0.007	NT [6]	2.00
6264/BH322/1.5-1.6	1.5-1.6	F	15	10	< 0.005	< 0.005	NT [6]	1.00
6264/BH322/3.0-3.1	3.0-3.1	F	12	9	< 0.005	< 0.005	NT [6]	0.90
6264/BH325/0.5-0.6	0.5-0.6	M	**22**	**18**	< 0.005	< 0.005	NT [6]	2.00
6264/BH325/1.0-1.1	1.0-1.1	F	**28**	**22**	< 0.005	0.008	NT [6]	2.00
Assessment Criteria: (For exposed soil >1000t, use coarse textured criteria)		(F)ine textured; > 40 % clay	62	62	0.100	0.100	0.100	
		(M)edium textured; 5-40 % clay	36	36	0.060	0.060	0.060	
		(C)oarse textured; < 5 % clay	18	18	0.030	0.030	0.030	

Notes:
1. Material type based on field texture assessment or laboratory report.
2. Total Actual Acidity. Highlighted values exceed ASSMAC (1998) action criteria.
3. Chromium Reducible Sulfur. Highlighted values exceed ASSMAC (1998) action criteria.
4. Percentage net acid soluble sulfur. Highlighted values exceed ASSMAC (1998) action criteria.
5. From laboratory test results (refer to laboratory test certificates). Calculated using a FOS of 1.5.
6. Not tested.

ASS Laboratory Test Results Interpretation

Method based on Acid Sulfate Soil Manual (ASSMAC, 1998)
Method ST-50 V05 Revised 30.04.2018

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PROJECT DETAILS

Client	Stevens Group	Page	2 of 2
Project	Geotechnical and Acid Sulfate Soils Assessment	Date	04.12.2020
Sampling Site	Mardi Old Farm, 414 Old Maitland Road, Mardi, NSW	Job Number	P1706264
Sample History	03.11.2020, 04.11.2020 and 17.11.2020	Sampled By	SvK

SAMPLE DETAILS / TEST RESULTS

Sample ID	Sample Depth (m)	Material Type [1]	Net Acidity (mol H+/t)	TAA[2] (mol H+/t)	Scr [3] (%w/w S)	S_{NAS} [4] (%w/w S)	ANC (%w/w S)	Liming Rate (kg $CaCO_3$/t)[5]
6264/BH325/2.0-2.1	2.0-2.1	F	7.8	8	< 0.005	NT [6]	NT [6]	< 0.75
6264/BH305/0.5-0.6	0.5-0.6	F	**22**	**18**	< 0.005	0.005	NT [6]	2.00
6264/BH305/1.0-1.1	1.0-1.1	F	14	9	< 0.005	0.005	NT [6]	1.00
6264/BH305/2.0-2.1	2.0-2.1	F	< 5	< 5	< 0.005	NT [6]	NT [6]	< 0.75
6264/BH305/2.5-2.6	2.0-2.1	F	< 5	< 5	< 0.005	NT [6]	NT [6]	< 0.75
6264/BH305/3.0-3.1	3.0-3.1	F	< 5	< 5	< 0.005	NT [6]	NT [6]	< 0.75
6264/BH312/0.5-0.6	0.5-0.6	F	**67**	**53**	0.007	0.017	NT [6]	5
6264/BH312/1.0-1.1	1.0-1.1	F	**70**	**55**	< 0.005	0.022	NT [6]	5
6264/BH312/1.5-1.6	1.5-1.6	F	**72**	**55**	< 0.005	0.025	NT [6]	5
6264/BH312/2.0-2.1	2.0-2.1	F	**20**	11	< 0.005	0.013	NT [6]	1
6264/BH312/2.5-2.6	2.0-2.1	F	**27**	16	< 0.005	0.016	NT [6]	2
6264/BH312/3.0-3.6	3.0-3.1	F	**26**	16	0.005	0.012	NT [6]	2
Assessment Criteria: (For exposed soil >1000t, use coarse textured criteria)		(F)ine textured; > 40 % clay	62	62	0.100	0.100	0.100	
		(M)edium textured; 5-40 % clay	36	36	0.060	0.060	0.060	
		(C)oarse textured; < 5 % clay	18	18	0.030	0.030	0.030	

Notes:

1. Material type based on field texture assessment or laboratory report.
2. Total Actual Acidity. Highlighted values exceed ASSMAC (1998) action criteria.
3. Chromium Reducible Sulfur. Highlighted values exceed ASSMAC (1998) action criteria.
4. Percentage net acid soluble sulfur. Highlighted values exceed ASSMAC (1998) action criteria.
5. From laboratory test results (refer to laboratory test certificates). Calculated using a FOS of 1.5.
6. Not tested.

13 Attachment E – Laboratory Test Certificates

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

Test Report

Customer: Martens & Associates Pty Ltd
Project: P1706264
Location: 414 Old Maitland Road, Mardi NSW

Job number: 20-0096
Report number: 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.	23063	23067	23068	23069	23070
Customer sample no.	BH302/S/1/ 1.8-2.2m	BH310/S/1/ 0.3-1.0m	BH310/S/1/ 1.0-2.0m	BH323/S/1/ 1.0-1.5m	BH323/S/1/ 2.0-2.5m
Date sampled	03/11/2020-04/11/2020 & 17/11/2020	03/11/2020-04/11/2020 & 17/11/2020	03/11/2020-04/11/2020 & 17/11/2020	03/11/2020-04/11/2020 & 17/11/2020	03/11/2020-04/11/2020 & 17/11/2020
Material description	silty CLAY, trace of sand, red-brown/grey	sandy silty CLAY, brown/yellow-brown/grey	clayey SAND, grey/brown	silty CLAY, with sand, brown/ yellow-brown/grey	silty CLAY, with sand, brown/grey
Liquid limit (%)	43	27	22	30	28
Plastic limit (%)	15	16	15	13	13
Plasticity index (%)	28	11	7	17	15
Linear shrinkage (%)	13.0	6.5	3.0	5.5	5.5
Cracking / Curling / Crumbling	Cracking	Cracking	Cracking	Cracking	Cracking
Sample history	Air dried	Air dried	Air dried	Air dried	Air dried
Preparation	Dry sieved	Dry sieved	Dry sieved	Dry sieved	Dry sieved

Approved Signatory: C. Greely

Date: 02/12/2020

NATA ACCREDITED FOR TECHNICAL COMPETENCE

Accredited for compliance with ISO/IEC 17025 - Testing.

