

Bayview Golf Club



Geotechnical Assessment: Green Renovation Works - Bayview Golf Course, Bayview, NSW

ENVIRONMENTAL



WATER



WASTEWATER



GEOTECHNICAL



CIVIL



PROJECT
MANAGEMENT



P2309440JR01V01

April 2023

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Bayview Golf Course, Bayview, NSW
P2309440JR01V01 – April 2023
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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, 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, Lot 1 DP 19161.
LGA	Northern Beaches Council (Council).
Site Area	Approximately 38.42 Ha (Six Maps, 2021).
Background	Martens & Associates (MA) has previously undertaken the following site assessments: - o A geotechnical and acid sulfate soils assessment in August 2018 for a proposed seniors living development. Refer to P1706099JR02V03 for further details. - o Supplementary geotechnical assessment in December 2018 for the Bayview Golf Course and a seniors living development. Refer to P1706099JC09V02 for further details. - o Geotechnical assessment in October 2021 for stormwater harvesting and irrigation works for the Bayview Golf Course. Refer to P2108584JR01V01 for further details. Results of these assessments have been considered for but not reproduced (unless where of benefit for clarity) within this report.
Proposed Development	From the plans provided by the client (CC, 2023), we understand that it is proposed to upgrade 12 greens, requiring varying amounts of cut and fill across the works areas. It is understood that the maximum proposed excavation depth is 1.75 mbgl. Maximum excavation at each green, assessed soil strata at depth of excavation and soil description is presented in Table 3 in Section 2.1 of this report.
Assessment Purpose	Geotechnical assessment to provide geotechnical advice and recommendations to support a development application (DA) submission to Council.
Investigation Scope of Work	Review of previous investigation results. Field investigation on 1 March 2023, which included: - o General site walkover survey. - o Drilling of seventeen boreholes near proposed cut locations at the greens, using a hydraulic hand push tube up to a maximum depth of 1.6 mbgl (refer to Attachment B for borehole logs and associated explanatory notes in Attachment H). - o Thirteen dynamic cone penetration (DCP) tests adjacent to the boreholes up to approximately 2.28 mbgl (refer to Attachment C for DCP test results). Investigation locations are shown in site layout plan GE01 Attachment A.

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
Landscape	The NSW Office of Environment and Heritage's (OEH) information system indicates the following: <u>Central, west and north eastern portions</u> ○ Terrain disturbed by human activity, with local relief < 2 m. ○ Disturbed ground includes berms, cut faces, embankments, mounds, pits and trenches. ○ Slopes levelled to < 3 %. <u>Eastern portion</u> ○ Flooded valleys infilled with alluvium and surrounded by steep to precipitous Hawkesbury sandstone slopes. ○ Gently undulating alluvial floodplain with slopes <3 %, elevation <10 m. <u>North west and south eastern portions</u> ○ 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 predominantly underlain by Quaternary deposits: silty to peaty quartz sand, silt, and clay with ferruginous and humic cementation in places and common shell layers. The north western portion is indicated to be underlain by Newport Formation and Garie Formation: interbedded laminate, shale, quartz, to lithic-quartz sandstone and clay pellet sandstone (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 south of Cabbage Tree Road. Slopes become moderate to steep (10 to >25 %) and elevation ranges from 4 to 38 mAHD north of Cabbage Tree Road. The south eastern portion of the site (near 11th green and clubhouse) rises up to 14 mAHD.
Existing Development	The site is developed as a golf course. Cabbage Tree Road bisects the Bayview Golf Course in the west, into Area 1 in the south and Area 2 in the north (refer to GE01, Attachment A).
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 to the north east.
Neighbouring environment	The site is bordered by: ○ Residential properties and bushland to the west. ○ Cabbage Tree Road to the north and Park Street and residential properties to the south. ○ Pittwater Road to the east followed by a school.
Drainage	Depressions and swamps in the northern and eastern portions of the site collect water during rainfall events. Cahill Creek flows from the south west to the eastern portion of the site and ultimately into Winnererremy Bay, Pittwater,

Item	Comment
	located approximately 260 m north east of the site. The northern portion of the site generally drains centrally to an inlet that connects to a dam in the west.
Subsurface soil units	The greens have typically been filled with inferred moderately compacted sands and clays with thicknesses ranging typically from 0.4 (BH108) to 1.4m (BH107a). Natural soils underlying the fill comprised: - Quaternary deposits in low lying areas (Area 1 mostly) comprising beds of silt / sandy silt / clayey silt, sand and clay / sandy clay. Some layers were dark grey and black, indicating possible presence of organic matter. - Investigation Area 2 and the elevated south eastern portion of investigation Area 1 encountered residual clayey soils, either underlying fill or alluvial soils, typically of high plasticity. Encountered conditions are described in more detail on borehole logs in Attachment B and associated explanatory notes in Attachment F and in Martens previous assessment reports. For DCP test result refer to Attachment C. Investigation areas (Area 1 and Area 2) are shown in Attachment A.
Groundwater	Groundwater inflow was encountered at 0.8 mbgl during the drilling of borehole BH101a, and between 1.1 and 1.4 mbgl in BH107b, BH110, BH112a and BH112b. Groundwater level fluctuations may occur due to tidal variations. Should further information on groundwater fluctuations be required, additional assessment would need to be carried out (i.e. installation of groundwater monitoring wells).
Acid Sulfate Soils	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 P2309440JR02V01. For further details and results of the previous ASS assessments undertaken by Martens refer MA report P2108485JR02V01 and P1706099JR04V01.

3 Geotechnical Assessment

3.1 Potential Geotechnical Constraints

We consider the proposed development will likely be constrained by the following key geotechnical conditions:

- Presence of soft / loose soils.
- Shallow groundwater levels.
- Slope instability.

3.2 Excavation Summary

Table 3 summarises soil descriptions from observations made during excavation. Excavation locations are shown in site layout plan GE01 Attachment A.

Table 3: Excavation Summary

Green number	Maximum Excavation Depth (m)	End Excavation Strata	End Excavation Soil Description
1	0.75	Fill	Fine grained silty clayey SAND
2	0.25	Fill	Fine to medium grained clayey SAND
3	1.25	Inferred Alluvium	Inferred high plasticity silty CLAY
4	1.25	Residual Soil	High plasticity silty CLAY
5	0.75	Residual Soil / Alluvium	Medium plasticity silty CLAY
6	1.75	Inferred Residual Soil	Inferred residual CLAY
7	0.75	Fill	Medium plasticity silty CLAY to fine grained clayey SAND
8	0.75	Alluvium	Medium plasticity sandy CLAY
10	0.25	Fill	Low plasticity silty sandy CLAY
11	1.75	Inferred Alluvium	Medium plasticity silty CLAY
12	-	Fill	Fine grained silty SAND
13	0.25	Inferred Fill	Inferred fine grained silty clayey SAND

3.3 Risk of Slope Instability

3.3.1 Area 1 Assessment

Area 1 falls outside the landslide risk Hazard 1 or Hazard 2 zones shown on Pittwater Geotechnical Hazard Maps (refer to Map GE03 in Attachment A). No evidence of recent land instability was observed within this area.

A detailed slope risk assessment in accordance with Australian Geomechanics Society's Landslide Risk Management Guidelines (2007) was not undertaken.

However, 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 due to 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.

3.3.2 Area 2 Assessment

Area 2 includes a landslide risk Hazard 1 zone shown on Pittwater Geotechnical Hazard Maps (refer to Map GE03 in Attachment A). The proposed work areas do not intercept the risk zone, although works may be impacted by the hazards.

3.3.2.1 Hazard Identification

Area 2 is located within the Narrabeen Group outcrop zone. This geology is prone to slope movements. Slope movement is furthermore dominant in south facing slopes.

From our field mapping and investigation results, including previous sampled rock core, identified the following elements that may be indicative of former ground movement at the site:

- A deep soil and extremely weathered rock profile, encountered in the majority of deep boreholes across the site (MA, 2018a).
- The presence of sheared zones and seams, identified in all rock core between approximately 10.0 and 13.5 mAHD (including zones of no rock core retrieval), suggesting that the site and possibly its surroundings may have formerly been impacted by a

historical large-scale landslide. This slide is considered to be relict.

