

Bayview Golf Club



Geotechnical Assessment: Stormwater Harvesting and Irrigation Works - Bayview Golf Course, Cabbage Tree Road, Bayview, NSW

ENVIRONMENTAL



WATER



WASTEWATER



GEOTECHNICAL



CIVIL



PROJECT
MANAGEMENT



P2108485JR01V01
October 2021

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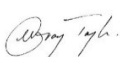
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All enquiries regarding this project are to be directed to the Project Manager.



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1 Proposed Development and Investigation Scope

Proposed development details are summarised in Table 1.

Table 1: Summary of proposed development.

Item	Details
Site address	52 Cabbage Tree Road and 1825 Pittwater Road, Bayview NSW 2103, known as Bayview Golf Club.
Lot / DP	Lot 1 DP 662920, Lot 5 DP 45114, Lot 191 DP 1039481, Lot A DP 339874, Lot 150 DP 1003518, Lots 1, 2 and 3 DP 986894, Lot 300 DP 1139238.
LGA	Northern Beaches Council (Council).
Site Area	Approximately 15.92 Ha (Six Maps, 2021).
Background	<p>Martens & Associates (MA) has previously undertaken the following site assessments:</p> <ul style="list-style-type: none"> ○ A geotechnical and acid sulfate soils assessment in October 2017 for a proposed seniors living development. Refer to P1706099JR02V03 for further details. ○ Acid sulfate soil assessment in November 2017 for proposed flood mitigation earthworks. Refer to P1706099JR04V01 for further details. ○ Acid sulfate soil management plan in December 2018 for a proposed seniors living development. Refer to P1706099JR07V02 for further details. ○ Acid sulfate soil assessment in December 2018 for the Bayview Golf Course and a seniors living development. Refer to P1706099JR08V02 for further details. <p>Results of these assessments have been considered and reproduced (where of benefit for clarity) within this report.</p>
Proposed Development	<p>A master plan set (CC, 2021a and CC, 2021b), provided by the client, shows a proposal to collect, divert, store, filter and distribute water into the golf course landscape. This will require trenching for installation of power and drainage and pressured pipework, which will connect into existing in-ground services and storage ponds. The development will include the following infrastructure:</p> <ul style="list-style-type: none"> ○ Subsoil drainage lines in all Zones connecting to underground sump pits (450 mm x 450 mm & 900 mm x 900 mm) – expected excavation up to approximately 1.0 meter below ground level (mbgl). ○ 80 mm diameter irrigation pressure pipe, power and communications conduits and power control cabinet in Zone 1 – expected excavation up to approximately 0.6 mbgl. ○ Buried 10,500 litre pump tank and pump pit no. 2 in Zone 1 – expected excavation up to approximately 3 mbgl and 1.5 mbgl) respectively. ○ Buried pump station in Zones 8 and 9 – expected excavation up to approximately 1.5 – 2.0 mbgl.
Assessment Purpose	Geotechnical assessment to provide geotechnical advice and recommendations to support a development application (DA) submission to the council.
Investigation Scope of Work	<p>Review of previous investigation results.</p> <p>An additional field investigation on 10 September 2021, which included:</p> <ul style="list-style-type: none"> ○ General site walkover survey. ○ Drilling of three boreholes (BH501 and BH503) near proposed deeper excavations, with 4WD mounted drilling rig up to approximately 4.0 mbgl (refer Attachment B for borehole logs and associated explanatory notes in Attachment F).

Item	Details
	<ul style="list-style-type: none"><li data-bbox="630 360 1425 439">○ Three dynamic cone penetration (DCP) tests (DCP101 to DCP103) adjacent to the boreholes up to approximately 5.0 mbgl (refer Attachment C for DCP test results). <p data-bbox="582 448 1425 544">BH501 and DCP501 were undertaken near the pump tank in Zone 1. BH502 and DCP502 were undertaken near the Zone 1 pump pit no.2. BH503 and DCP503 were undertaken near the Zone 8 pump station. Investigation locations are shown in Figure 1, Attachment A.</p>

2 Site Details

Table 2 summarises the general site details considered relevant to the assessment and proposed development.

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

Item	Comment
Soil landscape	<p>The NSW Office of Environment and Heritage's (OEH) information system indicates the following:</p> <p><u>North, north eastern portion</u></p> <ul style="list-style-type: none"> ○ Terrain disturbed by human activity, with local relief < 2 m. ○ Disturbed ground to include berms, cut faces, embankments, mounds, pits and trenches. ○ Slopes levelled to < 3 %. <p><u>Eastern portion</u></p> <ul style="list-style-type: none"> ○ Flooded valleys infilled with alluvium and surrounded by steep to precipitous Hawkesbury sandstone slopes. ○ Gently undulating alluvial floodplain with slopes <3 %, elevation <10 m. <p><u>South east portion</u></p> <ul style="list-style-type: none"> ○ Gently undulating plains and rolling undulating rises of broad, level to very gently inclined swales and dunes. ○ Elevation and local relief usually < 20 m. ○ Isolated steep rises with slopes up to 35 %.
Expected geology	The published geological map covering this area indicates that the development area is underlain by Quaternary deposits: silty to peaty quartz sand, silt, and clay with ferruginous and humic cementation in places and common shell layers (Sydney 1:100 000 Geological Sheet 9130, 1st edition).
Typical slopes, elevation	Slopes are generally low (<2%) and elevation generally ranges from approximately 1 to 2 mAHD.
Existing Development	The site is developed as a golf course.
Vegetation	Grass covered fairways, with trees along fairway edges (typically Casuarinas and Melaleucas). Mangroves along some areas of the inlet which connects to Winnererremy Bay.
Neighbouring environment	<p>The site is bordered by:</p> <ul style="list-style-type: none"> ○ Cabbage Tree Road to the north. ○ Parkland Road to the west. ○ Residential properties to the south. ○ Pittwater Road to the east followed by a school.
Drainage	<p>Depressions and swamps in the northern and eastern portions of the site collect water during rainfall events. Cahill Creek flows from the northern to the eastern portion of the site.</p> <p>The site generally drains somewhat centrally to an inlet which ultimately connects to Winnererremy Bay, Pittwater, located approximately 260 m north east of the site.</p>