NATA Accredited Laboratory Number: **17062**

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

Test Report

Customer: Martens & Associates Pty Ltd
Project: P1706264
Location: 414 Old Maitland Road, Mardi NSW

Job number: 20-0096
Report number: 1
Page: 2 of 2

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.	23072	23074	23081		
Customer sample no.	BH313/S/1/ 0.3-0.8m	BH315/S/1/ 0.5-1.0m	BH307/S/1/ 0.5-1.0m		
Date sampled	03/11/2020-04/11/2020 & 17/11/2020	03/11/2020-04/11/2020 & 17/11/2020	03/11/2020-04/11/2020 & 17/11/2020		
Material description	clayey SAND, brown/yellow-brown	silty CLAY, grey/red/ yellow-brown	silty CLAY, yellow-brown/ brown/grey		
Liquid limit (%)	23	57	52		
Plastic limit (%)	17	18	19		
Plasticity index (%)	6	39	33		
Linear shrinkage (%)	2.5	10.0	13.5		
Cracking / Curling / Crumbling	Cracking	-	-		
Sample history	Air dried	Air dried	Air dried		
Preparation	Dry sieved	Dry sieved	Dry sieved		

Approved Signatory: C. Greely

Date: 02/12/2020

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Test Report

Customer: Martens & Associates Pty Ltd
Project: P1706264
Location: 414 Old Maitland Road, Mardi NSW

Job number: 20-0096
Report number: 2

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.	23065	23066	23071	23072
Customer sample no.	BH304/S/1/ 0.3-0.8m	BH309/S/1/ 0.3-1.0m	BH324/S/1/ 0.6-1.0m	BH313/S/1/ 0.3-0.8m
Date sampled	03/11/2020- 04/11/2020 & 17/11/2020	03/11/2020- 04/11/2020 & 17/11/2020	03/11/2020- 04/11/2020 & 17/11/2020	03/11/2020- 04/11/2020 & 17/11/2020
Material description	silty clayey SAND, dark brown	silty sandy CLAY, brown	silty CLAY, trace of sand, brown/ yellow-brown/grey	clayey SAND, brown/yellow-brown
Maximum dry density (t/m^3)	1.96	1.83	1.90	1.87
Optimum moisture content (%)	10.9	15.0	13.3	13.0
Field moisture content (%)	n/a	n/a	n/a	n/a
Oversize retained on 19.0mm sieve (%)	0	0	0	0
Minimum curing time (hours)	48	48	48	48
Dry density before soak (t/m^3)	1.93	1.80	1.86	1.83
Dry density after soak (t/m^3)	1.94	1.80	1.83	1.83
Moisture content before soak (%)	10.5	14.7	13.4	13.1
Moisture content after soak (%)	11.4	16.7	15.7	14.9
Moisture content after test - top 30mm (%)	11.3	17.2	16.8	14.7
Moisture content after test - remaining depth (%)	10.9	15.8	14.9	14.2
Density ratio before soaking (%)	98.5	98.5	98.0	98.0
Moisture ratio before soaking (%)	96.5	98.0	101.0	100.5
Period of soaking (days)	4	4	4	4
Compactive effort	Standard	Standard	Standard	Standard
Mass of surcharge applied (kg)	4.5	4.5	4.5	4.5
Swell after soaking (%)	0.0	0.0	1.5	0.0
Penetration (mm)	5.0	5.0	5.0	5.0
CBR Value (%)	**25**	**19**	**2.5**	**35**

Notes: Specified LDR: 98 ±1%

Method of establishing plasticity level - Visual / tactile

Approved Signatory: C. Greely

Date: 03/12/2020

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resource laboratories
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Test Report

Customer: Martens & Associates Pty Ltd
Project: P1706264
Location: 414 Old Maitland Road, Mardi NSW

Job number: 20-0096
Report number: 2

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.	23073			
Customer sample no.	BH314/S/1/ 0.3-0.8m			
Date sampled	03/11/2020- 04/11/2020 & 17/11/2020			
Material description	silty clayey SAND, brown/grey/ yellow-brown			
Maximum dry density (t/m^3)	1.96			
Optimum moisture content (%)	11.6			
Field moisture content (%)	n/a			
Oversize retained on 19.0mm sieve (%)	0			
Minimum curing time (hours)	48			
Dry density before soak (t/m^3)	1.93			
Dry density after soak (t/m^3)	1.93			
Moisture content before soak (%)	11.3			
Moisture content after soak (%)	12.6			
Moisture content after test - top 30mm (%)	12.6			
Moisture content after test - remaining depth (%)	12.1			
Density ratio before soaking (%)	98.5			
Moisture ratio before soaking (%)	97.0			
Period of soaking (days)	4			
Compactive effort	Standard			
Mass of surcharge applied (kg)	4.5			
Swell after soaking (%)	0.0			
Penetration (mm)	5.0			
CBR Value (%)	**25**			

Notes: Specified LDR: 98 ±1%

Method of establishing plasticity level - Visual / tactile

Approved Signatory: C. Greely

Date: 03/12/2020

NATA
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Accredited for compliance with ISO/IEC 17025 - Testing.

