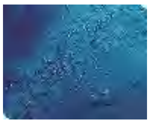
Cariste Pty Ltd

Geotechnical Assessment:
Lot 1 DP 408800,
62 Hillside Road, Newport, NSW

martens consulting engineers

ENVIRONMENTAL

WATER



WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT
MANAGEMENT

P1203617JR04V01
June 2016

Copyright Statement

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

Contents

1 Introduction

1.1 Overview

This report provides the findings of a geotechnical assessment completed to support a development application (DA) for a proposed 4 lot subdivision at 62 (Lot 1 DP 408800) Hillside Road, Newport, NSW. Martens and Associates have previously completed a geotechnical assessment for Lot 2 at 85 Hillside Road, Newport, NSW (ref. P1002791JR02V01) and is therefore not part of this assessment. The assessment determines preliminary geotechnical parameters for the proposed subdivision and associated risks which may affect the site, surrounding land and the proposed dwellings, and provide recommendations for managing identified risks.

The assessment was carried out in accordance with the following guidelines:

- Pittwater Council (2009), *Geotechnical Risk Management Policy for Pittwater*
- Australian Geomechanics Society, *Practice Note Guidelines for Landslide Risk Management* (2007)
- Australian Standard 1726 (1993), *Geotechnical site investigations*
- Australian Standard 2870 (2011), *Residential slabs and footings*
- Australian Standard 1289.6.3.2 (1997), *Determination of the penetration resistance of a soil – 9 kg dynamic cone penetrometer test*

1.2 Development Proposal

It is our understanding that the development proposal includes the following:

- Subdivision of Lot 1 DP 408800 into 4 Lots.
- Establishment of ancillary services such as stormwater, electrical, sewer and gas.

Proposed works are shown on the site plan in Attachment A.

Construction of approved internal access road will occur in accordance with approved plans (refer Pittwater Council consent number: N0274/09, 2010).

1.3 Previous Field Investigations

This report makes use of previous field investigation data collected from the site by Martens and Associates on 15 February 2007, 19 November 2008, 1 October 2010 and 19 February 2015. The report also makes use of previous field investigation data collected from the site by EIS (division of the Jeffery and Katauskas Group) on 3 May 2002 and Jeffery and Katauskas on 1 December 2003. This is documented in Jeffery and Katauskas report number 18204SLrpt (12 January 2004). Relevant previous field sub-surface test locations are shown on the site plan in Attachment A.

Martens and Associates previously undertook a geotechnical investigation for the approved driveway (ref. P0802169JR02_V1) and a geotechnical assessment for Lot 2 (ref. P1002791JR02V02). Both of these geotechnical reports should be read in conjunction with this report.

A summary of sub-surface conditions encountered during previous works within Lot 1 DP 408800 and Lot 2 DP 1036400 is summarised in Table 8, Attachment F.

1.4 Site Description

Site details are summarised in Table 1. General surrounds are provided in Figure 1 (Attachment A).

Table 1: Site detail summary.

Element	Description/ Detail
Investigation address	62 Hillside Road, Newport, NSW.
Lot/DP	Lot 1 DP 408800
LGA	Pittwater Council
Site area	5,974 m^2
Existing site development	Residential property with a derelict cottage and shed.
Current land use	Residential
Proposed land use	Residential
Aspect and typical slopes	The site slopes predominantly in a south to south east direction. The upper northern perimeter forms part of the southern edge of the Bilgola Plateau. The majority of the northern portion of the site is relatively steep with average site slopes of 44%, although there are some flatter areas with grades lower than 10%.
Vegetation	Bushland with some clearing surrounding the existing cottage.
Easements	None, based on review and site observation.
Drainage	An unnamed ephemeral creek is located near the western lot boundary and flows into Newport Beach, approximately 525 m south east.
Neighbouring environment	The site is bordered by existing residential dwellings to the north, west and south, and Attunga Reserve to the east.

2 Geotechnical Assessment

2.1 Field Investigations

Field investigations for the geotechnical assessment, undertaken on 19 February, 2015, included:

- Walkover survey to assess existing site conditions including local topographic, geomorphic and exposed soil conditions, drainage and vegetation.
- Drilling of nine (9) boreholes using a hand auger to characterise sub-surface soils. Six boreholes within 62 Hillside Road, Newport and 3 boreholes within 82 Hillside Road, Newport.
- Eighteen (18) Dynamic Cone Penetrometer (DCP) tests up to approximately 3.25m bgl to assist soil characterisation, estimate soil strength and assess depth to top of weathered rock. Fifteen DCPs within 62 Hillside Road, Newport and three DCPs within 82 Hillside Road, Newport.

Approximate borehole and DCP test locations are provided on site plan, Attachment A.

2.2 Expected Geology and Soil Profile

The Sydney 1:100,000 Geological Series Sheet 9130 (1983) indicates the lower portions of the site to be underlain by Newport Formation consisting of interbedded laminate, shale and quartz, to lithic quartz sandstone of the Narrabeen Group. The upper portions of the site (Bilgola Plateau) are underlain by Hawkesbury Sandstone consisting of medium to coarse-grained quartz sandstone, very minor shale and laminite lenses.

The NSW Office of Environment and Heritage's (OEH) Google Maps-based information system (eSPADE) indicates the site to be located in the Watagan soil landscape. This landscape comprises rolling to very steep hills on fine grained Narrabeen Group sediments. The soils are likely to comprise shallow to deep (30-200cm) lithosols/siliceous sands and yellow podzolic soils. They typically have a high soil erosion hazard and are a mass movement hazard.

2.3 Groundwater

Site sub-surface investigations did not intercept any groundwater. Based on slope and elevation, we estimate permanent groundwater is within the sandstone bedrock pore space at more than 6 m below ground level at the subject site. We expect that some seepage flows are likely to occur at the soil/rock interface after rainfall events.

2.4 Observed Sub-Surface Conditions

Sub-surface investigations encountered typically silty sand topsoil between about 0.0 m and 0.2 mbgl overlying clayey sand colluvium between about 0.2 m and 1.2 mbgl grading into residual clays. Fill consisting of clayey sand/sandy clays was encountered in BH101 and BH102 near the entrance to the driveway and is between about 0.2 m and 0.6 m thick.

Soil and rock conditions encountered in the boreholes and inferred from field test results are summarised in Table 2. For a more detailed description of the sub-surface conditions, refer to the borehole logs in Attachment B and DCP 'N' counts in Attachment C.

Table 2: Summary of soil and rock profiles at borehole locations.