Item	Comment
Sub surface soil units	<p>The site is underlain by:</p> <ul style="list-style-type: none"> ○ In areas inferred moderately compacted fill of variable sand and clay content with thickness ranging typically from 0.06 (BH415) to 2.5 (BH408) mbgl. ○ Natural Quaternary deposits comprising beds of silt / sandy silt / clayey silt, sand and clay / sandy clay. Some silt layers were black, indicating possible presence of organic matter. <p>The areas of proposed deeper excavation are expected to be underlain by the following generalised subsurface units, inferred from our site observations, BH501 to BH503 and DCP test results:</p> <ul style="list-style-type: none"> ○ Alluvial sandy silt / silt, varying from soft to stiff, encountered up to approximately 0.8 mbgl. ○ Alluvial silty sand, loose up to approximately 1.5 mbgl becoming medium dense, up to 4.0 mbgl. ○ Material density below 4 mbgl at DCP501 reduced to loose to very loose / soft, which may be as a result of the presence of organics. <p>Encountered conditions are described in more detail on borehole logs in Attachment B and associated explanatory notes in Attachment F and Martens previous assessment reports. For DCP test result refer Attachment C.</p>
Groundwater	<p>Groundwater inflow was encountered at 0.6 – 0.7 mbgl during the drilling of boreholes BH501, BH502 and BH503. Groundwater level fluctuations may occur. Should further information on ground water fluctuations be required, additional assessment would need to be carried out (i.e. installation of groundwater monitoring wells).</p>
Acid Sulfate Soils	<p>The site soils are considered to be PASS (Potential Acid Sulfate Soils). For further details and results of the ASS assessment undertaken by Martens refer to MA report P2108485JR02V01 and P1706099JR04V01.</p>

3 Geotechnical Assessment

3.1 Risk of Slope Instability

The site area falls outside the landslide risk Hazard 1 or Hazard 2 zones shown on Pittwater Geotechnical Hazard Maps (refer Figure 2 in Attachment A). No evidence of recent land instability was observed within the site, during the site walkover survey.

In accordance with Section 5 of NBC's geotechnical risk management policy, a Geotechnical Report is not required. A detailed slope risk assessment in accordance with Australian Geomechanics Society's Landslide Risk Management Guidelines (2007) was not undertaken.

However, trench and pit excavations in sandy silty soils have a potential to collapse unless supported. Recommendations presented in this report are provided to mitigate risks associated with potential excavation instability during construction.

We consider the risk to property and loss of life by potential slope instability to be very low and the consequences to be insignificant, subject to the recommendations in this report and adoption of relevant engineering standards and guidelines.

Pittwater risk Form 1 has been included as Attachment E.

3.2 Preliminary Material Properties

Preliminary material properties inferred from observations during borehole drilling, such as auger penetration resistance, DCP test results as well as engineering judgement are summarised in Table 3.

Table 3: Preliminary estimates of soil and rock strength properties.

Layer	$\gamma_{in-situ}^1$ (kN/m ³)	C_u^2 (kPa)	C'^3 (kPa)	ϕ'^4 (deg)	K_0^5	K_a^5	K_p^5
Fill: SAND and CLAY; inferred moderately compacted	17	25	2	28			
Quaternary Sandy SILT / SILT, varying from loose to stiff	16/18	25	1	24	0.6	0.4	2.4
Quaternary Silty SAND above 1.5 mbgl, loose to medium dense	16/19	NA ⁶	NA ⁶	27			
Quaternary Silty SAND below 1.5 mbgl; medium dense	17/20	NA ⁶	NA ⁶	32	0.5	0.3	3.3

Notes:

1. Material unit weight, based on visual assessment ($\pm 10\%$), dry / saturated.
2. Undrained shear strength (clay), silt).
3. Drained cohesion (clay), silt).
4. Effective internal friction angle ($\pm 2^\circ$) estimate, assuming drained conditions (sand).
5. k_a = Coefficient of active earth pressure; k_p = Coefficient of passive earth pressure; k_0 = Coefficient of earth pressure at rest.
6. Not applicable.

4 Geotechnical Recommendations

4.1 Recommendations

General geotechnical recommendations for the proposed development are provided in Attachment D. Additional recommendations are as follows:

4.1.1 Excavation

Excavation of fill and quaternary deposits can be achieved using a hydraulic tracked excavator fitted with a bucket.

Care must be taken to maintain adequate plant offset from open excavations to prevent plant loading induced excavation side collapse during trench / pit excavations.