NATA Accredited Laboratory Number: **17062**

Envirolab Services Pty Ltd
ABN 37 112 535 645
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www.envirolab.com.au

CERTIFICATE OF ANALYSIS 256049

Client Details

Client	Martens & Associates Pty Ltd
Attention	Shaun van Kal
Address	Suite 201, 20 George St, Hornsby, NSW, 2077

Sample Details

Your Reference	**P1706264 - 414 Old Maitland Road, Mardi NSW**
Number of Samples	46 Soil
Date samples received	18/11/2020
Date completed instructions received	18/11/2020

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.

Report Details

Date results requested by	25/11/2020
Date of Issue	24/11/2020

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Results Approved By
Priya Samarawickrama, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

sPOCAS field test						
Our Reference		256049-1	256049-2	256049-3	256049-4	256049-5
Your Reference	UNITS	BH311/S/1/	BH311/S/1/	BH311/S/1/	BH311/S/1/	BH311/S/1/
Depth		0.5-0.6	1.0-1.1	1.5-1.6	2.0-2.1	2.5-2.6
Date Sampled		17/11/2020	17/11/2020	17/11/2020	17/11/2020	17/11/2020
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	20/11/2020	20/11/2020	20/11/2020	20/11/2020	20/11/2020
Date analysed	-	20/11/2020	20/11/2020	20/11/2020	20/11/2020	20/11/2020
pH_F (field pH test)*	pH Units	5.6	5.8	5.5	5.6	5.4
pH_{FOX} (field peroxide test)*	pH Units	4.0	4.6	4.5	4.3	3.9
Reaction Rate*	-	Low reaction	Low reaction	Low reaction	Low reaction	Low reaction

sPOCAS field test						
Our Reference		256049-6	256049-7	256049-8	256049-9	256049-10
Your Reference	UNITS	BH311/S/1/	BH311/S/1/	BH311/S/1/	BH311/S/1/	BH322/S/1/
Depth		3.0-3.1	3.5-3.6	4.0-4.1	4.5-4.6	0.5-0.6
Date Sampled		17/11/2020	17/11/2020	17/11/2020	17/11/2020	17/11/2020
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	20/11/2020	20/11/2020	20/11/2020	20/11/2020	20/11/2020
Date analysed	-	20/11/2020	20/11/2020	20/11/2020	20/11/2020	20/11/2020
pH_F (field pH test)*	pH Units	5.4	5.6	5.6	5.5	5.4
pH_{FOX} (field peroxide test)*	pH Units	3.9	4.5	4.9	4.5	2.2
Reaction Rate*	-	Low reaction	Low reaction	Low reaction	Low reaction	Medium reaction

sPOCAS field test						
Our Reference		256049-11	256049-12	256049-13	256049-14	256049-15
Your Reference	UNITS	BH322/S/1/	BH322/S/1/	BH322/S/1/	BH322/S/1/	BH322/S/1/
Depth		1.0-1.1	1.5-1.6	2.0-2.6	2.5-2.6	3.0-3.1
Date Sampled		17/11/2020	17/11/2020	17/11/2020	17/11/2020	17/11/2020
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	20/11/2020	20/11/2020	20/11/2020	20/11/2020	20/11/2020
Date analysed	-	20/11/2020	20/11/2020	20/11/2020	20/11/2020	20/11/2020
pH_F (field pH test)*	pH Units	5.7	5.9	5.6	6.0	5.7
pH_{FOX} (field peroxide test)*	pH Units	3.1	3.6	5.2	4.8	3.6
Reaction Rate*	-	Low reaction	Low reaction	Low reaction	Low reaction	Low reaction

sPOCAS field test						
Our Reference		256049-16	256049-17	256049-18	256049-19	256049-20
Your Reference	UNITS	BH322/S/1/	BH322/S/1/	BH325/S/1/	BH325/S/1/	BH325/S/1/
Depth		3.5-3.6	4.0-4.1	0.5-0.6	1.0-1.1	1.5-1.6
Date Sampled		17/11/2020	17/11/2020	17/11/2020	17/11/2020	17/11/2020
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	20/11/2020	20/11/2020	20/11/2020	20/11/2020	20/11/2020
Date analysed	-	20/11/2020	20/11/2020	20/11/2020	20/11/2020	20/11/2020
pH_F (field pH test)*	pH Units	6.2	6.3	5.7	5.5	5.7
pH_{FOX} (field peroxide test)*	pH Units	5.0	4.4	2.7	2.7	4.2
Reaction Rate*	-	Low reaction	Low reaction	Low reaction	Low reaction	Low reaction

sPOCAS field test						
Our Reference		256049-21	256049-22	256049-23	256049-24	256049-25
Your Reference	UNITS	BH325/S/1/	BH325/S/1/	BH325/S/1/	BH325/S/1/	BH325/S/1/
Depth		2.0-2.1	2.5-2.6	3.0-3.1	3.5-3.6	4.0-4.1
Date Sampled		17/11/2020	17/11/2020	17/11/2020	17/11/2020	17/11/2020
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	20/11/2020	20/11/2020	20/11/2020	20/11/2020	20/11/2020
Date analysed	-	20/11/2020	20/11/2020	20/11/2020	20/11/2020	20/11/2020
pH_F (field pH test)*	pH Units	5.9	6.8	6.9	7.0	6.9
pH_{FOX} (field peroxide test)*	pH Units	3.9	5.6	5.7	4.8	4.9
Reaction Rate*	-	Low reaction	Low reaction	Low reaction	Low reaction	Low reaction