Layer[1]	Depth (mBGL)[2]								
	BH101[4]	BH102[4]	BH103[4]	BH104[3]	BH105[3]	BH106[3]	BH107[3]	BH108[3]	BH109[3]
FILL: Clayey SAND - Varied Strengths[5]	0.0 – 0.4	0.0 – 0.2	-	-	-	-	-	-	-
FILL: Sandy CLAY - Varied Strengths[5]	0.4 – 0.6	-	-	-	-	-	-	-	-
TOPSOIL: Silty SAND - Loose	-	-	0.0 – 0.2	0.0 – 0.1	0.0 – 0.1	0.0 – 0.1	0.0 – 0.1	0.0 – 0.1	0.0 – 0.1
COLLUVIUM: Clayey SAND - Loose to medium dense	-	-	0.2 – 1.2[6]	0.1 – 0.3[7]	0.1 – 0.25	0.1 – 0.3[7]	0.1 – 1.2	0.1 – 0.65	0.1 – 0.3[7]
RESIDUAL: CLAY - Firm to very stiff	0.6 – 1.4[6]	0.2 – 0.8[6]	-	-	0.25 – 0.4[7]	-	1.2 – 1.3[8]	0.65 – 1.0[8]	-

Notes:

[1] Based on visual assessment/drilling spoil. Refer to site plan (Attachment A) for borehole locations and borehole logs (Attachment B) for more detailed descriptions. May vary between boreholes.

[2] Approximate depths in (m) below ground level.

[3] Undertaken within Lot 1 DP 408800 No 62 Hillside Road, Newport, NSW.

[4] Undertaken within Lot 2 DP 1036400 No 85 Hillside Road, Newport, NSW.

[5] Uncontrolled fill.

[6] Hand auger refusal on sandstone cobble.

[7] Hand auger refusal on inferred sandstone bedrock.

[8] Hand auger refusal on stiff clay.

2.5 Preliminary Soil and Rock Strength Properties

Preliminary soil and rock strength properties, estimated from field test results in conjunction with borehole derived soil profile data, are summarised in Table 3.

Table 3: Preliminary geotechnical soil and rock strength properties.

Soil Description	γ^1 (kN/m^3)	$C_U{}^2$ (kPa)	ϕ^3 (°)	E'^4 (mPa)
TOPSOIL: Silty SAND - Loose	15	NA	27	10
COLLUVIUM: Clayey SAND - Loose to medium dense	17	NA	32	20
RESIDUAL: CLAY - Firm to very stiff	17	50	NA	20
WEATHERED ROCK: SANDSTONE (inferred low strength)	23	NA	28	150

Notes:

[1] Dry Unit Weight, based on visual assessment (+/- 10 %).

[2] Undrained cohesion, assuming normally consolidated clay (+/-10 %).

[3] Effective internal friction angle (+/-2 °).

[4] Effective elastic modulus (based on visual assessment, +/- 10 %).

NA = Non applicable.

2.6 Geotechnical Risk Assessment

2.6.1 Pittwater Council Geotechnical Hazard Mapping

The site is mapped by Pittwater Council (2007) as 'Geotechnical Hazard H1'. Hazard zone H1 is described as 'An area where the likelihood of instability occurring is assessed as Possible, Likely, or Almost Certain' (Revisions to the Geotechnical Risk Management, December 2007).

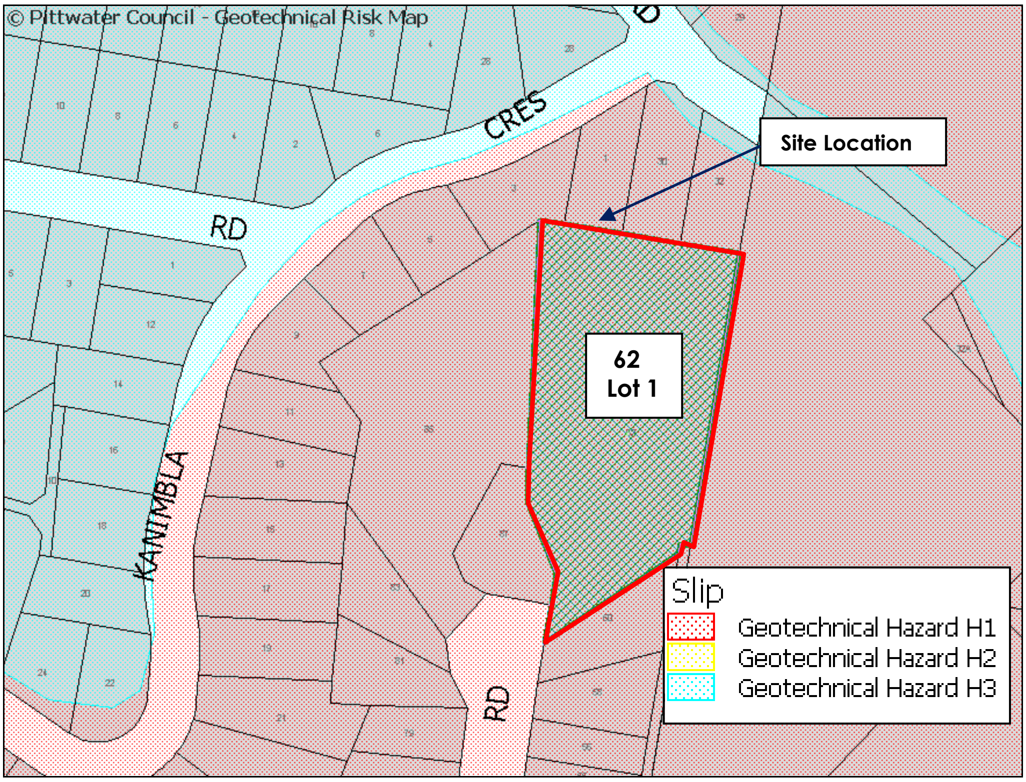

Figure 1: Pittwater Council's Geological Hazard Mapping and the site (Source: Pittwater Council).

2.6.2 Site Stability and Condition of Existing Structures

The following conditions were observed:

- Evidence of soil creep was observed as certain trees were on a lean indicative of soil creep.
- Minor soil stripping was observed in exposed/weathered cuts.
- Minor rock fall from the sandstone escarpment was observed. However, no boulders appeared to have been recently subjected to mass movement.
- Evidence of past rotational sliding was observed in the form of benches and mounding in the mid slopes. This is illustrated in the inferred geological cross-section provided in Attachment D.

2.6.3 *Risk Assessment of Proposed Development Works*

A geotechnical hazard risk assessment for the proposed residential subdivision has been completed in accordance with the qualitative risk matrices provided in Section 7 of the AGS (2007) guidelines. It is considered that four potential forms of geotechnical hazard are possible at the site: deep rotational slide, shallow rotational slide, soil creep and rock fall (Table 4). Risk calculation sheets are provided in Attachment E.

Table 4: Summary of slope instability risk assessment, based on AGS (2007).