Contractor should consider presence of shallow groundwater when developing their excavation methodologies as part of construction planning and plant selection.

Dewatering of deep excavations below groundwater level will be required.

We recommend that excavated materials are suitably stockpiled for reuse or off-site disposal to a suitable location in accordance with NSW EPA (2014) Waste Classification Guidelines.

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

4.1.2 Excavation support

Excavation in granular soils and silt to depths of greater than 0.5 m should be temporarily battered back or supported / permanently retained to maintain excavation stability. Temporary support may include:

- Trench shoring, where excavations remain above groundwater level.
- Sheet piles for deeper excavations below groundwater level, either cantilevered or braced with internal bracing. The sheet piles can be sacrificial or removed following construction of permanent retention.

Temporary shoring or retaining wall design may adopt preliminary earth pressure coefficients provided in Table 3.

Temporary batters should not exceed grades of 1V:2H above groundwater level and 1V:3H below groundwater level.

4.1.3 Footings and Foundations

Pump tank, pump pit, pump station excavations to below 1.5 m depth will extend into medium dense sand. An allowable bearing capacity of 100 kPa may be adopted for design of foundations in medium dense sand.

Bearing capacity for foundation design is subject to the following:

- The excavation base is clean, free of loose / soft soils or excavation spoil prior to foundation construction.
- Concrete placement / infrastructure installation is commenced as soon as possible following excavation completion and base cleaning, inspection and approval by a geotechnical engineer

Consideration should be given in foundation design of potential presence of organic material in layers and layers of soft soil beneath foundation level. Compression of these soils as a result of loading may occur. Additional assessments can be undertaken, if necessary.

Review of the final design by a senior geotechnical engineer as well as inspection and approval of foundation conditions by a geotechnical engineer during the construction stage is recommended.

4.1.4 Earthworks

New fill placement, if required, should be carried out under 'engineered' conditions and, under the guidance of a geotechnical engineer following removal of existing uncontrolled fill materials or any other unsuitable materials.

All earthworks should be carried out in accordance with AS3798 (2007) – Guidelines on Earthworks for Commercial and Residential Developments.

Further guidance should be sought from a geotechnical engineer during removal of unsuitable material and fill placement to ensure ground conditions are suitable as foundation for slabs on ground or as backfilling. Backfill should comprise granular material.

4.1.5 Buoyancy

Pump tank, pump pit and pump station structures should be designed as tanked structures with inclusion of appropriate water proofing. Design should also consider buoyancy forces as a result of shallow groundwater, particularly when structures are empty.

4.1.6 Dewatering and Drainage

Groundwater dewatering will be required during deeper excavations to lower the groundwater level below bulk excavation level. We recommend lowering the groundwater level to at least 1 meter below bulk excavation level to limit the impacts on the excavation base from soil heave due to pore water pressures or soil liquefaction due to the construction works.

It should be noted that groundwater levels and conditions may be influenced by seasonal variations such as heavy rainfall, flooding, damaged services, etc.

4.1.7 Site Classification

The site is classified as a Class "P" site in accordance with AS 2870 (2011) due to presence of fill, shallow groundwater levels and presence of soft / loose soils up to 1.5 m depth.

The site may be reclassified as Class "A" where footings found on medium dense natural sands.

Consideration shall be given to possible ground condition changes as a result of tree removal, such as increased soil moisture, ground disturbance and development of voids due to rotting roots.

5 Proposed Additional Works.

5.1 Further Works

We recommend the following is carried out for development of the final design and prior to construction:

- Installation of groundwater wells and monitoring of groundwater levels, if necessary for detailed design, to assess groundwater level fluctuations.
- Further geotechnical assessment, if necessary for detailed design, to identify the presence of organic materials or soft silt layers beneath foundation level and assess associated soil consolidation settlements.
- 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.

5.2 Construction Monitoring and Inspections

We recommend the following is inspected and monitored during construction of the project.

Table 4: Recommended inspection / monitoring requirements during site works.

Scope of Works	Frequency/Duration	Who to Complete
Inspect exposed material at foundation / subgrade level to verify suitability as foundation / subgrade before foundation construction.	Prior to reinforcement set-up and concrete placement, pit installations or fill placement	MA ¹
Monitor excavation support stability.	Ongoing	Builder
Monitor groundwater seepage from excavation faces, if encountered, to assess stability of retained materials and need for additional drainage or support requirements.	When encountered	Builder / MA ¹
Monitor earthworks.	As required	MA ¹

Notes:

1. MA = Martens and Associates engineer.

6 References

- Chrisp Consulting (2021), *STORMWATER HARVESTING AND IRRIGATION, BAYVIEW GOLF CLUB*, Job No. 20056, Drawing Nos. C100, C110 to C124, C130, C140, Revision F, dated 17 March 2021 (CC, 2021a).
- Chrisp Consulting (2021), *STORMWATER HARVESTING AND IRRIGATION, BAYVIEW GOLF CLUB, PUMP STATION AND GENERAL WORKS DETAILS*, Job No. 20056, Drawing No. C200, Revision B, dated 23 February 2021 (CC, 2021b).
- Herbert C. (1983) *Sydney 1:100 000 Geological Sheet 9130*, 1st edition, Geological Survey of New South Wales, Sydney.
- Northern Beaches Council (2021), *Development Application No: DA2021/1338 for Construction of water harvesting and sub-surface drainage of golf course fairways at 52 Cabbage Tree Road and 1825 Pittwater Road BAYVIEW*, dated 31 August 2021 (NBC, 2021).
- Martens and Associates (2021), *Acid Sulfate Soils Assessment: Stormwater Harvesting and Irrigation Works, Bayview Golf Course, Cabbage Tree Road, Bayview, NSW*, Report reference P2108485JR02V01, dated 18 October 2021 (MA, 2021).
- Martens and Associates (2018), *Geotechnical and Acid Sulfate Soils Assessment: Proposed Seniors Living Development, Cabbage Tree Road, Bayview, NSW*, Report reference P1706099JR02V03, dated 27 August 2018 (MA, 2018a).
- Martens and Associates (2018), *Acid Sulfate Soil Management Plan: Proposed Seniors Living Development, Bayview Golf Course, Cabbage Tree Road, Bayview, NSW*, Report reference P1706099JR07V02, dated 21 December 2018 (MA, 2018b).
- Martens and Associates (2018), *Acid Sulfate Soil Assessment: Bayview Golf Course and Seniors Living Development, Cabbage Tree Road, Bayview, NSW*, Report reference P1706099JR08V01, dated 21 December 2018 (MA, 2018c).
- Martens and Associates (2017), *Acid Sulfate Soil Assessment: Proposed Flood Mitigation Earthworks, Bayview Golf Course, Cabbage Tree Road, Bayview, NSW*, Report reference P1706099JR04V01, dated 29 November 2017 (MA, 2017a).

NSW Department of Environment & Heritage (2020) eSPADE, NSW soil and land information, www.environment.nsw.gov.au, accessed 21.09.2021.

Pittwater Local Environmental Plan (2014), *Geotechnical Hazard Map – Sheet GTH_011*.

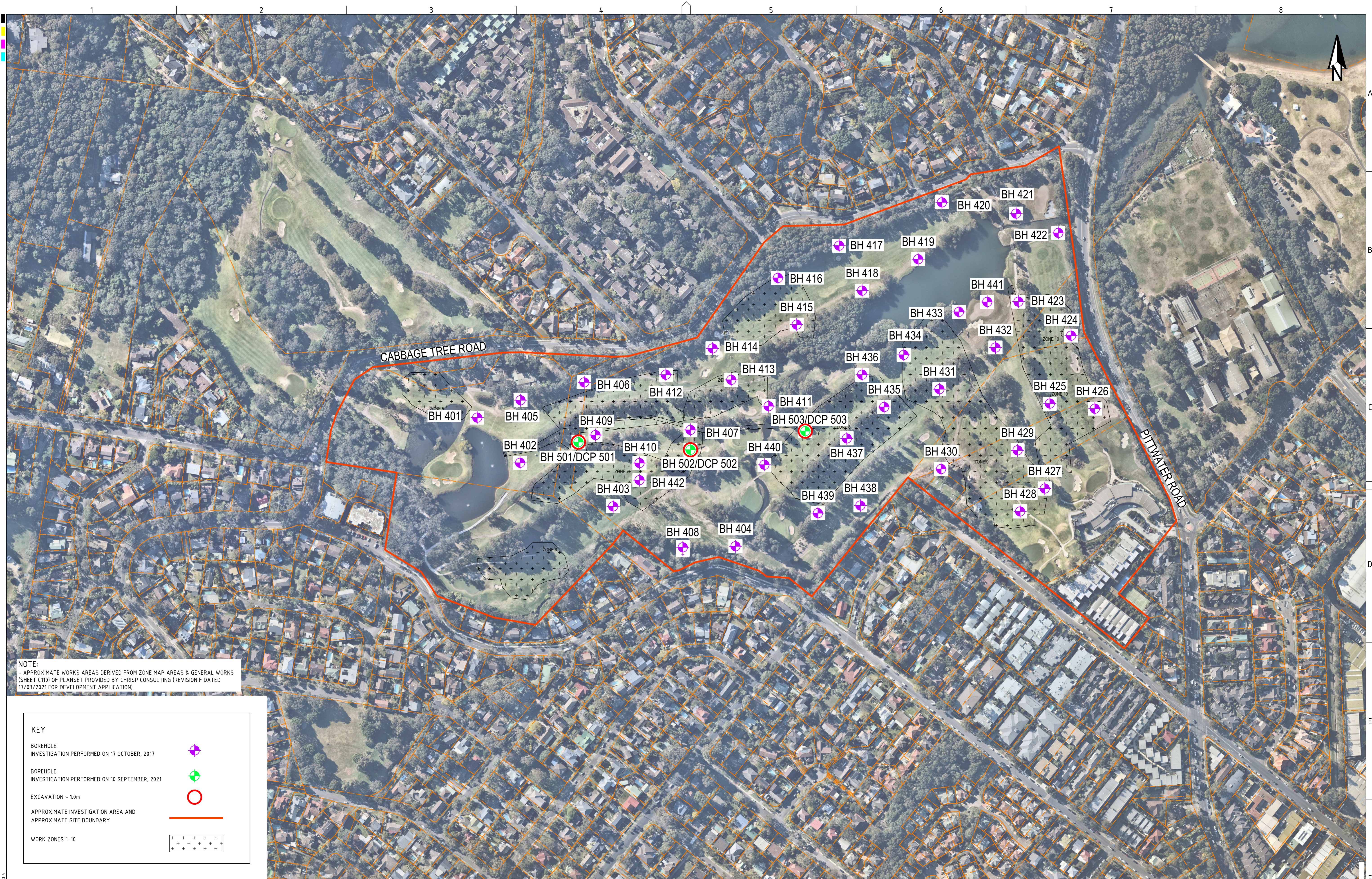
Standards Australia Limited (1997) AS 1289.6.3.2:1997, *Determination of the penetration resistance of a soil – 9kg dynamic cone penetrometer test*, SAI Global Limited.