sPOCAS field test						
Our Reference		256049-26	256049-27	256049-28	256049-29	256049-30
Your Reference	UNITS	BH325/S/1/	BH305/S/1/	BH305/S/1/	BH305/S/1/	BH305/S/1/
Depth		5.0-5.1	0.5-0.6	1.0-1.1	1.5-1.6	2.0-2.1
Date Sampled		17/11/2020	17/11/2020	17/11/2020	17/11/2020	17/11/2020
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	20/11/2020	20/11/2020	20/11/2020	20/11/2020	20/11/2020
Date analysed	-	20/11/2020	20/11/2020	20/11/2020	20/11/2020	20/11/2020
pH_F (field pH test)*	pH Units	6.7	5.6	5.6	6.7	7.2
pH_{FOX} (field peroxide test)*	pH Units	4.9	3.1	2.9	6.0	6.0
Reaction Rate*	-	Low reaction	Medium reaction	Medium reaction	Low reaction	Low reaction

sPOCAS field test						
Our Reference		256049-31	256049-32	256049-33	256049-34	256049-35
Your Reference	UNITS	BH305/S/1/	BH305/S/1/	BH305/S/1/	BH305/S/1/	BH312/S/1/
Depth		2.5-2.6	3.0-3.1	3.5-3.6	4.0-4.1	0.5-0.6
Date Sampled		17/11/2020	17/11/2020	17/11/2020	17/11/2020	17/11/2020
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	20/11/2020	20/11/2020	20/11/2020	20/11/2020	20/11/2020
Date analysed	-	20/11/2020	20/11/2020	20/11/2020	20/11/2020	20/11/2020
pH_F (field pH test)*	pH Units	7.3	6.9	6.8	7.1	5.1
pH_{FOX} (field peroxide test)*	pH Units	6.3	5.7	5.9	5.8	3.3
Reaction Rate*	-	Low reaction	Low reaction	Low reaction	Low reaction	Medium reaction

sPOCAS field test						
Our Reference		256049-36	256049-37	256049-38	256049-39	256049-40
Your Reference	UNITS	BH312/S/1/	BH312/S/1/	BH312/S/1/	BH312/S/1/	BH312/S/1/
Depth		1.0-1.1	1.5-1.6	2.0-2.1	2.5-2.6	3.0-3.1
Date Sampled		17/11/2020	17/11/2020	17/11/2020	17/11/2020	17/11/2020
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	20/11/2020	20/11/2020	20/11/2020	20/11/2020	20/11/2020
Date analysed	-	20/11/2020	20/11/2020	20/11/2020	20/11/2020	20/11/2020
pH_F (field pH test)*	pH Units	4.9	4.6	5.1	5.2	5.4
pH_{FOX} (field peroxide test)*	pH Units	3.6	3.5	3.7	3.9	4.3
Reaction Rate*	-	Medium reaction	Low reaction	Low reaction	Medium reaction	Low reaction

sPOCAS field test				
Our Reference		256049-41	256049-42	256049-46
Your Reference	UNITS	BH312/S/1/	BH312/S/1/	BH325/S/1/
Depth		3.5-3.6	4.0-4.1	5.5
Date Sampled		17/11/2020	17/11/2020	17/11/2020
Type of sample		Soil	Soil	Soil
Date prepared	-	20/11/2020	20/11/2020	20/11/2020
Date analysed	-	20/11/2020	20/11/2020	20/11/2020
pH_F (field pH test)*	pH Units	6.2	6.4	6.9
pH_{FOX} (field peroxide test)*	pH Units	5.8	5.9	4.8
Reaction Rate*	-	Low reaction	Low reaction	Low reaction

Method ID	Methodology Summary
Inorg-063	pH- measured using pH meter and electrode. Soil is oxidised with Hydrogen Peroxide or extracted with water. Based on section H, Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004. To ensure accurate results these tests are recommended to be done in the field as pH may change with time thus these results may not be representative of true field conditions.

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.

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CERTIFICATE OF ANALYSIS 256049-A

Client Details

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

Sample Details

Your Reference	**P1706264 - 414 Old Maitland Road, Mardi NSW**
Number of Samples	46 Soil
Date samples received	18/11/2020
Date completed instructions received	26/11/2020

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.

Report Details

Date results requested by	03/12/2020
Date of Issue	03/12/2020

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Results Approved By
Priya Samarawickrama, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

Chromium Suite						
Our Reference		256049-A-1	256049-A-2	256049-A-3	256049-A-4	256049-A-5
Your Reference	UNITS	BH311/S/1/	BH311/S/1/	BH311/S/1/	BH311/S/1/	BH311/S/1/
Depth		0.5-0.6	1.0-1.1	1.5-1.6	2.0-2.1	2.5-2.6
Date Sampled		17/11/2020	17/11/2020	17/11/2020	17/11/2020	17/11/2020
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	27/11/2020	27/11/2020	27/11/2020	27/11/2020	27/11/2020
Date analysed	-	27/11/2020	27/11/2020	27/11/2020	27/11/2020	27/11/2020
pH_{kcl}	pH units	4.8	4.5	4.6	4.7	3.9
s-TAA pH 6.5	%w/w S	0.01	0.02	0.02	0.01	0.08
TAA pH 6.5	moles H^+ /t	8	10	10	9	49
Chromium Reducible Sulfur	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
a-Chromium Reducible Sulfur	moles H^+ /t	<3	<3	<3	<3	<3
S_{HCl}	%w/w S	NT	NT	NT	NT	0.011
S_{KCl}	%w/w S	<0.005	<0.005	<0.005	<0.005	0.005
S_{NAS}	%w/w S	NT	NT	NT	NT	0.006
ANC_{BT}	% $CaCO_3$	[NT]	[NT]	[NT]	[NT]	[NT]
s-ANC_{BT}	%w/w S	[NT]	[NT]	[NT]	[NT]	[NT]
s-Net Acidity	%w/w S	0.014	0.017	0.016	0.014	0.085
a-Net Acidity	moles H^+ /t	8.5	11	10	9.0	53
Liming rate	kg $CaCO_3$ /t	<0.75	0.8	0.8	<0.75	4
a-Net Acidity without ANCE	moles H^+ /t	8.5	11	10	9.0	53
Liming rate without ANCE	kg $CaCO_3$ /t	<0.75	0.81	0.77	<0.75	4.0
s-Net Acidity without ANCE	%w/w S	0.014	0.017	0.016	0.014	0.085