- Existing and former footpaths in the south western portion of Area 2 are typically located along transitions between shallower grading slopes compared with surrounding steeper grading slopes ($> 15^\circ$). Near-vertical soil exposures, up to 1.2 m high in places, typically extend along the upslope side of the paths. Although the paths may have been cut into the slope, these exposures could also represent scarps associated with former medium scale slides, considering the limited filling (typically expected under cut and fill operations) observed on the downslope side of paths and presence downslope features typical associated with landslides. Field survey results, including an absence of transverse, radial and crown cracking and landslide flanks, suggest that such slides are old and dormant.
- Slightly hummocky ground and some leaning trees in the steeper south-western portion of the site are indicative of more recent (estimated previous 10 to 100 years) shallow ground movement (typically < 1.5 m deep).

3.3.2.2 Hazard Assessment

For the purpose of this landslide risk assessment, only dormant medium landslides and recent shallow landslides have been identified as landslide mechanisms posing risk of slope movement impacting the proposed development.

3.3.2.3 Risk Assessment

The following most likely geotechnical hazards were considered.

1. Medium rotational / translational slide, typically 10 - 50 m in length and 3 - 5 m deep.
2. Shallow landslide, including soil creep, typically 2 - 5 m in length and 0.5 - 2m deep.

These have been further described in a slope instability risk summary matrix provided in Attachment F.

3.3.2.4 Conclusions and Recommendations

Based on the results of our risk assessments, we consider the proposed development to constitute an acceptable risk to life and low risk to property resulting from assessed geotechnical hazards, subject to

adoption of recommendations presented in MA 2018a and recommended slope treatment measures presented below.

We recommend the following treatment options to achieve the acceptable risk levels:

1. Ensure good hill slope engineering practices (refer Attachment E) are adopted during the development.
2. Retain or batter back all exposed excavation sides.
3. All temporary shoring and permanent retaining structures are to be engineer designed adopting preliminary material properties provided in Table 4, section 3.2 of this report.
4. Maintain vegetation cover where possible. Where required, vegetation removal from slopes is to be undertaken under geotechnical engineering guidance to ensure slope stability is maintained. Revegetate slopes, where possible, including planting of deep rooting species particularly across fill embankments and steep slopes (i.e. $>15^\circ$).
5. Do not over-steepen natural grades without suitable shoring support / batters.
6. Unless accounted for in design, do not place excessive load onto ground surfaces upslope of excavations or onto steep slopes ($>15^\circ$).
7. Provide adequate surface and subsurface water drainage to limit ponding and subsequent infiltration of surface water into the soil / weathered rock profile and prevent saturation of site soils, particularly upgrade of steeper slopes in Area 2.
8. Redirect all stormwater runoff away from proposed works.
9. Provide adequate backfill and backfill drainage behind shoring and retaining structures. Redirect all collected water to a suitable and approved discharge point downslope of the structures.
10. Limit cutting at the base of and filling at the crest of steep slopes.

Pittwater DCP21 Geotechnical Risk Management Policy for Pittwater Forms 1 and 1 (a) have been provided as Attachment F.

3.4 Preliminary Material Properties

Preliminary material properties for soils up to 2mbgl, inferred from observations during borehole drilling such as auger penetration resistance, DCP test results as well as engineering judgement, are summarised in Table 4.

Table 4: Preliminary estimates of soil properties.

Material Unit	$\gamma_{in-situ}^1$ (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 CLAY / Silty CLAY, varying from soft to stiff	16/18	25	1	24	0.6	0.4	2.4
Quaternary Silty / Clayey SAND, loose to medium dense	16/19	NA ⁶	NA ⁶	27			
Residual Silty CLAY, varying from firm to very stiff.	17/19	50	3	28	0.56	0.39	2.56

Notes:

1. Material unit weight, based on visual assessment, dry / saturated. Average for layer unit.
2. Undrained shear strength of clay, silt estimate ($\pm 10\%$). Average for layer unit.
3. Drained cohesion of clay, silt estimate ($\pm 10\%$). Average for layer unit.
4. Effective internal friction angle ($\pm 2^\circ$) of sand estimate ($\pm 10\%$), assuming drained conditions. Average for layer unit.
5. K_a = Coefficient of active earth pressure; K_p = Coefficient of passive earth pressure; K_0 = Coefficient of earth pressure at rest. Assumes horizontal ground surfaces.
6. Not applicable.

4 Geotechnical Recommendations

4.1 Recommendations

General geotechnical recommendations for the proposed development are provided in Attachment G. Additional recommendations are provided in the following sections:

4.1.1 Excavation

Excavation of fill, quaternary deposits and residual soils can be achieved using conventional earthmoving plant such as a hydraulic tracked excavator fitted with a bucket.

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

Excavations to depths of greater than 0.5 m should be temporarily battered back or supported / permanently retained to maintain excavation stability.

Temporary batters should not exceed grades of 1 Vertical (V): 2 Horizontal (H). Permanent batter slopes above groundwater should not exceed 1V:3H.

Temporary support may include cantilevered or soldier I Beams with timber infill panels. Permanent retaining should be adopted where batter grades cannot be met due to the sloping nature of the site.

Temporary support or retaining wall design may adopt preliminary earth pressure coefficients provided in Table 3, Section 3.2.

4.1.3 Earthworks

Site – won material is considered suitable for reuse subject to the following considerations:

- Clay dominant soils are mixed with granular material. All deleterious material is removed.
- PASS material is generally considered unsuitable for reuse. Exception may be given if the soil is treated by mixing with agricultural lime, subject to further quality assurance testing.

New granular fill placement, if required, should be carried out under the guidance of a geotechnical engineer following removal of any existing uncontrolled fill materials or any other unsuitable materials such as high plasticity clays or soils with deleterious inclusions.

All earthworks should be carried out in accordance with AS3798 (2007) – Guidelines on Earthworks for Commercial and Residential Developments. Earthworks should be completed under guidance of an experienced geotechnical engineer to confirm conditions and suitability of materials.

4.1.4 Retaining Wall Foundations

Retaining walls may be supported by footings embedded at least 0.8 mbgl. A preliminary allowable bearing capacity of 100 kPa may be adopted for the design of retaining wall foundations on natural soils below any soft to firm clay, organic clay or loose sand layers.

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.

4.1.5 Drainage

Divert stormwater in Area 1 towards existing drainage infrastructure leading into Winnererremy Bay to prevent water ponding.

Stormwater in Area 2 should be directed to existing drainage infrastructure along Cabbage Tree Road or into natural creeks / drainage depressions.

4.1.6 Trafficability

Due to the presence of soft soils, localised steep slopes and curated grass surfaces onsite, careful selection of plant is required. Consideration should be given to light – weight vehicles (such as a golf buggy) or track mounted vehicles.

Care should be taken to avoid plant loads at the crests of steep slopes such as bunkers and sand traps to avoid slope failure.

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.

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:

- 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 5: Recommended inspection / monitoring requirements during site works.

Scope of Works	Frequency/Duration	Who to Complete
Monitor excavation 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
Inspect exposed material at foundation/ subgrade level to verify suitability as foundation/ lateral support/ subgrade.	Prior to further fill placement	MA ¹

Notes:

1. MA = Martens and Associates engineer.

6 Conclusion

We consider the proposed upgrade of 12 greens at Bayview Golf Club to be suitable for the site from a geotechnical viewpoint.

7 Limitations

The recommendations presented in this report are based on limited preliminary investigations and include specific issues to be addressed during the design and construction phases of the project. In the event that any of the recommendations presented in this report are not implemented, the general recommendations may become inapplicable and Martens & Associates accept no responsibility whatsoever for the performance of the works undertaken where recommendations are not implemented in full and properly tested, inspected and documented.

Occasionally, subsurface 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.