Description	Treatment Measures	Likelihood[1]	Risk to Life		Risk to Property	
			Established Probability[2]	Risk	Consequence	Risk
A: Deep Rotational Slide (potentially existing failure)	Good hill slope engineering practice. Maintain vegetation cover where possible. Do not over-steepen natural grades. Limit surface water ponding at top of slopes. Footings to be taken to sandstone bedrock.	Unlikely to rare[1]	2.67×10^{-7}	Acceptable	Minor to moderate	Low - medium
B: Shallow Rotational Slide	Good hill slope engineering practice. Maintain vegetation cover where possible. Do not over-steepen natural grades. Limit surface water ponding at top of slopes. Footings to be taken to sandstone bedrock.	Unlikely[1]	2.24×10^{-7}	Acceptable	Minor to moderate	Low
C: Soil creep	Maintain vegetation where possible. Provide sub-surface drainage where possible. Limit surface water ponding at top of slopes. Ensure appropriate foundations and footings design.	Almost certain[1]	1.91×10^{-7}	Acceptable	Insignificant	Low
D: Rock Fall	Remove or stabilize boulders which may have unacceptable risk. Support rock faces where necessary.	Unlikely to rare[1]	1.80×10^{-7}	Acceptable	Minor to moderate	Low - medium

Notes: [1] Based on 'treated' site conditions as per recommendations of this report. [2] Annual probability of loss of life of an individual.

Considering the proposed development and assessed geotechnical conditions at the site, subject to the recommendations presented in this report and provided in the AGS (2007) guidelines (Attachment H), the proposed development is assessed to constitute a low to medium risk of damage to properties and tolerable risk of loss of life.

The risk of land instability associated with the proposed development is considered typically acceptable in accordance with the AGS (2007) guidelines, provided recommendations of this report are implemented. However, it is the responsibility of the client and stakeholders to ultimately assess whether the risk is acceptable.

2.7 Recommendations

2.7.1 Recommendations for Design and Construction

Preliminary geotechnical recommendations for development of the site and protection of neighbouring infrastructure and buildings during works are provided in Table 5.

Table 5: Preliminary geotechnical recommendations.

Recommendations	Description
Excavations	Heavy machinery should be avoided within 2 m of the top of any open excavation. All excavation work should be completed with reference to the Code of Practice 'Excavation Work', dated July 2015, by Safe Work Australia. Excavation method statements will need to be prepared by the excavation contractor prior to the issue of CC.
Batter Slopes	Any temporary or permanent excavations into soil exceeding 0.8 m depth should be supported by suitably designed and installed retaining or shoring structures or, alternatively, battered back using temporary (< 1 month) batter slopes of no greater than 1V:2H for silty sand, 1V:1H for sandy clay/clay and 2V:1H for weathered rock. Permanent batters are not recommended. It is recommended that unsupported soil excavations deeper than 1.0 m should be assessed by a geotechnical engineer for slope instability risk.
Footings	Footings of proposed structures are to be designed by a suitably qualified and experienced structural or geotechnical engineer. Preliminary design parameters for encountered sub-surface materials are provided in Section 2.7.2. It is recommended that all footings are socketed into bedrock. DCP test results indicate that depth to bedrock is approximately 1.95 – 3.25 m deep. DCP tests that bounced at depths less than 1.95 m deep, likely refused on sandstone boulder within colluvium and not sandstone bedrock. Requirement of depth of socket subject to further investigation, once detailed plans/drawings are provided. All footings should be constructed after excavation with minimal delay. All excavated bases should be free from all loose or softened materials prior to concrete placement. If water ponds in the base of the excavations, they should be pumped dry and then re-excavated to remove all loose and softened materials. If a delay in concrete placement is anticipated, a concrete blinding layer of at least 50 mm thickness is to be placed to protect the base of the shallow footing excavation. All footing excavations should be inspected by a geotechnical engineer to confirm the required founding strata has been reached.

Recommendations	Description
Retaining walls	Retaining wall design should take appropriate surcharge and hydrostatic loads into account, adopt preliminary earth pressure coefficients provided in Section 2.7.2 and take into consideration the recommendations presented in this report. All retaining wall footings should be socketed into bedrock and not within colluvium. We recommend a drainage system be installed behind all retaining walls to dissipate pore pressures from water that may collect behind the retaining walls. A drainage pipe e.g. Agg pipe is to be provided at the base of and behind retaining walls. Further consideration may need to be given to drainage below any basement slabs. Backfill materials between basement retaining walls and excavation faces should comprise free-draining gravel. Fill should be placed in maximum 200 mm horizontal layers and compacted using a hand held compactor. Care should be taken to ensure excessive compaction stresses are not transferred to retaining walls. Backfill areas are to be geotextile wrapped.
Surface and Groundwater	Proposed excavations will unlikely intercept the groundwater table. Sump and pump methods are considered to be appropriate for removing collected surface water and ephemeral groundwater inflow, likely from soil/rock interface after periods of substantial or prolonged rainfall, during construction. All site discharges should be passed through a filter material prior to release to the Council stormwater system or approved alternative. Groundwater ingress should be monitored during excavation by a geotechnical engineer.
Overland Flows	All surface runoff should be diverted away from excavation areas during construction works. Diverted flows should be directed (where possible) to a suitable stormwater system so as to prevent water accumulating in areas surrounding retaining structures, footings or the crest of embankments. All site discharges should be passed through a filter material prior to release. Easement located near the northern upslope site boundary must not leak and will need to be monitored for leaks. Existing sub-surface drainage is to be monitored and maintained. No new drainage is to be installed upslope of the proposed dwellings, unless subject to a detailed investigation. Future dwellings and roads should be designed to divert flows away from foundations and steep slopes.
Soil Erosion Control	Removal of soil overburden should be performed in a manner that reduces the risk of sedimentation occurring in the Council stormwater system and on neighbouring land. Erosion control measures should be provided to prevent transportation of sediments off-site, e.g. soil erosion control methods recommended by Landcom (2004).
Surface Boulder Management	In order to minimise the potential for any rock fall during construction of a new dwelling, a boulder management plan should be prepared as part of the pre-construction certificate works. The boulder management plan should include the following as a minimum: o Inspection of boulders likely to be affected by the proposed development as well as any boulders upslope of the proposed dwelling in regards to stability. o Boulders lying upslope of the proposed building envelope should not be disturbed unless they are identified as particularly unstable. o Remove or stabilise boulders which may have unacceptable risk. o If excavation occurs within 2 m downslope and/or upslope of a boulder then the boulder should be stabilised using mass concrete or similar treatment.

Recommendations	Description
Fill Material	We understand that no engineered fill will be required to be brought on-site as part of the development proposal. Should this change in the future, additional geotechnical engineering advice should be sought.
Soil Waste Disposal	If any soil is to be disposed of off-site, it should be classified in accordance with NSW EPA (2014) guidelines and disposed of at a suitably licensed waste transfer facility.

2.7.2 Preliminary Design Parameters

Preliminary design parameters for footing and retaining wall design are presented in Table 6. These have been estimated from field test results in conjunction with borehole derived soil profile data.

Table 6: Preliminary geotechnical parameters.