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

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

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

7 Attachment A – Figures



NOTE:
 - APPROXIMATE WORKS AREAS DERIVED FROM ZONE MAP AREAS & GENERAL WORKS (SHEET C110) OF PLANSET PROVIDED BY CHRISP CONSULTING (REVISION F DATED 17/03/2021 FOR DEVELOPMENT APPLICATION).

KEY

- BOREHOLE INVESTIGATION PERFORMED ON 17 OCTOBER, 2017
- BOREHOLE INVESTIGATION PERFORMED ON 10 SEPTEMBER, 2021
- EXCAVATION > 1.0m
- APPROXIMATE INVESTIGATION AREA AND APPROXIMATE SITE BOUNDARY
- WORK ZONES 1-10

REV	DESCRIPTION	DATE	DRAWN	DESIGNED	CHECKED	APPRVD
A	INITIAL RELEASE	29/09/2021	RK	WX	GT	GT

SCALE
 0 20 40 60 80 100 120 140 160 180 200
 A1 (A3) 1:2,000 (1:4,000) METRES

GRID GDA 94
 DATUM mAHD
 PROJECT MANAGER GT
 CLIENT BAYVIEW GOLF CLUB

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PROJECT NAME/PLANSET TITLE
STORMWATER HARVESTING & IRRIGATION
 GEOTECHNICAL ASSESSMENT
 CABBAGE TREE ROAD, BAYVIEW, NSW

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DRAWING TITLE TESTING LOCATION PLAN - FIGURE 1				
PROJECT NO. P21084.85	PLANSET NO. PS03	RELEASE NO. R02	DRAWING NO. PS03-J130	REVISION A

PRINTED: 08/10/2021 USER: P21084.85

A1 / A3 LANDSCAPE (A1LC_02.0.01)

DRAWING ID: P21084.85-PS03-R02-110



LEGEND
Pittwater Geotechnical Hazard Map

- Geotechnical Hazard H1
- Geotechnical Hazard H2



martens

Martens & Associates Pty Ltd ABN 85 070 240 890	
Drawn:	AG
Approved:	RE
Date:	21.09.2021

Environment | Water | Wastewater | Geotechnical | Civil | Management

STORMWATER HARVESTING AND IRRIGATION WORKS, Geotechnical Hazard Map (showing the site location relative to risk classes)
(Source: Pittwater LEP, 2014)

Drawing: FIGURE 2
Job No: P2108458JR01V01

8 Attachment B – Borehole Logs

CLIENT	Bayview Golf Club	COMMENCED	10/09/2021	COMPLETED	10/09/2021	REF BH501	
PROJECT	Geotechnical & Acid Sulfate Soil Assessment	LOGGED	DS	CHECKED	RE	Sheet 1 OF 1	
SITE	Bayview Golf Course, Bayview, NSW	GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P2108485	
EQUIPMENT	4WD ute-mounted hydraulic drill rig	LONGITUDE	151.2946	RL SURFACE	3 m	DATUM	AHD
EXCAVATION DIMENSIONS	ø100 mm x 4.00 m depth	LATITUDE	-33.6692	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
ADV				3.00				ML	Sandy SILT; low liquid limit; dark brown.				ALLUVIUM
				0.60									
				2.40					dark grey from 0.4 m.				
				0.80									
				2.20				SP	Silty SAND; fine to medium grained; pale grey; trace shell.				
				1.0	1.0/S/1 D 1.00 m								
				1.30									
				1.70						brown from 1.3 m.			
				2.0	2.0/S/1 D 2.00 m								
				2.5									
			3.0	3.0/S/1 D 3.00 m									
			3.5										
			4.0	3.9/S/1 D 3.90 m									
			4.00						Hole Terminated at 4.00 m				4.00: Target depth reached.
			4.5										

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

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P2108485BH501-BH503V01.GPJ <DrawingFile> 13/10/2021 12:01 10:02:00.04 D:\git\Lab and In Situ Tool - DGD | Lib: Martens 2.00 2016-11-13 Pjf: Martens 2.00 2016-11-13



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**Engineering Log -
 BOREHOLE**