8 References

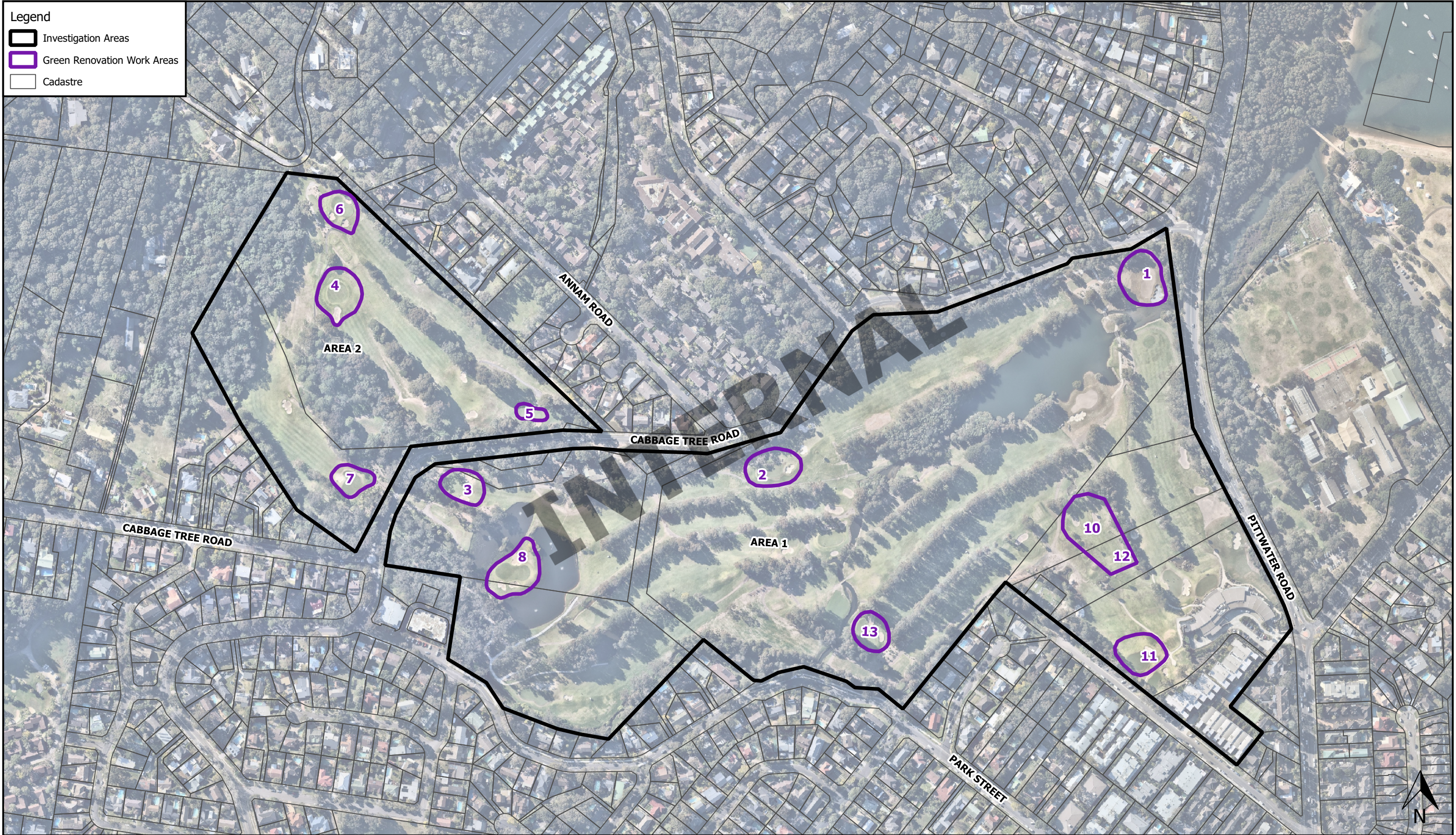
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9 Attachment A – Figures



0 40 80 120 160 200 m

1:4000 @ A3

Viewport

Notes:
- Aerial from Nearmap (2021)
- Cadastre from NSW DFSI Clip and Ship (2023)

Map Title / Figure:

Site Layout

GE01	Map
Bayview Golf Course, NSW	Site
Green Renovation Works	Project
Geotechnical and Acid Sulphate Soils Assessment	Sub-Project
Bayview Golf Club	Client
19/04/2023	Date



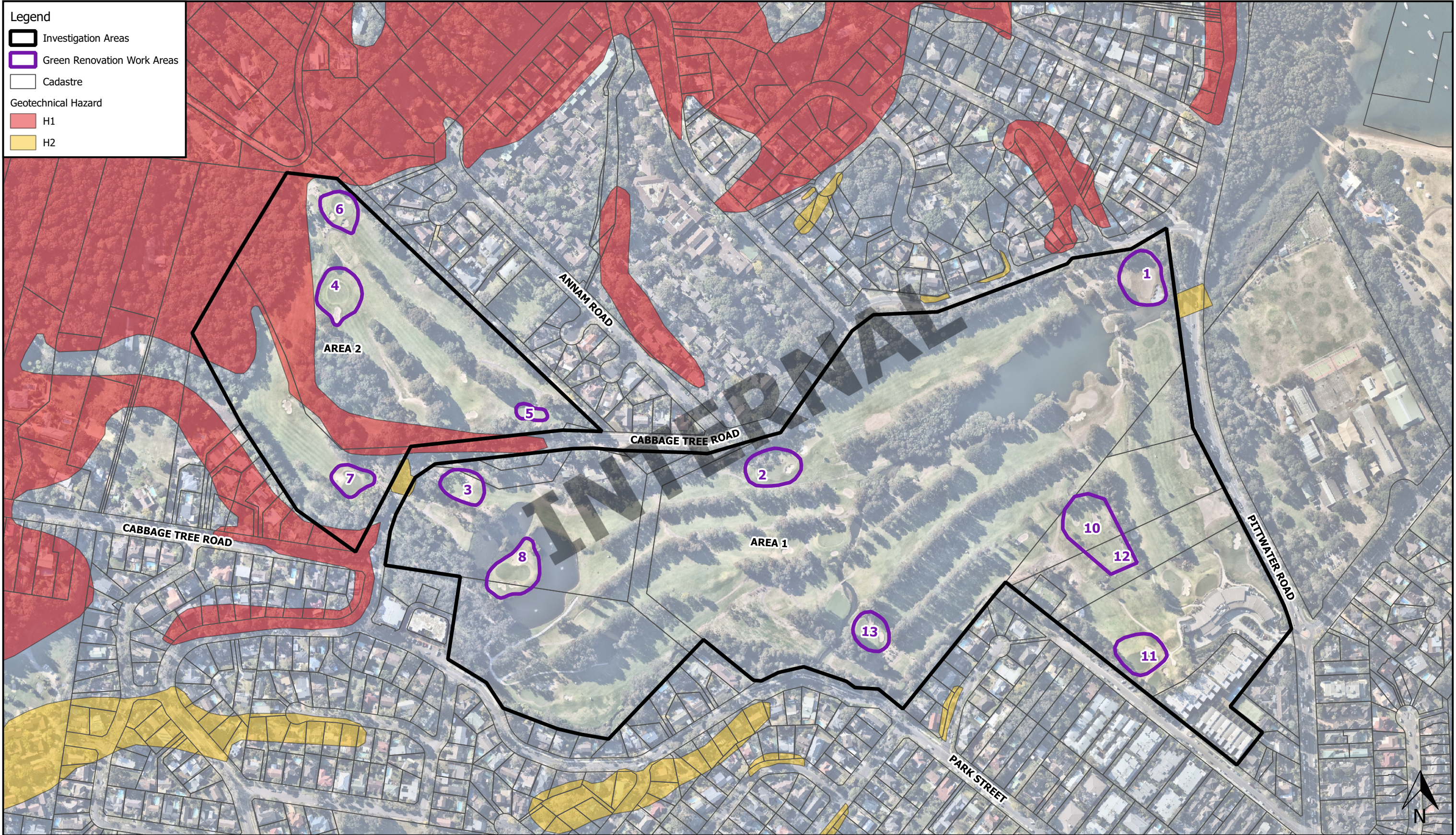
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Viewport