Soil Description	ABP Piles[1] (kPa)	ASF[2] (kPa)	Ka[3]	Kp[4]
TOPSOIL: Silty SAND - Loose	NA[5]	NA[5]	0.33	3.0
COLLUVIUM: Clayey SAND - Loose to medium dense	NA[5]	NA[5]	0.28	3.54
RESIDUAL: CLAY - Firm to very stiff	150	5	0.39	2.56
WEATHERED ROCK: SANDSTONE (inferred low strength)	1000	150	NA[5]	NA[5]

Notes

[1] Allowable end bearing pressure, assuming cast in situ bored piles and adopting a geotechnical strength reduction factor of 0.4. May be higher subject to additional testing.

[2] Allowable Skin Friction in compression.

[3] Coefficient of Active Earth Pressure.

[4] Coefficient of Passive Earth Pressure.

[5] NA= Not applicable.

The above design parameters assume the base of excavation is free of loose or soft soils and water prior to placement of concrete and an embedment of at least 0.5 m or one pile diameter, whichever is greatest, in the material unit.

2.7.3 Site Classification

The majority of the site consists of colluvium and residual clays, a preliminary classification of 'P' in accordance with AS 2870 (2011) may be considered. However, it is recommended that all footings found within rock and therefore a classification of 'A' may be adopted, subject to review of foundation conditions and design by a geotechnical engineer prior to construction.

3 Further Assessments, Monitoring and Contingency

3.1 Further Assessments

We recommend the following additional geotechnical assessments are carried out to better manage geotechnical risks at the site during development of final design and prior to issuing of a construction certificate:

- Laboratory testing of soils and rock if a more accurate assessment of conditions and design parameters is required.
- A detailed geotechnical assessment is to be undertaken for each of the 4 individual lots. This is to be completed when drawings/plans for the proposed dwellings are available and as part of their individual DA applications. Recommendations presented in this report should be considered.

3.2 Further Monitoring Program

We recommend the following is inspected and monitored (Table 7) during site works.

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

Scope of Works	Frequency/Duration	Who to Complete
Inspect excavation retention (shoring, retaining wall) installations and monitor associated performance.	Daily/As required	Builder/MA
Inspect unsupported cut and battered excavations to assess adequacy of design and additional support requirements.	1.0 depth increments during excavation	MA
Monitor groundwater seepage from excavation faces to assess adequacy of drainage provision.	When encountered	Builder/MA
Monitor sedimentation downslope of excavated areas.	During and after rainfall events	Builder
Monitor sediment and erosion control structures to assess adequacy and for removal of built up spoil.	After rainfall events	Builder
Inspect exposed material at foundation level to verify suitability as foundation/ lateral support.	Prior to reinforcement set-up and concrete placement	MA

3.3 Contingency Plan

In the event that the proposed development works cause an adverse impact on overall site stability or adjacent properties, works shall cease immediately. The nature of the impact shall be documented and the reason(s) for the adverse impact investigated. This might require further advice by a qualified geotechnical or structural engineer.

4 Conclusion

The proposed subdivision is suitable for the site in regard to geotechnical constraints subject to our recommendations being adhered to. Furthermore, following the subdivision we recommend that the proposed dwellings are subject to a geotechnical assessment as part of their DA application.

5 Investigation Limitations

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. In the event that any of the construction phase 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 foundations where recommendations are not implemented in full and properly tested, inspected and documented.

In the event that there are any significant changes to the development proposal described in this report, then all recommendations should be reviewed by Martens & Associates.

Occasionally sub-surface soil conditions between the completed boreholes may be found to be different from those expected. This can also occur with groundwater conditions, especially after climatic changes. Should, during site works, soil or water conditions be found to be significantly different to those detailed in this report, works shall cease immediately and the new conditions should be addressed by Martens & Associates to determine geotechnical implications before recommencement.

6 References

Australian Geomechanics Society, Landslide Zoning Working Group (March 2007), *Guidelines for Landslide Susceptibility, Hazard and Risk Zoning for Land Use Planning*, Australian Geomechanics Vol 42 No 1.

Australian Standard 1726 (1993), *Geotechnical site investigations.*

Australia Standard 1289.6.3.2 (1997), *Determination of the penetration resistance of a soil - 9kg dynamic cone penetrometer test.*

Australian Standard 2187.2 (1993), *Explosives - Storage, transport and use Part 2: Use of explosives.*

Australian Standard 2870 (2011), *Residential slabs and footings.*

Jeffery and Katauskas (2004), Borehole logs from report number 18204SLrpt.

NSW Department of Mineral Resources (1983), Sydney Australia 1:100,000 Geological Series Sheet 9130.

NSW Office of Environment and Heritage, *eSPADE, www.environment.nsw.gov.au/eSpadeWebapp.*

Pittwater Council (2009), *Geotechnical Risk Management Policy for Pittwater.*

7 Attachment A – Site Plan

REV.	DESCRIPTION	DATE	ISSUED
A	GEOTECHNICAL ASSESSMENT	1.03.16	GMT

BAR SCALE

DESIGNED: GMT
DATUM: mAHD
REVIEWED: DM
HORIZONTAL RATIO: 1:300
PAPER SIZE: A1
VERTICAL RATIO: 1:300

CLIENT / PROJECT
CARISTE PTY LTD/
GEOTECHNICAL ASSESSMENT

THIS PLAN MUST NOT BE USED FOR CONSTRUCTION UNLESS SIGNED AS APPROVED BY PRINCIPAL CERTIFYING AUTHORITY
All measurements in mm unless otherwise specified

martens
& Associates Pty Ltd
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TITLE:
BH/DCP LOCATIONS
62 HILLSIDE RD, NEWPORT, NSW.

DRAWING ID: **Figure 1**

PROJECT MANAGER: DM
PROJECT NO.: P1203617
FILE: JD01V01
REVISION: A

8 Attachment B – Engineering Borehole Logs

CLIENT	**Cariste Pty Ltd**	**COMMENCED**	19/02/15	**COMPLETED**	19/02/15	**REF**	**BH101**
PROJECT	**Geotechnical Investigation**	**LOGGED**	GMT	**CHECKED**	RE	**Sheet** 1 **of** 1	
SITE	**62 Hillside Road, Newport, NSW.**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1203617
EQUIPMENT	Hand Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø90mm X 1.4m depth	**NORTHING**	NA	**ASPECT**	South East	**SLOPE**	>10%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	DRILLING RESISTANCE L M H R	GRAPHIC LOG	CLASSIFICATION	MATERIAL DESCRIPTION SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
HA	Nil	N	M	0.15			SC	Fill: Clayey SAND - Fine to medium grained, light brown, with sandstone gravels (5-50mm, angular).		D			- FILL
HA	Nil	N	D	0.25 0.4			SC	Fill: Clayey SAND - Fine to medium grained, dark brown.	St			0.25	- FILL
HA	Nil	N	D	0.5 0.6			CL	Fill: Sandy CLAY - Low plasticity, brown.	St			0.5	- FILL
HA	Nil	N	D	0.75 1.0 1.25 1.4			CL-CI	CLAY - Low to medium plasticity, light brown/orange.	St			0.75 1.0 1.25	- RESIDUAL
				1.5 1.75 2.0 2.25				Hand auger refusal at 1.4m on sandstone cobble.				1.5 1.75 2.0 2.25	