CLIENT	Bayview Golf Club	COMMENCED	10/09/2021	COMPLETED	10/09/2021	REF BH502	
PROJECT	Geotechnical & Acid Sulfate Soil Assessment	LOGGED	DS	CHECKED	RE	Sheet 1 OF 1	
SITE	Bayview Golf Course, Bayview, NSW	GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P2108485	
EQUIPMENT	4WD ute-mounted hydraulic drill rig	LONGITUDE	151.2958	RL SURFACE	2 m	DATUM	AHD
EXCAVATION DIMENSIONS	ø100 mm x 3.00 m depth	LATITUDE	-33.6691	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
ADV				2.00				ML	Sandy SILT; low liquid limit; dark brown.				ALLUVIUM
				0.40									
				1.60					dark grey from 0.4 m.	M	St		
				0.5		0.5/S/1 D 0.50 m					F		
				0.70									
				1.30				SM	Silty SAND; fine to medium grained; pale brown; trace shell.			L	
				1.0		1.0/S/1 D 1.00 m					MD		
				1.5					brown from 1.5 m.			L	
				1.50									
				0.50									
				2.0		2.0/S/1 D 2.00 m					W		
				2.5		2.5/S/1 D 2.50 m							
				3.0		2.9/S/1 D 2.90 m					MD		
				3.00					Hole Terminated at 3.00 m				3.00: Target depth reached.
				3.5									
				4.0									
				4.5									

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

MARTENS 2.00.LIB.GLB Log MARTENS BOREHOLE P2108485EH501-9H03V01.GPJ <DrawingFile> 13/10/2021 12:01 10:02:00.04 D:\git\Lab and in Situ Tool - DGD\1 Lib: Martens 2.00 2016-11-13 Pjf: Martens 2.00 2016-11-13



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 Phone: (02) 9476 9999 Fax: (02) 9476 8767
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**Engineering Log -
 BOREHOLE**

CLIENT	Bayview Golf Club	COMMENCED	10/09/2021	COMPLETED	10/09/2021	REF BH503	
PROJECT	Geotechnical & Acid Sulfate Soil Assessment	LOGGED	DS	CHECKED	RE	Sheet 1 OF 1	
SITE	Bayview Golf Course, Bayview, NSW	GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P2108485	
EQUIPMENT	4WD ute-mounted hydraulic drill rig	LONGITUDE	151.2972	RL SURFACE	4 m	DATUM	AHD
EXCAVATION DIMENSIONS	ø75 mm x 3.10 m depth	LATITUDE	-33.6694	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
ADV				4.00				ML	SILT; low liquid limit; dark brown; with sand.				ALLUVIUM
											F		
				0.5	0.5/S/1 D 0.50 m						M		
				0.60							St		
				3.40					SM	Silty SAND; fine to medium grained; brown, pale brown; trace shell.			
											L - MD		
				1.0	1.0/S/1 D 1.00 m								
				1.50									
				2.50					brown from 1.5 m.				
											MD		
				2.0	2.0/S/1 D 2.00 m						W		
				2.5	2.5/S/1 D 2.50 m								
				3.0	2.9/S/1 D 2.90 m								
				3.10							MD - D		
									Hole Terminated at 3.10 m				3.10: Target depth reached.
				3.5									
				4.0									
				4.5									

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

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P2108485BH501-BH503V01.GPJ <DrawingFile> 13/10/2021 12:01 10:02:00.04 D:\git\Lab and In Situ Tool - DGD | Lib: Martens 2.00 2016-11-13 Pjf: Martens 2.00 2016-11-13



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**Engineering Log -
 BOREHOLE**

9 Attachment C – DCP ‘N’ Counts

Dynamic Cone Penetrometer Test Log Summary



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

Site	Bayview Golf Course, Bayview, NSW	DCP Group Reference	P2108485JS01V01
Client	Bayview Golf Club	Log Date	10.09.2021
Logged by	DS		
Checked by	RE		
Comments	DCPs commenced at 50 mm BGL.		

TEST DATA

Depth Interval (m)	DCP501	DCP502	DCP503						
0.15	2	6	6						
0.30	2	5	5						
0.45	3	5	8						
0.60	5	5	8						
0.75	1	2	3						
0.90	1	2	3						
1.05	2	4	5						
1.20	2	3	5						
1.35	5	4	4						
1.50	5	2	4						
1.65	5	4	4						
1.80	5	3	5						
1.95	5	4	6						
2.10	5	4	5						
2.25	6	4	6						
2.40	8	4	5						
2.55	8	6	7						
2.70	8	6	8						
2.85	6	7	7						
3.00	3	7	6						
3.15	4	7	6						
3.30	6	7	8						
3.45	3	4	8						
3.60	4	7	7						
3.75	4	8	10						
3.90	4	6	9						
4.05	2	5	9						
4.20	3	DCP terminated due to target depth reached at 4.1 mbgl.	DCP terminated due to target depth reached at 4.1 mbgl.						
4.35	2								
4.50	4								
4.65	4								
4.80	4								
4.95	3								
5.10	DCP terminated due to target depth reached at 5.0 mbgl.								
5.25									

10 Attachment D – General Geotechnical Recommendations

Geotechnical Recommendations

Important Recommendations About Your Site (1 of 2)

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

Batter Slopes

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

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

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

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

Earthworks

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

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

Excavations

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

1. 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

Important Recommendations About Your Site (2 of 2)

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.

**11 Attachment E – Geotechnical Risk Management Policy
for Pittwater – Form 1**

**GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER
FORM NO. 1 – To be submitted with Development Application**

Development Application for <u>Bayview Golf Club</u>	Name of Applicant
Address of site <u>Bayview Golf Course, Cabbage Tree Road, Bayview, NSW</u>	

Declaration made by geotechnical engineer or engineering geologist or coastal engineer (where applicable) as part of a geotechnical report

I, RALPH ERNI on behalf of MARTENS AND ASSOCIATES PTY LTD
(Insert Name) (Trading or Company Name)

on this the 14/10/2021 certify that I am a geotechnical engineer or engineering geologist or coastal engineer as defined by the Geotechnical Risk Management Policy for Pittwater - 2009 and I am authorised by the above organisation/company to issue this document and to certify that the organisation/company has a current professional indemnity policy of at least \$2million.