Notes:
- Aerial from Nearmap (2021)
- Cadastre from NSW DFSI Clip and Ship (2023)

Map Title / Figure:
Borehole Location Plan



Legend

- Investigation Areas
- Green Renovation Work Areas
- Cadastre
- Geotechnical Hazard
 - H1
 - H2

0 40 80 120 160 200 m

1:4000 @ A3

Viewport

Notes:
- Aerial from Nearmap (2021)
- Cadastre from NSW DFSI Clip and Ship (2023)
- Geotechnical hazard areas from Pittwater Local Environmental Plan LEP 2014

Map Title / Figure:
Geotechnical Hazard Identification

GE03	Map
Bayview Golf Course, NSW	Site
Green Renovation Works	Project
Geotechnical and Acid Sulphate Soils Assessment	Sub-Project
Bayview Golf Club	Client
19/04/2023	Date

10 Attachment B – Borehole Logs

CLIENT			Bayview Golf Club			COMMENCED		01/03/2023		COMPLETED		01/03/2023		REF BH101a		
PROJECT			Geotechnical and ASS Investigation			LOGGED		BC		CHECKED		RE		Sheet 1 OF 1 PROJECT NO. P2309440		
SITE			Bayview Golf Course, Bayview, NSW			GEOLOGY		Quaternary Deposits		VEGETATION		Grass				
EQUIPMENT			Hand Push Tube			LONGITUDE		151.30031		RL SURFACE		1.05 m		DATUM AHD		
EXCAVATION DIMENSIONS			Ø100 mm x 1.60 m depth			LATITUDE		-33.66725		ASPECT		S		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
PT	H	Inflow	1.05					CL	FILL: Silty Sandy CLAY; low plasticity; dark brown; trace rootlets, inferred poorly - moderately compacted.							FILL
			0.2	0.1-0.3/S/1 D 0.10-0.30 m								M (=PL)				
			0.4													
			0.50													
			0.55													
			0.6	0.6-0.8/S/1 D 0.60-0.80 m				SP	FILL: Silty Clayey SAND; fine grained; grey, inferred poorly - moderately compacted.							
			0.8										W			
			1.0	1.00 0.05				CI-CH	Silty CLAY; medium to high plasticity; brown.							ALLUVIUM
			1.2	1.2-1.4/S/1 D 1.20-1.40 m												
			1.4										M (>PL)	St		
			1.6	1.60					Hole Terminated at 1.60 m (Target depth reached)							
			1.8													
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																
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CLIENT	Bayview Golf Club			COMMENCED	01/03/2023	COMPLETED	01/03/2023	REF BH101b					
PROJECT	Geotechnical and ASS Investigation			LOGGED	BC	CHECKED	RE	Sheet 1 OF 1					
SITE	Bayview Golf Course, Bayview, NSW			GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P2309440					
EQUIPMENT		Hand Push Tube			LONGITUDE	151.30029	RL SURFACE	1.79 m	DATUM AHD				
EXCAVATION DIMENSIONS		ø100 mm x 1.60 m depth			LATITUDE	-33.66699	ASPECT	S	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
PT	H	Not Encountered		1.79				SC	FILL: Clayey SAND; fine grained; brown, inferred poorly to moderately compacted.				FILL
			0.2		0.2-0.4/S/1 D 0.20-0.40 m						M		
			0.4	0.40 1.39					Gravels.				
			0.6	0.60 1.19				CI	Silty CLAY; medium plasticity; brown, red; trace sand; trace charcoal.				ALLUVIUM
			0.8		0.7-0.9/S/1 D 0.70-0.90 m						M (<PL)		
				1.30 0.49				CI-CH	Silty CLAY; medium to high plasticity; dark grey; organic smell.			M (=PL)	St
				1.4	1.4-1.5/S/1 D 1.40-1.50 m								
				1.6					Hole Terminated at 1.60 m (Target depth reached)				
				1.8									
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS													
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CLIENT	Bayview Golf Club				COMMENCED	01/03/2023	COMPLETED	01/03/2023	REF BH103				
PROJECT	Geotechnical and ASS Investigation				LOGGED	BC	CHECKED	RE	Sheet 1 OF 1				
SITE	Bayview Golf Course, Bayview, NSW				GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P2309440				
EQUIPMENT		Hand Push Tube			LONGITUDE	151.292353	RL SURFACE	3.99 m	DATUM	AHD			
EXCAVATION DIMENSIONS		Ø100 mm x 0.70 m depth			LATITUDE	-33.668813	ASPECT	S	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
PT	H	Not Encountered		3.99				SP	FILL: Clayey SAND; fine to medium grained; red - brown, yellow - brown; trace rootlets.				FILL
			0.2	0.1-0.2/S/1 D 0.10-0.20 m						M			
			0.4	0.3-0.5/S/1 D 0.30-0.50 m									
			0.50 3.49					CH	Silty CLAY; high plasticity; grey, brown, red, black.				ALLUVIUM
			0.6	0.6-0.7/S/1 D 0.60-0.70 m					M (<PL)	F - St			
			0.70						Hole Terminated at 0.70 m				
			0.8										
			1.0										
			1.2										
			1.4										
			1.6										
			1.8										
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS													
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CLIENT	Bayview Golf Club			COMMENCED	01/03/2023	COMPLETED	01/03/2023	REF BH104					
PROJECT	Geotechnical and ASS Investigation			LOGGED	BC	CHECKED	RE	Sheet 1 OF 1					
SITE	Bayview Golf Course, Bayview, NSW			GEOLOGY	Narrabeen Formation	VEGETATION	Grass	PROJECT NO. P2309440					
EQUIPMENT		Hand Push Tube			LONGITUDE	151.29091	RL SURFACE	28.55 m	DATUM AHD				
EXCAVATION DIMENSIONS		ø100 mm x 1.30 m depth			LATITUDE	-33.6671	ASPECT	S	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
PT	H	Not Encountered		28.55				SP	FILL: Clayey SAND; fine to medium grained; dark grey, brown, yellow - brown; trace rootlets.				FILL
			0.2	0.1-0.3/S/1 D 0.10-0.30 m									
			0.4		0.5-0.7/S/1 D 0.50-0.70 m					M			
			0.6										
			0.8	0.80 27.75				CH	Silty CLAY; high plasticity; dark grey; trace gravels.				RESIDUAL SOIL
			1.0		1.0-1.2/S/1 D 1.00-1.20 m					M (<PL)	St		
			1.2										
			1.30						Hole Terminated at 1.30 m (Target depth reached)				
			1.4										
			1.6										
			1.8										
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS													
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CLIENT	Bayview Golf Club				COMMENCED	01/03/2023	COMPLETED	01/03/2023	REF BH105a Sheet 1 OF 1 PROJECT NO. P2309440			
PROJECT	Geotechnical and ASS Investigation				LOGGED	BC	CHECKED	RE				
SITE	Bayview Golf Course, Bayview, NSW				GEOLOGY	Narrabeen Formation	VEGETATION	Grass				
EQUIPMENT		Hand Push Tube				LONGITUDE	151.2932	RL SURFACE	8.43 m	DATUM	AHD	
EXCAVATION DIMENSIONS		ø100 mm x 0.90 m depth				LATITUDE	-33.66803	ASPECT	SE	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
PT	H	Not Encountered	8.43					SP	FILL: Clayey SAND; fine grained; grey, brown; trace rootlets.			FILL
			0.2		0.1-0.2/S/1 D 0.10-0.20 m					M		
			0.4	0.40 8.03	0.4-0.6/S/1 D 0.40-0.60 m			CL-CI	Silty Sandy CLAY; low to medium plasticity; brown, black.		M (<PL)	ALLUVIUM
			0.6									
			0.7	0.70 7.73	0.7-0.9/S/1 D 0.70-0.90 m			CI	Silty CLAY; medium plasticity; dark brown, black.		M (<PL)	RESIDUAL SOIL - ALLUVIUM
			0.90						Hole Terminated at 0.90 m			0.90: Push Tube refusal on white clay.
			1.0									
			1.2									
			1.4									
			1.6									
			1.8									
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS												
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CLIENT	Bayview Golf Club				COMMENCED	01/03/2023	COMPLETED	01/03/2023	REF BH105b									
PROJECT	Geotechnical and ASS Investigation				LOGGED	BC	CHECKED	RE	Sheet 1 OF 1									
SITE	Bayview Golf Course, Bayview, NSW				GEOLOGY	Narrabeen Formation	VEGETATION	Grass	PROJECT NO. P2309440									
EQUIPMENT		Hand Push Tube				LONGITUDE	151.29301	RL SURFACE	8.77 m	DATUM AHD								
EXCAVATION DIMENSIONS		ø100 mm x 1.30 m depth				LATITUDE	-33.66811	ASPECT	SE	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						
PT	H	Not Encountered	8.77	0.0-0.2/S/1 D 0.00-0.20 m			SC	FILL: Clayey SAND; fine grained; grey - brown; trace rootlets.			VSt	FILL						
			0.2															
			0.30															
			8.47												FILL: Crushed IRONSTONE / SANDSTONE; red, yellow - brown; medium grained.			
			0.4															
			0.6	0.6-0.8/S/1 D 0.60-0.80 m														
			0.8															
			0.90															
			7.87												CI	Silty CLAY; medium plasticity; dark brown; black.		RESIDUAL SOIL - ALLUVIUM
			1.0	1.0-1.2/S/1 D 1.00-1.20 m														
1.2																		
1.30																		
			1.4						Hole Terminated at 1.30 m (Target depth reached)									
			1.6															
			1.8															
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																		
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CLIENT	Bayview Golf Club			COMMENCED	01/03/2023	COMPLETED	01/03/2023	REF BH106					
PROJECT	Geotechnical and ASS Investigation			LOGGED	BC	CHECKED	RE	Sheet 1 OF 1					
SITE	Bayview Golf Course, Bayview, NSW			GEOLOGY	Narrabeen Formation	VEGETATION	Grass	PROJECT NO. P2309440					
EQUIPMENT	Hand Push Tube			LONGITUDE	151.29111	RL SURFACE	36.02 m	DATUM	AHD				
EXCAVATION DIMENSIONS	ø100 mm x 0.60 m depth			LATITUDE	-33.66641	ASPECT	SE	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
PT	H	Not Encountered	36.02					SP	FILL: Silty Clayey SAND; fine to medium grained; brown, grey, red, yellow; trace rootlets; trace crushed ironstone.				FILL
			0.2	0.2-0.4/S/1 D 0.20-0.40 m							M		
			0.4	0.4-0.6/S/1 D 0.40-0.60 m									
			0.6	0.60					Hole Terminated at 0.60 m				0.60: Push Tube refusal on fill.
			0.8										
			1.0										
			1.2										
			1.4										
			1.6										
			1.8										
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS													
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CLIENT	Bayview Golf Club	COMMENCED	01/03/2023	COMPLETED	01/03/2023	REF BH107a Sheet 1 OF 1 PROJECT NO. P2309440	
PROJECT	Geotechnical and ASS Investigation	LOGGED	BC	CHECKED	RE		
SITE	Bayview Golf Course, Bayview, NSW	GEOLOGY	Narrabeen Formation	VEGETATION	Grass		
EQUIPMENT	Hand Push Tube	LONGITUDE	151.29096	RL SURFACE	3.32 m	DATUM	AHD
EXCAVATION DIMENSIONS	ø100 mm x 1.40 m depth	LATITUDE	-33.6687	ASPECT	S	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
PT	H	Not Encountered	3.32					SP	FILL: Clayey SAND; fine to medium grained; brown, grey - brown; trace rootlets.				FILL
			0.2		0.1-0.3/S/1 D 0.10-0.30 m					M			
			0.4	0.40 2.92				GP	FILL: Crushed IRONSTONE; trace clay.				
			0.6		0.5-0.7/S/1 D 0.50-0.70 m								
			0.70 2.62					SP-SC	FILL: Clayey SAND; fine grained; pale grey, grey - brown.			M	
			0.8										
			1.0		1.0-1.2/S/1 D 1.00-1.20 m								
			1.2										
			1.4	1.40					Hole Terminated at 1.40 m (Target depth reached)				
			1.6										
			1.8										