EQUIPMENT / METHOD
- N Natural exposure
- X Existing excavation
- BH Backhoe bucket
- HA Hand auger
- S Spade
- CC Concrete Corer
- V V-Bit
- TC Tungsten Carbide Bit
- PT Push tube

SUPPORT
- SH Shoring
- SC Shotcrete
- RB Rock Bolts
- Nil No support

WATER
- N None observed
- X Not measured
- ▽ Water level
- ◁ Water outflow
- ▷ Water inflow

MOISTURE
- D Dry
- M Moist
- W Wet
- Wp Plastic limit
- Wl Liquid limit

DRILLING RESISTANCE
- L Low
- M Moderate
- H High
- R Refusal

CONSISTENCY
- VS Very Soft
- S Soft
- F Firm
- St Stiff
- VSt Very Stiff
- H Hard
- F Friable

DENSITY
- VL Very Loose
- L Loose
- MD Medium Dense
- D Dense
- VD Very Dense

SAMPLING & TESTING
- A Auger sample
- B Bulk sample
- U Undisturbed sample
- D Disturbed sample
- M Moisture content
- Ux Tube sample (x mm)
- pp Pocket penetrometer
- S Standard penetration test
- VS Vane shear
- DCP Dynamic cone penetrometer
- FD Field density
- WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
- Y USCS
- N Agricultural

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

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Engineering Log - Borehole

CLIENT	**Cariste Pty Ltd**	**COMMENCED**	19/02/15	**COMPLETED**	19/02/15	**REF**	**BH102**
PROJECT	**Geotechnical Investigation**	**LOGGED**	GMT	**CHECKED**	RE	**Sheet**	**1 of 1**
SITE	**62 Hillside Road, Newport, NSW.**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1203617
EQUIPMENT	Hand Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø90mm X 0.8m depth	**NORTHING**	NA	**ASPECT**	South East	**SLOPE**	>10%

EXCAVATION DATA | MATERIAL DATA | SAMPLING & TESTING

METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	DRILLING RESISTANCE L M H R	GRAPHIC LOG	CLASSIFICATION	**MATERIAL DESCRIPTION** SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
HA	Nil	N	D	0.2			SC	Fill: Clayey SAND - Fine to medium grained, light brown/orange, with sandstone and blue metal gravels (5-20mm, angular).		D			- FILL
HA	Nil	N	D	0.25 0.5 0.75 0.8			CL-CI	CLAY - Low to medium plasticity, light brown/ orange, white.	St		A	0.4	- RESIDUAL 3617/102/ 0.4
				1.0 1.25 1.5 1.75 2.0 2.25				Hand auger refusal at 0.8m on sandstone cobble.					

EQUIPMENT / METHOD
- N Natural exposure
- X Existing excavation
- BH Backhoe bucket
- HA Hand auger
- S Spade
- CC Concrete Corer
- V V-Bit
- TC Tungsten Carbide Bit
- PT Push tube

SUPPORT
- SH Shoring
- SC Shotcrete
- RB Rock Bolts
- Nil No support

WATER
- N None observed
- X Not measured
- ⊻ Water level
- ◁ Water outflow
- ▷ Water inflow

MOISTURE
- D Dry
- M Moist
- W Wet
- Wp Plastic limit
- Wl Liquid limit

DRILLING RESISTANCE
- L Low
- M Moderate
- H High
- R Refusal

CONSISTENCY
- VS Very Soft
- S Soft
- F Firm
- St Stiff
- VSt Very Stiff
- H Hard
- F Friable

DENSITY
- VL Very Loose
- L Loose
- MD Medium Dense
- D Dense
- VD Very Dense

SAMPLING & TESTING
- A Auger sample
- B Bulk sample
- U Undisturbed sample
- D Disturbed sample
- M Moisture content
- Ux Tube sample (x mm)
- pp Pocket penetrometer
- S Standard penetration test
- VS Vane shear
- DCP Dynamic cone penetrometer
- FD Field density
- WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
- Y USCS
- N Agricultural

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

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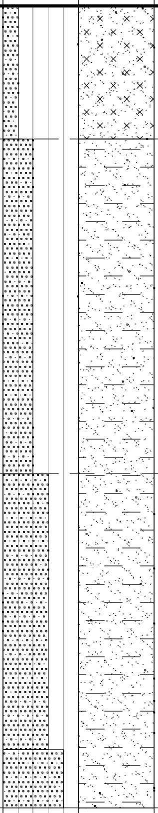
Engineering Log - Borehole

CLIENT	**Cariste Pty Ltd**	**COMMENCED**	19/02/15	**COMPLETED**	19/02/15	**REF**	**BH103**
PROJECT	**Geotechnical Investigation**	**LOGGED**	GMT	**CHECKED**	RE	**Sheet**	**1** of **1**
SITE	**62 Hillside Road, Newport, NSW.**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1203617
EQUIPMENT	Hand Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø90mm X 1.2m depth	**NORTHING**	NA	**ASPECT**	South East	**SLOPE**	>10%



EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	**SUPPORT**	**WATER**	**MOISTURE**	**DEPTH (M)**	**DRILLING RESISTANCE** L M H R	**GRAPHIC LOG**	**CLASSIFICATION**	**MATERIAL DESCRIPTION** SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	**CONSISTENCY**	**DENSITY INDEX**	**TYPE**	**DEPTH (M)**	**RESULTS AND ADDITIONAL OBSERVATIONS**
HA	Nil	N	D	0.2			SM	Silty SAND - Fine to medium grained, brown, with rootlets.		L			- TOPSOIL
HA	Nil	N	D	0.25 0.5 0.7			SC	Clayey SAND - Fine to medium grained, brown.		L-MD			- COLLUVIUM 0.25 0.5
HA	Nil	N	D	0.75 1.0 1.2			SC	Clayey SAND - Fine to medium grained, light brown, with sandstone gravels (5-100mm, subangular).		D			- COLLUVIUM 0.75 1.0
				1.25 1.5 1.75 2.0 2.25				Hand auger refusal at 1.2m on sandstone cobble.					1.25 1.5 1.75 2.0 2.25

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
▽ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

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Engineering Log - Borehole

CLIENT	**Cariste Pty Ltd**	**COMMENCED**	19/02/15	**COMPLETED**	19/02/15	**REF**	**BH104**
PROJECT	**Geotechnical Investigation**	**LOGGED**	GMT	**CHECKED**	RE	**Sheet 1 of 1**	
SITE	**62 Hillside Road, Newport, NSW.**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1203617
EQUIPMENT	Hand Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø90mm X 0.3m depth	**NORTHING**	NA	**ASPECT**	South	**SLOPE**	>10%