I:

Please mark appropriate box

- have prepared the detailed Geotechnical Report referenced below in accordance with the Australia Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009
- am willing to technically verify that the detailed Geotechnical Report referenced below has been prepared in accordance with the ~~Australian Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007)~~ and the Geotechnical Risk Management Policy for Pittwater - 2009
- have examined the site and the proposed development in detail and have carried out a risk assessment in accordance with Section 6.0 of the Geotechnical Risk Management Policy for Pittwater - 2009. I confirm that the results of the risk assessment for the proposed development are in compliance with the Geotechnical Risk Management Policy for Pittwater - 2009 and further detailed geotechnical reporting is not required for the subject site.
- have examined the site and the proposed development/alteration in detail and I am of the opinion that the Development Application only involves Minor Development/Alteration that does not require a Geotechnical Report or Risk Assessment and hence my Report is in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009 requirements.
- have examined the site and the proposed development/alteration is separate from and is not affected by a Geotechnical Hazard and does not require a Geotechnical Report or Risk Assessment and hence my Report is in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009 requirements.
- have provided the coastal process and coastal forces analysis for inclusion in the Geotechnical Report

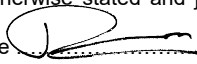
Geotechnical Report Details:

Report Title: <u>Geotechnical Assessment</u>
Report Date: <u>October 2021</u>
Author: <u>Akshaya Ghimire</u>
Author's Company/Organisation: <u>Martens and Associates Pty Ltd.</u>

Documentation which relate to or are relied upon in report preparation:

<u>Chrisp Consulting; Plans, dated 17 March 2021, Job No. 20056</u>

I am aware that the above Geotechnical Report, prepared for the abovementioned site is to be submitted in support of a Development Application for this site and will be relied on by Pittwater Council as the basis for ensuring that the Geotechnical Risk Management aspects of the proposed development have been adequately addressed to achieve an "Acceptable Risk Management" level for the life of the structure, taken as at least 100 years unless otherwise stated and justified in the Report and that reasonable and practical measures have been identified to remove foreseeable risk.

Signature .....
 Name RALPH ERNI.....
 Chartered Professional Status CPENG NER.....
 Membership No. 2061149.....
 Company Martens and Associates Pty Ltd......

12 Attachment F – Notes About This Report

Information

Important Information About Your Report (1 of 2)

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

Engineering Reports - Limitations

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

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

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

Engineering Reports – Project Specific Criteria

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

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

Engineering Reports – Recommendations

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

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

Engineering Reports – Use for Tendering Purposes

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

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

Engineering Reports – Data

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

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

Engineering Reports – Other Projects

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

Subsurface Conditions - General

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

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

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

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

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

Subsurface Conditions - Changes

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

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

Subsurface Conditions - Site Anomalies

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

Report Use by Other Design Professionals

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

Subsurface Conditions – Geo-environmental Issues

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

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

Responsibility

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

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

Site Inspections

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

Definitions

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

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

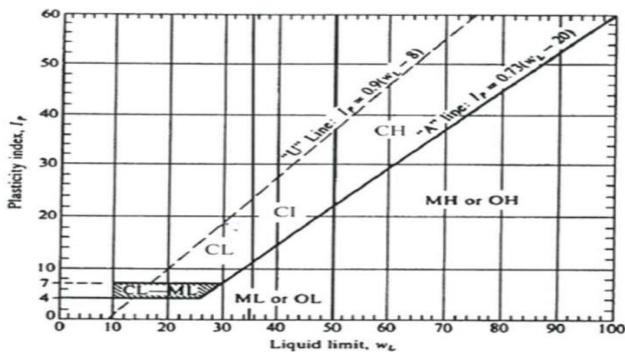
Particle Size

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






Symbols for Soils and Other

SOILS

	COBBLES/BOULDERS
	GRAVEL (GP or GW)
	Silty GRAVEL (GM)
	Clayey GRAVEL (GC)
	SAND (SP or SW)
	Silty SAND (SM)
	Clayey SAND (SC)

	SILT (ML or MH)
	ORGANIC SILT or CLAY (OH or OL)
	CLAY (CL, CI or CH)
	Silty CLAY
	Sandy CLAY
	PEAT (Pt)
	Gravelly CLAY

OTHER

	FILL
	TALUS
	ASPHALT
	CONCRETE
	TOPSOIL

Unified Soil Classification Scheme (USCS)

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	
			GRAVEL-SILT and GRAVEL-SAND mixtures (±5% fines)	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 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	
			GRAVEL-SILT and GRAVEL-SAND mixtures (±12% fines) ¹	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	
			SAND-SILT and SAND-CLAY mixtures (±12% fines) ¹	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	
			SAND-SILT and SAND-CLAY mixtures (±12% fines) ¹	With excess plastic fines (for identification procedures see CL below); medium to high dry strength	SC	Clayey SAND	
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)	IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 MM					
		DRY STRENGTH (Crushing Characteristics)	DILATANCY	TOUGHNESS	DESCRIPTION	USCS	Primary Name
		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, gravelly clays, sandy clays, silty clays, lean clays	CL (or CL ⁺)	CLAY
		Low to Medium	Slow	Low	Organic silts 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 ≤35%; Medium Plasticity Clay – Liquid limit W _L >35%, ≤50%; High Plasticity Clay - Liquid limit W _L > 50%.							
3. Low Plasticity Silt – Liquid Limit W _L ≤50%; High Plasticity Silt - Liquid limit W _L > 50%.							
4. CI may be adopted for clay of medium plasticity to distinguish from clay of low plasticity.							