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

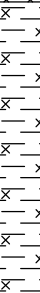


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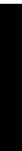
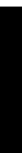
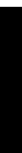
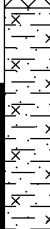
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CLIENT	Bayview Golf Club				COMMENCED	01/03/2023	COMPLETED	01/03/2023	REF BH107b				
PROJECT	Geotechnical and ASS Investigation				LOGGED	BC	CHECKED	RE	Sheet 1 OF 1				
SITE	Bayview Golf Course, Bayview, NSW				GEOLOGY	Narrabeen Formation	VEGETATION	Grass	PROJECT NO. P2309440				
EQUIPMENT		Hand Push Tube				LONGITUDE	151.29092	RL SURFACE	4.21 m	DATUM AHD			
EXCAVATION DIMENSIONS		ø100 mm x 1.30 m depth				LATITUDE	-33.66888	ASPECT	S	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
PT	H			4.21				SP	FILL: Clayey SAND; fine to medium grained; grey - brown; trace rootlets.				FILL
			0.2		0.2-0.4/S/1 D 0.20-0.40 m					M			
			0.4	0.40 3.81				CI	FILL: Silty CLAY; medium plasticity; grey - brown, brown; trace crushed ironstone.				
			0.6		0.5-0.7/S/1 D 0.50-0.70 m					M (<PL)			
			0.8	0.80 3.41				CI-CH	Silty CLAY; medium to high plasticity; dark grey - black; trace sand.				ALLUVIUM
			1.0		1.0-1.2/S/1 D 1.00-1.20 m					M (=PL)	St - VSt		
			1.2										
			1.30						Hole Terminated at 1.30 m (Target depth reached)				
			1.4										
			1.6										
			1.8										
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS													
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CLIENT		Bayview Golf Club			COMMENCED	01/03/2023	COMPLETED	01/03/2023	REF BH108				
PROJECT		Geotechnical and ASS Investigation			LOGGED	BC / WX	CHECKED	RE	Sheet 1 OF 1				
SITE		Bayview Golf Course, Bayview, NSW			GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P2309440				
EQUIPMENT		Hand Push Tube			LONGITUDE	151.29282	RL SURFACE	2.57 m	DATUM	AHD			
EXCAVATION DIMENSIONS		ø100 mm x 1.50 m depth			LATITUDE	-33.66988	ASPECT	S	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
PT	H	Inflow	2.57					CL	FILL: Silty CLAY; low plasticity; brown, black - brown.		M (<PL)		FILL
			0.2		0.1-0.4/S/1 D 0.10-0.40 m								
			0.4	0.40 2.17				CI	Sandy CLAY; medium plasticity; dark grey; trace rootlets.		St to F		ALLUVIUM
			0.6										
			0.8		0.8-1.0/S/1 D 0.80-1.00 m								
			1.0	1.00 1.57				SP-SC	Clayey SAND; medium grained; grey - dark grey.				
			1.2										
			1.4		1.3-1.5/S/1 D 1.30-1.50 m					W			
			1.50						Hole Terminated at 1.50 m (Target depth reached)				
			1.6										
			1.8										
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS													
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CLIENT	Bayview Golf Club	COMMENCED	01/03/2023	COMPLETED	01/03/2023	REF BH110 Sheet 1 OF 1 PROJECT NO. P2309440	
PROJECT	Geotechnical and ASS Investigation	LOGGED	BC / WX	CHECKED	RE		
SITE	Bayview Golf Course, Bayview, NSW	GEOLOGY	Quaternary Deposits	VEGETATION	Grass		
EQUIPMENT	Hand Push Tube	LONGITUDE	151.29958	RL SURFACE	1.44 m	DATUM	AHD
EXCAVATION DIMENSIONS	ø100 mm x 1.50 m depth	LATITUDE	-33.669306	ASPECT	NE	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
PT	H	Inflow	1.44	1.44	0.1-0.3/S/1 D 0.10-0.30 m			CL	FILL: Silty Sandy CLAY; low plasticity; dark brown, black.	M (<PL)			FILL
			0.2										
			0.30										
			1.14										
			0.4										
			0.6		0.7-0.9/S/1 D 0.70-0.90 m					M			
0.8													
1.0													
1.00													
0.44													
			1.2		1.1-1.4/S/1 D 1.10-1.40 m			CI	Sandy Silty CLAY; medium plasticity; dark grey, black; trace rootlets.	M (=PL)			ALLUVIUM
1.4													
1.50													
			1.6						Hole Terminated at 1.50 m (Target depth reached)				
			1.8										