Chromium Suite						
Our Reference		256049-A-6	256049-A-7	256049-A-10	256049-A-11	256049-A-12
Your Reference	UNITS	BH311/S/1/	BH311/S/1/	BH322/S/1/	BH322/S/1/	BH322/S/1/
Depth		3.0-3.1	3.5-3.6	0.5-0.6	1.0-1.1	1.5-1.6
Date Sampled		17/11/2020	17/11/2020	17/11/2020	17/11/2020	17/11/2020
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	27/11/2020	27/11/2020	27/11/2020	27/11/2020	27/11/2020
Date analysed	-	27/11/2020	27/11/2020	27/11/2020	27/11/2020	27/11/2020
pH_{kcl}	pH units	4.0	4.2	4.3	4.3	4.4
s-TAA pH 6.5	%w/w S	0.06	0.03	0.04	0.03	0.02
TAA pH 6.5	moles H^+ /t	40	18	24	21	10
Chromium Reducible Sulfur	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
a-Chromium Reducible Sulfur	moles H^+ /t	<3	<3	<3	<3	<3
S_{HCl}	%w/w S	0.024	0.015	0.009	0.010	0.009
S_{KCl}	%w/w S	0.011	0.008	<0.005	<0.005	0.005
S_{NAS}	%w/w S	0.013	0.007	0.007	0.007	<0.005
ANC_{BT}	% $CaCO_3$	[NT]	[NT]	[NT]	[NT]	[NT]
s-ANC_{BT}	%w/w S	[NT]	[NT]	[NT]	[NT]	[NT]
s-Net Acidity	%w/w S	0.079	0.037	0.046	0.041	0.023
a-Net Acidity	moles H^+ /t	50	23	29	26	15
Liming rate	kg $CaCO_3$ /t	4	2	2	2	1
a-Net Acidity without ANCE	moles H^+ /t	50	23	29	26	15
Liming rate without ANCE	kg $CaCO_3$ /t	3.7	1.8	2.2	1.9	1.1
s-Net Acidity without ANCE	%w/w S	0.079	0.037	0.046	0.041	0.023

Chromium Suite						
Our Reference		256049-A-15	256049-A-18	256049-A-19	256049-A-21	256049-A-27
Your Reference	UNITS	BH322/S/1/	BH325/S/1/	BH325/S/1/	BH325/S/1/	BH305/S/1/
Depth		3.0-3.1	0.5-0.6	1.0-1.1	2.0-2.1	0.5-0.6
Date Sampled		17/11/2020	17/11/2020	17/11/2020	17/11/2020	17/11/2020
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	27/11/2020	27/11/2020	27/11/2020	27/11/2020	27/11/2020
Date analysed	-	27/11/2020	27/11/2020	27/11/2020	27/11/2020	27/11/2020
pH $_{kcl}$	pH units	4.5	4.4	4.3	4.6	4.3
s-TAA pH 6.5	%w/w S	0.01	0.03	0.04	0.01	0.03
TAA pH 6.5	moles H^+ /t	9	18	22	8	18
Chromium Reducible Sulfur	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
a-Chromium Reducible Sulfur	moles H^+ /t	<3	<3	<3	<3	<3
S_{HCl}	%w/w S	0.007	0.007	0.011	NT	0.008
S_{KCl}	%w/w S	<0.005	<0.005	<0.005	0.010	<0.005
S_{NAS}	%w/w S	<0.005	<0.005	0.008	NT	0.005
ANC_{BT}	% $CaCO_3$	[NT]	[NT]	[NT]	[NT]	[NT]
s-ANC_{BT}	%w/w S	[NT]	[NT]	[NT]	[NT]	[NT]
s-Net Acidity	%w/w S	0.020	0.035	0.046	0.012	0.035
a-Net Acidity	moles H^+ /t	12	22	28	7.8	22
Liming rate	kg $CaCO_3$ /t	0.9	2	2	<0.75	2
a-Net Acidity without ANCE	moles H^+ /t	12	22	28	7.8	22
Liming rate without ANCE	kg $CaCO_3$ /t	0.94	1.6	2.1	<0.75	1.7
s-Net Acidity without ANCE	%w/w S	0.020	0.035	0.046	0.012	0.035