Soil Agricultural Classification Scheme

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

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

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 (I_s 50) and refers to the strength of the rock substance in the direction normal to the loading. The test procedure is described by the International Society of Rock Mechanics.

Term (Strength)	I _s (50) MPa	Uniaxial Compressive Strength MPa	Field Guide	Symbol
Very low	>0.03 ≤0.1	0.6 – 2	May be crumbled in the hand. Sandstone is 'sugary' and friable.	VL
Low	>0.1 ≤0.3	2 – 6	Core 150mm long x 50mm diameter may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.	L
Medium	>0.3 ≤1.0	6 – 20	Core 150mm long x 50mm diameter can be broken by hand with considerable difficulty. Readily scored with a knife.	M
High	>1 ≤3	20 – 60	Core 150mm long x 50mm diameter cannot be broken by unaided hands, can be slightly scratched or scored with a knife. Breaks with single blow from pick.	H
Very high	>3 ≤10	60 – 200	Core 150mm long x 50mm diameter, broken readily with hand held hammer. Cannot be scratched with knife. Breaks after more than one pick strike.	VH
Extremely high	>10	>200	A piece of core 150mm long x 50mm diameter is difficult to break with hand held hammer. Rings when struck with a hammer.	EH

Degree of Fracturing

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

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

Rock Core Recovery

TCR = Total Core Recovery

SCR = Solid Core Recovery

RQD = Rock Quality Designation

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

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

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

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)	Planarity	Roughness
BP Bedding plane parting	PI Planar	Pol Polished
FL Foliation	Cu Curved	Sl Slickensided
CL Cleavage	Un Undulating	Sm Smooth
JT Joint	St Stepped	Ro Rough
FC Fracture	Ir Irregular	VR Very rough
SZ/SS Sheared zone/ seam (Fault)	Dis Discontinuous	
CZ/CS Crushed zone/ seam	Thickness	Coating or Filling
DZ/DS Decomposed zone/ seam	Zone > 100 mm	Cn Clean
FZ Fractured Zone	Seam > 2 mm < 100 mm	Sn Stain
IS Infilled seam	Plane < 2 mm	Ct Coating
VN Vein		Vnr Veneer
CO Contact		Fe Iron Oxide
HB Handling break		X Carbonaceous
DB Drilling break		Qz Quartzite
		MU Unidentified mineral
	Inclination	
	Inclination of defect is measured from perpendicular to and down the core axis. Direction of defect is measured clockwise (looking down core) from magnetic north.	

Test, Drill and Excavation Methods

Explanation of Terms (1 of 3)

Sampling

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

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

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

Drilling / Excavation Methods

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

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

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

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

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

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

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

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

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

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

In-situ Testing and Interpretation

Cone Penetrometer Testing (CPT)

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

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

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

- (i) Cone resistance (q_c) - the actual end bearing force divided by the cross sectional area of the cone, expressed in MPa.
- (ii) Sleeve friction (q_f) - the frictional force of the sleeve divided by the surface area, expressed in kPa.
- (iii) Friction ratio - the ratio of sleeve friction to cone resistance, expressed in percent.

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

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

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

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

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

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

Test, Drill and Excavation Methods

Explanation of Terms (2 of 3)

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

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

Standard Penetration Testing (SPT)

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

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

- (i) Where full 450 mm penetration is obtained with successive blow counts for each 150 mm of say 4, 6 and 7 blows:
as 4, 6, 7
N = 13
- (ii) Where the test is discontinued, short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm
as 15, 30/40 mm.

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

Dynamic Cone (Hand) Penetrometers

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

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

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

Pocket Penetrometers

The pocket (hand) penetrometer (PP) is typically a light weight spring hand operated device with a stainless steel

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

$$q_u = 2 \times C_u.$$

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

Test Pit / Borehole Logs

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

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

Laboratory Testing

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

Ground Water

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

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

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

Test, Drill and Excavation Methods

Explanation of Terms (3 of 3)

DRILLING / EXCAVATION METHOD

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

SUPPORT

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

WATER

- Water level at date shown
 Water inflow
 Partial water loss
 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	CPT	Static cone penetration test
4,7,11	4,7,11 = Blows per 150mm.	CPTu	CPT with pore pressure (u) measurement
N=18	'N' = Recorded blows per 300mm penetration following 150mm seating	PP	Pocket penetrometer test expressed as instrument reading (kPa)
DCP	Dynamic Cone Penetration test to AS1289.6.3.2-1997.	FP	Field permeability test over section noted
	'n' = Recorded blows per 150mm penetration	VS	Field vane shear test expressed as uncorrected shear strength (sv = peak value, sr = residual value)
Notes:		PM	Pressuremeter test over section noted
RW	Penetration occurred under rod weight only	PID	Photoionisation Detector reading in ppm
HW	Penetration occurred under hammer and rod weight only	WPT	Water pressure tests
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)		

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	