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



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**Engineering Log -
BOREHOLE**

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P2309440BH101-112.GPJ <DrawingFile>> 21/04/2023 11:26 10.02.00.04 DigGel Lab and In Situ Tool - DGL [Lib: Martens 2.00 2016-11-13 Proj: Martens 2.00 2016-11-13]

CLIENT	Bayview Golf Club			COMMENCED	01/03/2023	COMPLETED	01/03/2023	REF BH111a					
PROJECT	Geotechnical and ASS Investigation			LOGGED	BC / WX	CHECKED	RE	Sheet 1 OF 1					
SITE	Bayview Golf Course, Bayview, NSW			GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P2309440					
EQUIPMENT		Hand Push Tube			LONGITUDE	151.30041	RL SURFACE	8.78 m	DATUM AHD				
EXCAVATION DIMENSIONS		ø100 mm x 1.50 m depth			LATITUDE	-33.67059	ASPECT	N	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
PT	H	Not Encountered		8.78				CL	FILL: Silty Sandy CLAY; low plasticity; dark brown; trace rootlets.				FILL
			0.2	0.2-0.4/S/1 D 0.20-0.40 m						M (<PL)			
			0.4										
			0.6										
			0.70 8.08	0.7-0.9/S/1 D 0.70-0.90 m			SM	FILL: Silty SAND; fine to medium grained; grey, yellow.		M			
			1.0	1.0-1.2/S/1 D 1.00-1.20 m			CH	Silty CLAY; high plasticity; dark grey - black.				ALLUVIUM	
			1.2						M (<PL)	St to VSt			
			1.4	1.40 7.38			CI-CH	Silty CLAY; medium to high plasticity; grey, red, brown.				RESIDUAL SOIL	
			1.50						Hole Terminated at 1.50 m (Target depth reached)				
			1.6										
			1.8										
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS													
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						Engineering Log - BOREHOLE							

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P2309440BH101-112.GPJ <DrawingFile>> 21/04/2023 11:26 10.02.00.04 D:\gel Lab and In Silu Tool - DGT\ Lib: Martens 2.00 2016-11-13 Proj: Martens 2.00 2016-11-13

CLIENT	Bayview Golf Club		COMMENCED	01/03/2023	COMPLETED	01/03/2023	REF BH111c							
PROJECT	Geotechnical and ASS Investigation		LOGGED	BC / WX	CHECKED	RE	Sheet 1 OF 1							
SITE	Bayview Golf Course, Bayview, NSW		GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P2309440							
EQUIPMENT	Hand Push Tube		LONGITUDE	151.30031	RL SURFACE	11.07 m	DATUM	AHD						
EXCAVATION DIMENSIONS	ø100 mm x 1.40 m depth		LATITUDE	-33.6708	ASPECT	N	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	
PT	H	Not Encountered	11.07					CL	FILL: Silty Sandy CLAY; low plasticity; dark grey.				FILL	
			0.2											
			0.4	0.40					SM	FILL: Silty Clayey SAND; fine to medium grained; grey.				
			1.0	1.00					CI	Silty CLAY; medium plasticity; dark grey, brown - red; trace shells.				ALLUVIUM
			1.4	1.40						Hole Terminated at 1.40 m				1.40: Push tube refusal.
			1.6											
			1.8											

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



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Engineering Log -
BOREHOLE

CLIENT

Bayview Golf Club

COMPLETED

01/03/2023

REF

BH112a

PROJECT

Geotechnical and ASS Investigation

LOGGED

BC / WX

CHECKED

RE

SHEET

1 OF 1

SITE

Bayview Golf Course, Bayview, NSW

GEOLOGY

Quaternary Deposits

VEGETATION

Grass

PROJECT NO.

P2309440

EQUIPMENT

Hand Push Tube

LONGITUDE

151.29995

RL SURFACE

1.19 m

DATUM

AHD

EXCAVATION DIMENSIONS

ø100 mm x 1.50 m depth

LATITUDE

-33.66973

ASPECT

N

SLOPE

<5%

Drilling

METHOD

PT

PENETRATION RESISTANCE

H

WATER

Inflow

DEPTH (metres)

1.19

DEPTH RL

0.30

DEPTH RL

0.89

DEPTH RL

1.20

DEPTH RL

-0.01

DEPTH RL

1.50

Sampling

SAMPLE OR FIELD TEST

RECOVERED

GRAPHIC LOG

USCS / ASCS CLASSIFICATION

SM

USCS / ASCS CLASSIFICATION

SP

USCS / ASCS CLASSIFICATION

SP

Field Material Description

SOIL/ROCK MATERIAL DESCRIPTION

FILL: Silty SAND; fine grained; grey, yellow, brown; trace rootlets.

SOIL/ROCK MATERIAL DESCRIPTION

FILL: SAND; fine grained; grey - yellow; trace silt and clay.

SOIL/ROCK MATERIAL DESCRIPTION

Clayey SAND; fine to medium grained; brown.

SOIL/ROCK MATERIAL DESCRIPTION

Hole Terminated at 1.50 m (Target depth reached)

MOISTURE CONDITION

CONSISTENCY

DENSITY

STRUCTURE AND ADDITIONAL OBSERVATIONS

FILL

STRUCTURE AND ADDITIONAL OBSERVATIONS

STRUCTURE AND ADDITIONAL OBSERVATIONS

ALLUVIUM

STRUCTURE AND ADDITIONAL OBSERVATIONS

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

Martens Logo

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Engineering Log - BOREHOLE

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P2309440BH101-112.GPJ <<DrawingFile>> 21/04/2023 11:26 10.02.00.04 DigGel Lab and In Situ Tool - DGT [Lib: Martens 2.00 2016-11-13 Proj: Martens 2.00 2016-11-13]

CLIENT	Bayview Golf Club			COMMENCED	01/03/2023	COMPLETED	01/03/2023	REF BH112b					
PROJECT	Geotechnical and ASS Investigation			LOGGED	BC / WX	CHECKED	RE	Sheet 1 OF 1					
SITE	Bayview Golf Course, Bayview, NSW			GEOLOGY	Quaternary Deposits	VEGETATION	Grass	PROJECT NO. P2309440					
EQUIPMENT	Hand Push Tube			LONGITUDE	151.29999	RL SURFACE	1.21 m	DATUM	AHD				
EXCAVATION DIMENSIONS	ø100 mm x 1.50 m depth			LATITUDE	-33.66963	ASPECT	N	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
PT	H		1.21					CL	FILL: Silty Sandy CLAY; low plasticity; dark brown; trace rootlets.				FILL
			0.2	0.2-0.4/S/1 D 0.20-0.40 m									
			0.4	0.40 0.81			SP	FILL: SAND; fine grained; yellow, brown; trace silt and clay.					
			0.6	0.5-0.7/S/1 D 0.50-0.70 m									
			0.8										
			1.10 0.11	1.1-1.3/S/1 D 1.10-1.30 m			SC	Clayey SAND; fine to medium grained; grey, dark grey.				ALLUVIUM	
			1.50						Hole Terminated at 1.50 m (Target depth reached)				
			1.6										
			1.8										
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS													
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11 **Attachment C – DCP ‘N’ Counts**

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Site	Bayview Golf Course, Bayview, NSW	DCP Group Reference	P2309440JS02V01
Client	Bayview Golf Club	Log Date	1/03/2023
Logged by	BC		
Checked by	RE		
Comments	All DCPs commenced at 50 mm bgl.		