Chromium Suite						
Our Reference		256049-A-28	256049-A-30	256049-A-31	256049-A-32	256049-A-35
Your Reference	UNITS	BH305/S/1/	BH305/S/1/	BH305/S/1/	BH305/S/1/	BH312/S/1/
Depth		1.0-1.1	2.0-2.1	2.5-2.6	3.0-3.1	0.5-0.6
Date Sampled		17/11/2020	17/11/2020	17/11/2020	17/11/2020	17/11/2020
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	27/11/2020	27/11/2020	27/11/2020	27/11/2020	27/11/2020
Date analysed	-	27/11/2020	27/11/2020	27/11/2020	27/11/2020	27/11/2020
pH $_{kcl}$	pH units	4.5	5.5	5.3	5.2	4.0
s-TAA pH 6.5	%w/w S	0.01	<0.01	<0.01	<0.01	0.08
TAA pH 6.5	moles H^+ /t	9	<5	<5	<5	53
Chromium Reducible Sulfur	%w/w	<0.005	<0.005	<0.005	<0.005	0.007
a-Chromium Reducible Sulfur	moles H^+ /t	<3	<3	<3	<3	4
S_{HCl}	%w/w S	0.008	NT	NT	NT	0.029
S_{KCl}	%w/w S	<0.005	<0.005	<0.005	<0.005	0.013
S_{NAS}	%w/w S	0.005	NT	NT	NT	0.017
ANC_{BT}	% $CaCO_3$	[NT]	[NT]	[NT]	[NT]	[NT]
s-ANC_{BT}	%w/w S	[NT]	[NT]	[NT]	[NT]	[NT]
s-Net Acidity	%w/w S	0.023	<0.005	0.0070	0.0060	0.11
a-Net Acidity	moles H^+ /t	14	<5	<5	<5	67
Liming rate	kg $CaCO_3$ /t	1	<0.75	<0.75	<0.75	5
a-Net Acidity without ANCE	moles H^+ /t	14	<5	<5	<5	67
Liming rate without ANCE	kg $CaCO_3$ /t	1.1	<0.75	<0.75	<0.75	5.1
s-Net Acidity without ANCE	%w/w S	0.023	<0.005	0.0070	0.0060	0.11

Chromium Suite						
Our Reference		256049-A-36	256049-A-37	256049-A-38	256049-A-39	256049-A-40
Your Reference	UNITS	BH312/S/1/	BH312/S/1/	BH312/S/1/	BH312/S/1/	BH312/S/1/
Depth		1.0-1.1	1.5-1.6	2.0-2.1	2.5-2.6	3.0-3.1
Date Sampled		17/11/2020	17/11/2020	17/11/2020	17/11/2020	17/11/2020
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	27/11/2020	27/11/2020	27/11/2020	27/11/2020	27/11/2020
Date analysed	-	27/11/2020	27/11/2020	27/11/2020	27/11/2020	27/11/2020
pH_{kcl}	pH units	3.8	3.8	4.3	4.2	4.3
s-TAA pH 6.5	%w/w S	0.09	0.09	0.02	0.03	0.02
TAA pH 6.5	moles H^+/t	55	55	11	16	16
Chromium Reducible Sulfur	%w/w	<0.005	<0.005	<0.005	<0.005	0.005
a-Chromium Reducible Sulfur	moles H^+/t	<3	<3	<3	<3	3
S_{HCl}	%w/w S	0.040	0.046	0.029	0.033	0.025
S_{KCl}	%w/w S	0.018	0.021	0.016	0.017	0.012
S_{NAS}	%w/w S	0.022	0.025	0.013	0.016	0.012
ANC_{BT}	% $CaCO_3$	[NT]	[NT]	[NT]	[NT]	[NT]
s-ANC_{BT}	%w/w S	[NT]	[NT]	[NT]	[NT]	[NT]
s-Net Acidity	%w/w S	0.11	0.12	0.032	0.043	0.042
a-Net Acidity	moles H^+/t	70	72	20	27	26
Liming rate	kg $CaCO_3$/t	5	5	1	2	2
a-Net Acidity without ANCE	moles H^+/t	70	72	20	27	26
Liming rate without ANCE	kg $CaCO_3$/t	5.3	5.4	1.5	2.0	2.0
s-Net Acidity without ANCE	%w/w S	0.11	0.12	0.032	0.043	0.042

Method ID	Methodology Summary
Inorg-068	Chromium Reducible Sulfur - Hydrogen Sulfide is quantified by iodometric titration after distillation to determine potential acidity. Based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004.

QUALITY CONTROL: Chromium Suite					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			27/11/2020	1	27/11/2020	27/11/2020		27/11/2020	[NT]
Date analysed	-			27/11/2020	1	27/11/2020	27/11/2020		27/11/2020	[NT]
pH $_{kcl}$	pH units		Inorg-068	[NT]	1	4.8	4.8	0	96	[NT]
s-TAA pH 6.5	%w/w S	0.01	Inorg-068	<0.01	1	0.01	0.01	0	[NT]	[NT]
TAA pH 6.5	moles H^+/t	5	Inorg-068	<5	1	8	6	29	90	[NT]
Chromium Reducible Sulfur	%w/w	0.005	Inorg-068	<0.005	1	<0.005	<0.005	0	[NT]	[NT]
a-Chromium Reducible Sulfur	moles H^+/t	3	Inorg-068	<3	1	<3	<3	0	115	[NT]
S_{HCl}	%w/w S	0.005	Inorg-068	<0.005	1	NT	NT		[NT]	[NT]
S_{KCl}	%w/w S	0.005	Inorg-068	<0.005	1	<0.005	<0.005	0	[NT]	[NT]
S_{NAS}	%w/w S	0.005	Inorg-068	<0.005	1	NT	NT		[NT]	[NT]
ANC_{BT}	% $CaCO_3$	0.05	Inorg-068	<0.05	1	[NT]	[NT]		[NT]	[NT]
s-ANC_{BT}	%w/w S	0.05	Inorg-068	<0.05	1	[NT]	[NT]		[NT]	[NT]
s-Net Acidity	%w/w S	0.005	Inorg-068	<0.005	1	0.014	0.013	7	[NT]	[NT]
a-Net Acidity	moles H^+/t	5	Inorg-068	<5	1	8.5	8.3	2	[NT]	[NT]
Liming rate	kg $CaCO_3$/t	0.75	Inorg-068	<0.75	1	<0.75	<0.75	0	[NT]	[NT]
a-Net Acidity without ANCE	moles H^+/t	5	Inorg-068	<5	1	8.5	8.3	2	[NT]	[NT]
Liming rate without ANCE	kg $CaCO_3$/t	0.75	Inorg-068	<0.75	1	<0.75	<0.75	0	[NT]	[NT]
s-Net Acidity without ANCE	%w/w S	0.005	Inorg-068	<0.005	1	0.014	0.013	7	[NT]	[NT]