EXCAVATION DATA						**MATERIAL DATA**					**SAMPLING & TESTING**		
METHOD	**SUPPORT**	**WATER**	**MOISTURE**	**DEPTH (M)**	**DRILLING RESISTANCE** L M H R	**GRAPHIC LOG**	**CLASSIFICATION**	**MATERIAL DESCRIPTION** SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	**CONSISTENCY**	**DENSITY INDEX**	**TYPE**	**DEPTH (M)**	**RESULTS AND ADDITIONAL OBSERVATIONS**
HA	Nil	N	D	0.1			SM	Silty SAND - Fine to medium grained, brown, with rootlets.		L			- TOPSOIL
HA	Nil	N	D	0.25 0.3			SC	Clayey SAND - Fine to medium grained, brown.		L			- COLLUVIUM 0.25
								Hand auger refusal at 0.3m on sandstone.					
				0.5									0.5
				0.75									0.75
				1.0									1.0
				1.25									1.25
				1.5									1.5
				1.75									1.75
				2.0									2.0
				2.25									2.25

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
⊽ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

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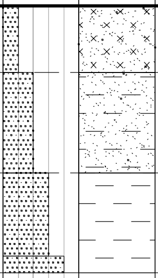
Engineering Log - Borehole

CLIENT	**Cariste Pty Ltd**	**COMMENCED**	19/02/15	**COMPLETED**	19/02/15	**REF BH105**
PROJECT	**Geotechnical Investigation**	**LOGGED**	GMT	**CHECKED**	RE	**Sheet 1 of 1**
SITE	**62 Hillside Road, Newport, NSW.**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.** P1203617
EQUIPMENT	Hand Auger	**EASTING**	NA	**RL SURFACE**	NA	
EXCAVATION DIMENSIONS	Ø90mm X 0.4m depth	**NORTHING**	NA	**ASPECT**	South	**SLOPE** >10%



EXCAVATION DATA						**MATERIAL DATA**						**SAMPLING & TESTING**		
METHOD	**SUPPORT**	**WATER**	**MOISTURE**	**DEPTH (M)**	**DRILLING RESISTANCE** L M H R	**GRAPHIC LOG**	**CLASSIFICATION**	**MATERIAL DESCRIPTION** SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	**CONSISTENCY**	**DENSITY INDEX**	**TYPE**	**DEPTH (M)**	**RESULTS AND ADDITIONAL OBSERVATIONS**	
HA	Nil	N	D	0.1			SM	Silty SAND - Fine to medium grained, brown, with rootlets.		L			- TOPSOIL	
HA	Nil	N	D	0.25			SC	Clayey SAND - Fine to medium grained, brown.		L			- COLLUVIUM	0.25
HA	Nil	N	D	0.4			CL-CI	CLAY - Low to medium plasticity, light brown/orange.	F				- COLLUVIUM	
								Hand auger refusal at 0.4m on sandstone.						
				0.5										0.5
				0.75										0.75
				1.0										1.0
				1.25										1.25
				1.5										1.5
				1.75										1.75
				2.0										2.0
				2.25										2.25

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
Water level
Water outflow
Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

Quality Sheet No. 4

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Engineering Log - Borehole

CLIENT	**Cariste Pty Ltd**	**COMMENCED**	19/02/15	**COMPLETED**	19/02/15	**REF**	**BH106**
PROJECT	**Geotechnical Investigation**	**LOGGED**	GMT	**CHECKED**	RE	**Sheet** 1 **of** 1	
SITE	**62 Hillside Road, Newport, NSW.**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1203617
EQUIPMENT	Hand Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø90mm X 0.3m depth	**NORTHING**	NA	**ASPECT**	South	**SLOPE**	>10%

EXCAVATION DATA						**MATERIAL DATA**					**SAMPLING & TESTING**		
METHOD	**SUPPORT**	**WATER**	**MOISTURE**	**DEPTH (M)**	**DRILLING RESISTANCE** L M H R	**GRAPHIC LOG**	**CLASSIFICATION**	**MATERIAL DESCRIPTION** SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	**CONSISTENCY**	**DENSITY INDEX**	**TYPE**	**DEPTH (M)**	**RESULTS AND ADDITIONAL OBSERVATIONS**
HA	Nil	N	D	0.1			SM	Silty SAND - Fine to medium grained, brown, with rootlets.		L			- TOPSOIL
HA	Nil	N	D	0.25 0.3			SC	Clayey SAND - Fine to medium grained, brown.		L			- COLLUVIUM 0.25
				0.5 0.75 1.0 1.25 1.5 1.75 2.0 2.25				Hand auger refusal at 0.3m on sandstone.					0.5 0.75 1.0 1.25 1.5 1.75 2.0 2.25

EQUIPMENT / METHOD
N Natural exposure
X Existing excavation
BH Backhoe bucket
HA Hand auger
S Spade
CC Concrete Corer
V V-Bit
TC Tungsten Carbide Bit
PT Push tube

SUPPORT
SH Shoring
SC Shotcrete
RB Rock Bolts
Nil No support

WATER
N None observed
X Not measured
⊻ Water level
◁ Water outflow
▷ Water inflow

MOISTURE
D Dry
M Moist
W Wet
Wp Plastic limit
Wl Liquid limit

DRILLING RESISTANCE
L Low
M Moderate
H High
R Refusal

CONSISTENCY
VS Very Soft
S Soft
F Firm
St Stiff
VSt Very Stiff
H Hard
F Friable

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

SAMPLING & TESTING
A Auger sample
B Bulk sample
U Undisturbed sample
D Disturbed sample
M Moisture content
Ux Tube sample (x mm)
pp Pocket penetrometer
S Standard penetration test
VS Vane shear
DCP Dynamic cone penetrometer
FD Field density
WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
Y USCS
N Agricultural

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

Quality Sheet No. 4

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Engineering Log - Borehole

CLIENT	**Cariste Pty Ltd**	**COMMENCED**	19/02/15	**COMPLETED**	19/02/15	**REF**	**BH107**
PROJECT	**Geotechnical Investigation**	**LOGGED**	GMT	**CHECKED**	RE	**Sheet** 1 **of** 1	
SITE	**62 Hillside Road, Newport, NSW.**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1203617
EQUIPMENT	Hand Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø90mm X 1.3m depth	**NORTHING**	NA	**ASPECT**	South	**SLOPE**	>10%

EXCAVATION DATA						**MATERIAL DATA**					**SAMPLING & TESTING**		
METHOD	**SUPPORT**	**WATER**	**MOISTURE**	**DEPTH (M)**	**DRILLING RESISTANCE** L M H R	**GRAPHIC LOG**	**CLASSIFICATION**	**MATERIAL DESCRIPTION** SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	**CONSISTENCY**	**DENSITY INDEX**	**TYPE**	**DEPTH (M)**	**RESULTS AND ADDITIONAL OBSERVATIONS**
HA	Nil	N	M	0.1			SM	Silty SAND - Fine to medium grained, brown, with rootlets.		L			- TOPSOIL
HA	Nil	N	M	0.25 0.5 0.75 1.0 1.2			SC	Clayey SAND - Fine to medium grained, brown.		L- MD			- COLLUVIUM 0.25 0.5 0.75 1.0
HA	Nil	N	M	1.25 1.3			CL- CI	CLAY - Low to medium plasticity, light brown.	VSt				- RESIDUAL 1.25
				1.5 1.75 2.0 2.25				Hand auger refusal at 1.3m on stiff clay.					1.5 1.75 2.0 2.25