TEST DATA

[illegible]

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Site	Bayview Golf Course, Bayview, NSW	DCP Group Reference	P2309440JS02V01
Client	Bayview Golf Club	Log Date	1/03/2023
Logged by	BC		
Checked by	RE		
Comments	All DCPs commenced at 50 mm bgl.		

[illegible]

12 **Attachment D – Slope Instability Risk Summary**

Slope Instability Risk - Summary Assessment

Method based on Walker *et al.* in AGS Vol 42 No. 1 March 2007
Method ST-38 Revised 08.07.09



Suite 201, George Street, Hornsby, NSW 2007, Ph: (02) 9476 9999 Fax: (02) 9476 8767, mail@martens.com.au, www.martens.com.au

PROJECT DETAILS

Project	Green Renovation Works - Bayview Golf Course, Bayview, NSW			Ref. No.	P2309440JS04V01
Author	BC	Reviewed	RE	Date Created	20.03.2023

RISK ASSESSMEENT

Risk	Identify Hazard					Description	Likelihood ¹	Risk to Life ¹		Risk to Property ¹		
								Probability	Assessment	Consequence	Assessment	
A	Shallow rotational slide	▼	Unlikely	▼	Minor	▼	Shallow rotational slide	Unlikely	6.94E-07	Lr-A	Minor	L
B	Deep seated rotational slide	▼	Rare	▼	Medium	▼	Deep seated rotational slide	Rare	6.30E-07	Lr-A	Medium	L
C	Soil creep	▼	Likely	▼	Insignificant	▼	Soil creep	Likely	6.67E-08	Lr-A	Insignificant	L
	None	▼		▼		▼						
		▼		▼		▼						

Notes

1. Assumes tretment measures are adopted.

Definitions

1. Risk to Life Assessment - Lr-A: Acceptable risk for loss of life for the person(s). Risk level suitable for new developments.

2. Risk to Life Assessment - Lr-T: Tolerable risk for loss of life for the person(s). Risk level suitable for existing structures > 10 years old. Risk level unsuitable for new developments.

3. Risk to Life Assessment - Lr-U: Unacceptable risk for loss of life for the person(s). Risk level unsuitable for new or existing (>10 years old) developments.

Risk Level Implications

1. VH - Very High Risk - Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce to Low. Cost could be prohibitive.

2. H - High Risk - Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Treatment will be costly.

3. M - Moderate Risk - May be tolerated in certain circumstances but requires investigation, planning and implementation to reduce risk to Low. Treatment options are practical.

4. L - Low Risk - Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.

5. VL - Very Low Risk - Acceptable. Manage by normal slope maintenance procedures.

Treatment Measures

Ensure good hill slope engineering practice is adopted (examples are provided in Attachment E). Maintain vegetation cover. Do not over-steepen existing grades without suitable shoring support. Do not place excessive load onto reaining walls or existing and final sloping surfaces unless designed for. Ensure appropriate foundation and footing design. Ensure placement of all new footings on rock. Provide / maintain appropriate surface and sub-surface drainage. Refer report text for further recommendations.

13 **Attachment E – Hill Slope Engineering Practices**

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

GOOD ENGINEERING PRACTICE

POOR ENGINEERING PRACTICE

ADVICE

GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical practitioner at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
-------------------------	---	--

PLANNING

SITE PLANNING	Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind.	Plan development without regard for the Risk.
---------------	---	---

DESIGN AND CONSTRUCTION

HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	Indiscriminatory bulk earthworks.
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use clean fill materials and compact to engineering standards. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill, which if it fails, may flow a considerable distance including onto property below. Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, trees, vegetation, topsoil, boulders, building rubble etc in fill.
ROCK OUTCROPS & BOULDERS	Remove or stabilise boulders which may have unacceptable risk. Support rock faces where necessary.	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on rock where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally inadequate wall such as sandstone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOOTINGS	Found within rock where practicable. Use rows of piers or strip footings oriented up and down slope. Design for lateral creep pressures if necessary. Backfill footing excavations to exclude ingress of surface water.	Found on topsoil, loose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.	
DRAINAGE		
SURFACE	Provide at tops of cut and fill slopes. Discharge to street drainage or natural water courses. Provide general falls to prevent blockage by siltation and incorporate silt traps. Line to minimise infiltration and make flexible where possible. Special structures to dissipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond on bench areas.
SUBSURFACE	Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	Discharge roof runoff into absorption trenches.
SEPTIC & SULLAGE	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some areas if risk is acceptable. Storage tanks should be water-tight and adequately founded.	Discharge sullage directly onto and into slopes. Use absorption trenches without consideration of landslide risk.
EROSION CONTROL & LANDSCAPING	Control erosion as this may lead to instability. Revegetate cleared area.	Failure to observe earthworks and drainage recommendations when landscaping.

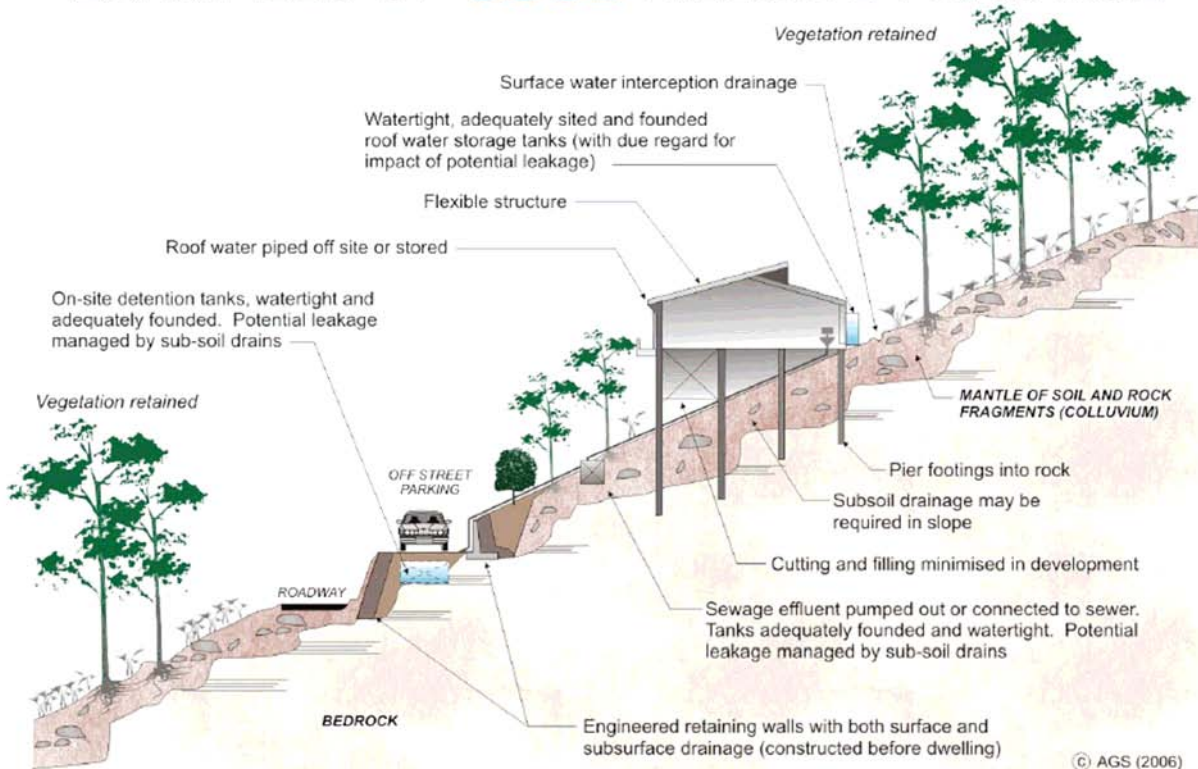
DRAWINGS AND SITE VISITS DURING CONSTRUCTION

DRAWINGS	Building Application drawings should be viewed by geotechnical consultant	
SITE VISITS	Site Visits by consultant may be appropriate during construction/	