QUALITY CONTROL: Chromium Suite					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-2	[NT]
Date prepared	-			[NT]	11	27/11/2020	27/11/2020		27/11/2020	[NT]
Date analysed	-			[NT]	11	27/11/2020	27/11/2020		27/11/2020	[NT]
pH_{kcl}	pH units		Inorg-068	[NT]	11	4.3	4.3	0	97	[NT]
s-TAA pH 6.5	%w/w S	0.01	Inorg-068	[NT]	11	0.03	0.03	0	[NT]	[NT]
TAA pH 6.5	moles H^+/t	5	Inorg-068	[NT]	11	21	21	0	95	[NT]
Chromium Reducible Sulfur	%w/w	0.005	Inorg-068	[NT]	11	<0.005	<0.005	0	[NT]	[NT]
a-Chromium Reducible Sulfur	moles H^+/t	3	Inorg-068	[NT]	11	<3	<3	0	115	[NT]
S_{HCl}	%w/w S	0.005	Inorg-068	[NT]	11	0.010	0.010	0	[NT]	[NT]
S_{KCl}	%w/w S	0.005	Inorg-068	[NT]	11	<0.005	<0.005	0	[NT]	[NT]
S_{NAS}	%w/w S	0.005	Inorg-068	[NT]	11	0.007	0.006	15	[NT]	[NT]
s-Net Acidity	%w/w S	0.005	Inorg-068	[NT]	11	0.041	0.041	0	[NT]	[NT]
a-Net Acidity	moles H^+/t	5	Inorg-068	[NT]	11	26	26	0	[NT]	[NT]
Liming rate	kg $CaCO_3$/t	0.75	Inorg-068	[NT]	11	2	2	0	[NT]	[NT]
a-Net Acidity without ANCE	moles H^+/t	5	Inorg-068	[NT]	11	26	26	0	[NT]	[NT]
Liming rate without ANCE	kg $CaCO_3$/t	0.75	Inorg-068	[NT]	11	1.9	1.9	0	[NT]	[NT]
s-Net Acidity without ANCE	%w/w S	0.005	Inorg-068	[NT]	11	0.041	0.041	0	[NT]	[NT]

QUALITY CONTROL: Chromium Suite					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	31	27/11/2020	27/11/2020		[NT]	[NT]
Date analysed	-			[NT]	31	27/11/2020	27/11/2020		[NT]	[NT]
pH $_{kcl}$	pH units		Inorg-068	[NT]	31	5.3	5.3	0	[NT]	[NT]
s-TAA pH 6.5	%w/w S	0.01	Inorg-068	[NT]	31	<0.01	<0.01	0	[NT]	[NT]
TAA pH 6.5	moles H^+/t	5	Inorg-068	[NT]	31	<5	<5	0	[NT]	[NT]
Chromium Reducible Sulfur	%w/w	0.005	Inorg-068	[NT]	31	<0.005	<0.005	0	[NT]	[NT]
a-Chromium Reducible Sulfur	moles H^+/t	3	Inorg-068	[NT]	31	<3	<3	0	[NT]	[NT]
S_{HCl}	%w/w S	0.005	Inorg-068	[NT]	31	NT	NT		[NT]	[NT]
S_{KCl}	%w/w S	0.005	Inorg-068	[NT]	31	<0.005	<0.005	0	[NT]	[NT]
S_{NAS}	%w/w S	0.005	Inorg-068	[NT]	31	NT	NT		[NT]	[NT]
s-Net Acidity	%w/w S	0.005	Inorg-068	[NT]	31	0.0070	0.0060	15	[NT]	[NT]
a-Net Acidity	moles H^+/t	5	Inorg-068	[NT]	31	<5	<5	0	[NT]	[NT]
Liming rate	kg $CaCO_3$/t	0.75	Inorg-068	[NT]	31	<0.75	<0.75	0	[NT]	[NT]
a-Net Acidity without ANCE	moles H^+/t	5	Inorg-068	[NT]	31	<5	<5	0	[NT]	[NT]
Liming rate without ANCE	kg $CaCO_3$/t	0.75	Inorg-068	[NT]	31	<0.75	<0.75	0	[NT]	[NT]
s-Net Acidity without ANCE	%w/w S	0.005	Inorg-068	[NT]	31	0.0070	0.0060	15	[NT]	[NT]

Result Definitions

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

Quality Control Definitions

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

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

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.

14 Attachment F – General Geotechnical Recommendations

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

Batter Slopes

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

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

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

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

Earthworks

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

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

Excavations

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

1. Extremely low to low strength rock - conventional hydraulic earthmoving equipment.

2. Medium strength or stronger rock - hydraulic earthmoving equipment with rock hammer or ripping tyne attachment.

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

Fill

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

Foundations

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

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

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

Shoring - Anchors

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

Shoring - Permanent

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

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

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

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

Shoring - Temporary

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

Soil Erosion Control

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

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

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

Trafficability and Access

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

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

Vibration Management

Where excavation is to be extended into medium or higher strength rock, care will be required when using a rock hammer to limit potential structural distress from excavation-induced vibrations where nearby structures may be affected by the works.