EQUIPMENT / METHOD
- N Natural exposure
- X Existing excavation
- BH Backhoe bucket
- HA Hand auger
- S Spade
- CC Concrete Corer
- V V-Bit
- TC Tungsten Carbide Bit
- PT Push tube

SUPPORT
- SH Shoring
- SC Shotcrete
- RB Rock Bolts
- Nil No support

WATER
- N None observed
- X Not measured
- ⊽ Water level
- ◁ Water outflow
- ▷ Water inflow

MOISTURE
- D Dry
- M Moist
- W Wet
- Wp Plastic limit
- Wl Liquid limit

DRILLING RESISTANCE
- L Low
- M Moderate
- H High
- R Refusal

CONSISTENCY
- VS Very Soft
- S Soft
- F Firm
- St Stiff
- VSt Very Stiff
- H Hard
- F Friable

DENSITY
- VL Very Loose
- L Loose
- MD Medium Dense
- D Dense
- VD Very Dense

SAMPLING & TESTING
- A Auger sample
- B Bulk sample
- U Undisturbed sample
- D Disturbed sample
- M Moisture content
- Ux Tube sample (x mm)
- pp Pocket penetrometer
- S Standard penetration test
- VS Vane shear
- DCP Dynamic cone penetrometer
- FD Field density
- WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
- Y USCS
- N Agricultural

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

Quality Sheet No. 4

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Engineering Log - Borehole

CLIENT	**Cariste Pty Ltd**	**COMMENCED**	19/02/15	**COMPLETED**	19/02/15	**REF**	**BH108**
PROJECT	**Geotechnical Investigation**	**LOGGED**	GMT	**CHECKED**	RE	**Sheet**	**1 of 1**
SITE	**62 Hillside Road, Newport, NSW.**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1203617
EQUIPMENT	Hand Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø90mm X 1.0m depth	**NORTHING**	NA	**ASPECT**	South	**SLOPE**	>10%

EXCAVATION DATA · MATERIAL DATA · SAMPLING & TESTING

METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	DRILLING RESISTANCE L M H R	GRAPHIC LOG	CLASSIFICATION	MATERIAL DESCRIPTION SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS
HA	Nil	N	M	0.1			SM	Silty SAND - Fine to medium grained, brown, with rootlets.		L			- TOPSOIL
HA	Nil	N	M	0.25 0.5 0.65			SC	Clayey SAND - Fine to medium grained, brown.		L			- COLLUVIUM 0.25 0.5
HA	Nil	N	M	0.75 1.0			CL-CI	CLAY - Low to medium plasticity, light brown/orange.	St				- RESIDUAL 0.75 1.0
				1.25 1.5 1.75 2.0 2.25				Hand auger refusal at 1.0m on clay.					1.25 1.5 1.75 2.0 2.25

EQUIPMENT / METHOD
- N Natural exposure
- X Existing excavation
- BH Backhoe bucket
- HA Hand auger
- S Spade
- CC Concrete Corer
- V V-Bit
- TC Tungsten Carbide Bit
- PT Push tube

SUPPORT
- SH Shoring
- SC Shotcrete
- RB Rock Bolts
- Nil No support

WATER
- N None observed
- X Not measured
- ⊻ Water level
- ◁ Water outflow
- ▷ Water inflow

MOISTURE
- D Dry
- M Moist
- W Wet
- Wp Plastic limit
- Wl Liquid limit

DRILLING RESISTANCE
- L Low
- M Moderate
- H High
- R Refusal

CONSISTENCY
- VS Very Soft
- S Soft
- F Firm
- St Stiff
- VSt Very Stiff
- H Hard
- F Friable

DENSITY
- VL Very Loose
- L Loose
- MD Medium Dense
- D Dense
- VD Very Dense

SAMPLING & TESTING
- A Auger sample
- B Bulk sample
- U Undisturbed sample
- D Disturbed sample
- M Moisture content
- Ux Tube sample (x mm)
- pp Pocket penetrometer
- S Standard penetration test
- VS Vane shear
- DCP Dynamic cone penetrometer
- FD Field density
- WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
- Y USCS
- N Agricultural

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

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Engineering Log - Borehole

CLIENT	**Cariste Pty Ltd**	**COMMENCED**	19/02/15	**COMPLETED**	19/02/15	**REF**	**BH109**
PROJECT	**Geotechnical Investigation**	**LOGGED**	GMT	**CHECKED**	RE	**Sheet** 1 **of** 1	
SITE	**62 Hillside Road, Newport, NSW.**	**GEOLOGY**	Sandstone	**VEGETATION**	Grass	**PROJECT NO.**	P1203617
EQUIPMENT	Hand Auger	**EASTING**	NA	**RL SURFACE**	NA		
EXCAVATION DIMENSIONS	Ø90mm X 0.3m depth	**NORTHING**	NA	**ASPECT**	South	**SLOPE**	>10%

EXCAVATION DATA						MATERIAL DATA					SAMPLING & TESTING		
METHOD	**SUPPORT**	**WATER**	**MOISTURE**	**DEPTH (M)**	**DRILLING RESISTANCE** L M H R	**GRAPHIC LOG**	**CLASSIFICATION**	**MATERIAL DESCRIPTION** SOIL NAME, plasticity or particle characteristics, colour, secondary and minor components, moisture condition, consistency/relative density, ROCK NAME, grain size, texture/fabric, colour, strength, weathering.	**CONSISTENCY**	**DENSITY INDEX**	**TYPE**	**DEPTH (M)**	**RESULTS AND ADDITIONAL OBSERVATIONS**
HA	Nil	N	D	0.1			SM	Silty SAND - Fine to medium grained, brown, with rootlets.		L			- TOPSOIL
HA	Nil	N	D	0.25 0.3			SC	Clayey SAND - Fine to medium grained, brown.		L			- COLLUVIUM 0.25
				0.5 0.75 1.0 1.25 1.5 1.75 2.0 2.25				Hand auger refusal at 0.3m on sandstone.					0.5 0.75 1.0 1.25 1.5 1.75 2.0 2.25

EQUIPMENT / METHOD
- N Natural exposure
- X Existing excavation
- BH Backhoe bucket
- HA Hand auger
- S Spade
- CC Concrete Corer
- V V-Bit
- TC Tungsten Carbide Bit
- PT Push tube

SUPPORT
- SH Shoring
- SC Shotcrete
- RB Rock Bolts
- Nil No support

WATER
- N None observed
- X Not measured
- ▽ Water level
- ◁ Water outflow
- ▷ Water inflow

MOISTURE
- D Dry
- M Moist
- W Wet
- Wp Plastic limit
- Wl Liquid limit

DRILLING RESISTANCE
- L Low
- M Moderate
- H High
- R Refusal

CONSISTENCY
- VS Very Soft
- S Soft
- F Firm
- St Stiff
- VSt Very Stiff
- H Hard
- F Friable