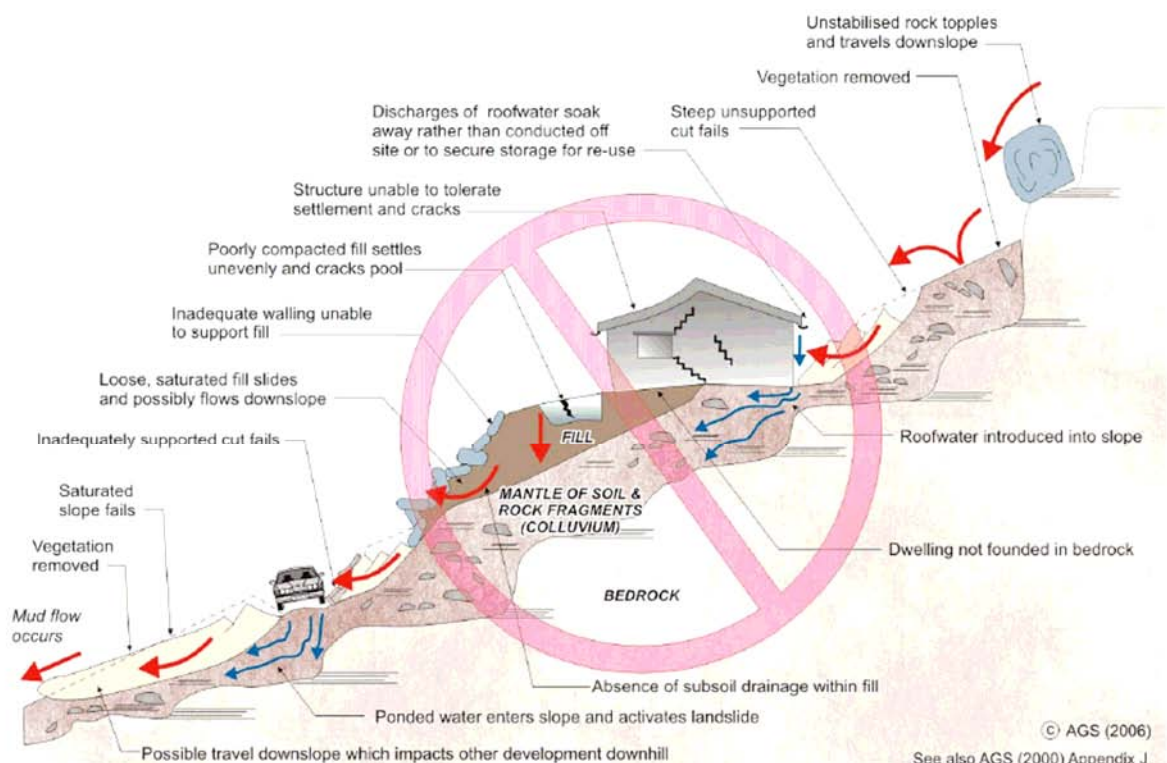
INSPECTION AND MAINTENANCE BY OWNER

OWNER'S RESPONSIBILITY	Clean drainage systems; repair broken joints in drains and leaks in supply pipes. Where structural distress is evident see advice. If seepage observed, determine causes or seek advice on consequences.	
------------------------	--	--

EXAMPLES OF **GOOD** HILLSIDE PRACTICE



EXAMPLES OF **POOR** HILLSIDE PRACTICE



**14 Attachment F – Geotechnical Risk Management Policy
for Pittwater – Form 1 and Form 1 (a)**

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

Development Application for Bayview Golf Club

Name of Applicant

Address of site 52 Cabbage Tree Road and 1825 Pittwater Road, Bayview, NSW

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 & Associates Pty Ltd
(Insert Name) (Trading or Company Name)

on this the 21st April 2023 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: Geotechnical Assessment P2309440JR01V01

Report Date: 21 April 2023

:

Author: Ben Cornish

Author's Company/Organisation: Martens & Associates Pty Ltd

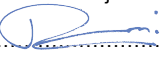
Documentation which relate to or are relied upon in report preparation:

Martens & Associates report reference P1706099JR02V03

Martens & Associates report reference P1706099JC09V02

Martens & Associates report reference P2108584JR01V01

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 & Associates

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER
FORM NO. 1(a) - Checklist of Requirements For Geotechnical Risk Management Report for Development Application

Development Application for Bayview Golf Club
 Name of Applicant
 Address of site 52 Cabbage Tree Road and 1825 Pittwater Road, Bayview, NSW

The following checklist covers the minimum requirements to be addressed in a Geotechnical Risk Management Geotechnical Report. This checklist is to accompany the Geotechnical Report and its certification (Form No. 1).

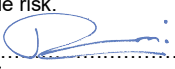
Geotechnical Report Details:

Report Title: Geotechnical Assessment P2309440JR01V01
 Report Date: 21 April 2023
 Author: Ben Cornish
 Author's Company/Organisation: Martens & Associates

Please mark appropriate box

- ☒ Comprehensive site mapping conducted 19 February 2015 and 29 November 2018
 (date)
- ☒ Mapping details presented on contoured site plan with geomorphic mapping to a minimum scale of 1:200 (as appropriate)
- ☒ Subsurface investigation required
☐ No Justification
☒ Yes Date conducted 1 March 2023
- ☒ Geotechnical model developed and reported as an inferred subsurface type-section
- ☒ Geotechnical hazards identified
☒ Above the site
☒ On the site
☒ Below the site
☒ Beside the site
- ☒ Geotechnical hazards described and reported
- ☒ Risk assessment conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
☒ Consequence analysis
☒ Frequency analysis
- ☒ Risk calculation
- ☒ Risk assessment for property conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
- ☒ Risk assessment for loss of life conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
- ☒ Assessed risks have been compared to "Acceptable Risk Management" criteria as defined in the Geotechnical Risk Management Policy for Pittwater - 2009
- ☒ Opinion has been provided that the design can achieve the "Acceptable Risk Management" criteria provided that the specified conditions are achieved.
- ☒ Design Life Adopted:
☒ 100 years
☐ Other specify
- ☒ Geotechnical Conditions to be applied to all four phases as described in the Geotechnical Risk Management Policy for Pittwater - 2009 have been specified
- ☒ Additional action to remove risk where reasonable and practical have been identified and included in the report.
- ☐ Risk assessment within Bushfire Asset Protection Zone.

I am aware that Pittwater Council will rely on the Geotechnical Report, to which this checklist applies, as the basis for ensuring that the geotechnical risk management aspects of the proposal 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 & Associates

15 Attachment G – 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.

16 Attachment H – Notes About This Report

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.

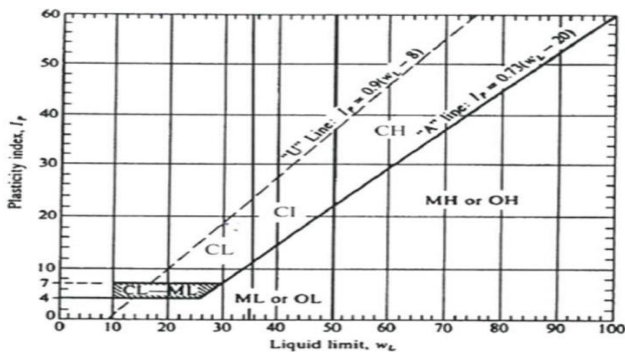
Particle Size

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



TOPSOIL

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

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

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

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

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)	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		
DZ/DS Decomposed zone/ seam		
FZ Fractured Zone	Thickness	Coating or Filling
IS Infilled seam	Zone > 100 mm	Cn Clean
VN Vein	Seam > 2 mm < 100 mm	Sn Stain
CO Contact	Plane < 2 mm	Ct Coating
HB Handling break		Vnr Veneer
DB Drilling break		Fe Iron Oxide
		X Carbonaceous
		Qz Quartzite
		MU Unidentified mineral
	Inclination	
	Inclination of defect is measured from perpendicular to and down the core axis. Direction of defect is measured clockwise (looking down core) from magnetic north.	

Test, Drill and Excavation Methods

Explanation of Terms (1 of 3)

Sampling

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

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

Undisturbed samples may be taken by pushing a thin-walled sampling tube, e.g. U₅₀ (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		