To limit vibrations, we recommend limiting rock hammer size and set frequency, and setting the hammer parallel to bedding planes and along defect planes, where possible, or as advised by a geotechnical engineer. We recommend limiting vibration peak particle velocities (PPV) caused by construction equipment or resulting from excavation at the site to 5 mm/s (AS 2187.2, 2006, Appendix J).

Waste – Spoil and Water

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

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

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

Water Management - Groundwater

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

Water Management – Surface Water

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

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

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

Contingency Plan

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

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

15 Attachment G – 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

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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.

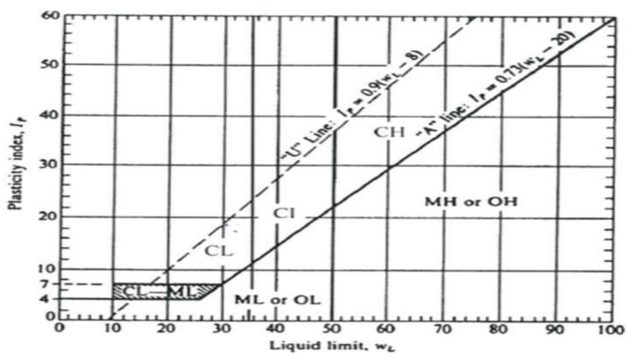
Particle Size

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

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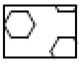
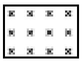
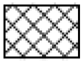
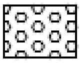
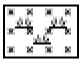
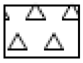
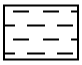
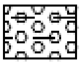
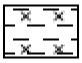
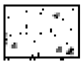
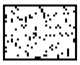
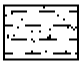
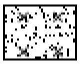
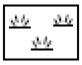
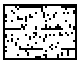
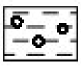
Symbols for Soils and Other

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

Unified Soil Classification Scheme (USCS)

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 63 mm and basing fractions on estimated mass)					USCS	Primary Name
COARSE GRAINED SOILS More than 65 % of material less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.36 mm.	GRAVEL and GRAVEL-SAND Mixtures (≤ 5% fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes; not enough fines to bind coarse grains; no dry strength	GW	GRAVEL
				Predominantly one size or a range of sizes with some intermediate sizes missing; not enough fines to bind coarse grains; no dry strength	GP	GRAVEL
			GRAVEL-SILT and GRAVEL-SAND-SILT mixtures (≥12% fines) [1]	With excess non-plastic fines (for identification procedures see ML below); zero to medium dry strength; may also contain sand	GM	Silty GRAVEL
				With excess plastic fines (for identification procedures see CL below); medium to high dry strength; may also contain sand	GC	Clayey GRAVEL
		SANDS More than half of coarse fraction is smaller than 2.36 mm	SAND and GRAVEL-SAND mixtures (≤5% fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes; not enough fines to bind coarse grains; no dry strength.	SW	SAND
				Predominantly one size or a range of sizes with some intermediate sizes missing; not enough fines to bind coarse grains; no dry strength	SP	SAND
			SAND-SILT and SAND-CLAY mixtures (≥12% fines) [1]	With excess non-plastic fines (for identification procedures see ML below); zero to medium dry strength;	SM	Silty SAND
				With excess plastic fines (for identification procedures see CL below); medium to high dry strength	SC	Clayey SAND

		IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 MM					
		DRY STRENGTH (Crushing Characteristics)	DILATANCY	TOUGHNESS	DESCRIPTION	USCS	Primary Name
FINE GRAINED SOILS More than 35 % of material less than 63 mm is smaller than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	None to Low	Quick to Slow	Low	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or silt with low plasticity [2]	ML	SILT [3]
		Medium to High	None to Slow	Medium	Inorganic clays of low to medium plasticity, gravely clays, sandy clays, silty clays, lean clays	CL (or CI[4])	CLAY
		Low to Medium	Slow	Low	Organic slits and organic silty clays of low plasticity	OL	Organic SILT or CLAY
		Low to Medium	None to Slow	Low to Medium	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	MH	SILT [3]
		High to Very High	None	High	Inorganic clays of high plasticity, fat clays	CH	CLAY
		Medium to High	None to Very Slow	Low to Medium	Organic clays of medium to high plasticity, organic silt of high plasticity	OH	Organic SILT or CLAY
HIGHLY ORGANIC SOILS		Readily identified by colour, odour, spongy feel and frequently by fibrous texture				Pt	PEAT

Notes:

1. Between 5% and 12% - dual classification, e.g. GP-GM.
2. Low Plasticity Clay – Liquid Limit $W_L \leq 35\%$; Medium Plasticity Clay – Liquid limit $W_L > 35\%, \leq 50\%$; High Plasticity Clay - Liquid limit $W_L > 50\%$.
3. Low Plasticity Silt – Liquid Limit $W_L \leq 50\%$; 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 Data

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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

SEDIMENTARY ROCK

- BRECCIA
- CONGLOMERATE
- CONGLOMERATIC SANDSTONE
- SANDSTONE/QUARTZITE
- SILTSTONE
- MUDSTONE/CLAYSTONE
- SHALE

- COAL
- LIMESTONE
- LITHIC TUFF

IGNEOUS ROCK

- GRANITE
- DOLERITE/BASALT

METAMORPHIC ROCK

- SLATE, PHYLLITE, SCHIST
- GNEISS
- METASANDSTONE
- METASILTSTONE
- METAMUDSTONE

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

Rock Data

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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

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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 (MPa) = (0.4 to 0.6) 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)

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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		