DENSITY
- VL Very Loose
- L Loose
- MD Medium Dense
- D Dense
- VD Very Dense

SAMPLING & TESTING
- A Auger sample
- B Bulk sample
- U Undisturbed sample
- D Disturbed sample
- M Moisture content
- Ux Tube sample (x mm)
- pp Pocket penetrometer
- S Standard penetration test
- VS Vane shear
- DCP Dynamic cone penetrometer
- FD Field density
- WS Water sample

CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION
- Y USCS
- N Agricultural

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

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Engineering Log - Borehole

9 Attachment C – DCP Test Log Sheet

Dynamic Cone Penetrometer Test Log Summary

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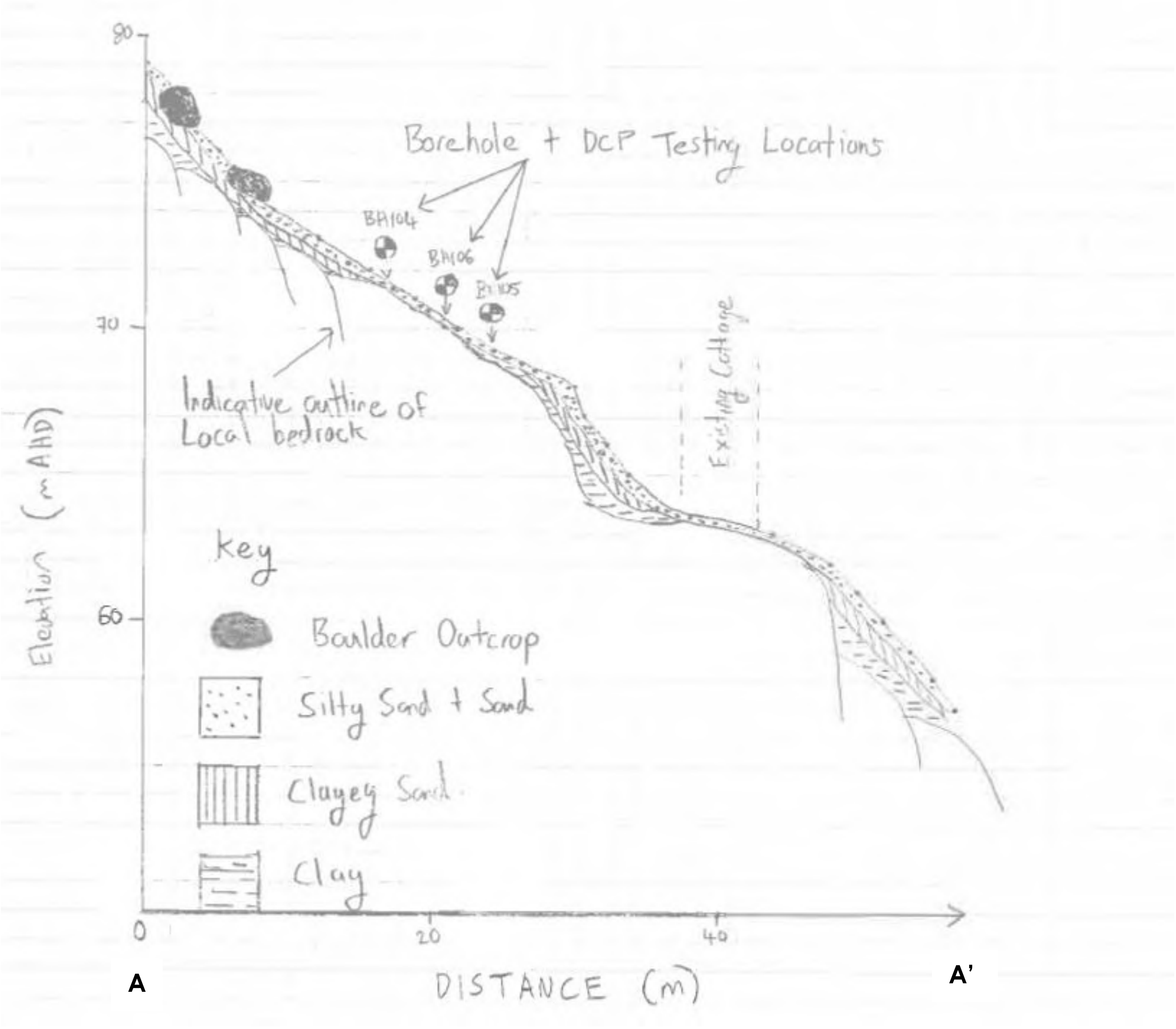
Site	Geotechnical Assessment - 62 and 85 Hillside Road, Newport, NSW	**DCP Group Reference**	**P1203617**
Client	Cariste Pty Ltd	**Log Date**	20.2.15
Logged by	GMT		
Checked by	RE		
Comments			

TEST DATA

Depth Interval (m)	DCP 101	DCP 102	DCP 103	DCP 104	DCP 105	DCP 106	DCP 107	DCP 108	DCP 109	DCP 110	DCP 111	DCP 112	DCP 113	DCP 114	DCP 115	DCP 116	DCP 117	DCP 118	Design
0.15	10	8	2	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	**1**
0.30	6	3	2	2	2	2	2	2	2	5	2	2	2	2		2	2	2	**2**
0.45	6	8	2	Bounce	2	4	2	3	40+	10	6	Bounce	2	3	2	40+	40+	2	**2**
0.60	4	10	6	@ 0.3m	4	Bounce	2	3	Bounce	10	7	@ 0.3m	2	3	2	Bounce	Bounce	3	**2**
0.75	4	6	5		Bounce	@ 0.3m	4	4	@ 0.3m	8	Bounce		3	5	3	@ 0.3m	@ 0.25m	2	**2**
0.90	4	8	6		@ 0.6m		6	7		10	@ 0.75m		3	5	10			14	**3**
1.05	3	40+	8				6	9		8			3	4	12			6	**3**
1.20	4	Bounce	7				7	11		8			4	4	7			6	**4**
1.35	6	@ 1.1m	10				19	15		6			6	5	10			5	**5**
1.50	4		14				24	40+		8			5	7	13			6	**4**
1.65	5		15				40+	Bounce		9			6	6	15			11	**5**
1.80	4		18				Bounce	@ 1.5m		10			6	10	26			12	**4**
1.95	7		22				@ 1.65m			10			7	40+	40+			18	**7**
2.10	7		24							16			9	Bounce	Bounce			32	**7**
2.25	10		23							21			10	@ 1.95m	@ 1.95m			40+	**10**
2.40	9		27							29			Bounce					Bounce	**9**
2.55	8		32							35			@ 2.3m					@ 2.25m	**8**
2.70	11		40+							40+									**11**
2.85	9		Termination							Termination									**9**
3.00	12		@ 2.75m							@ 2.65m									**12**
3.15	24																		**24**
	40+																		
	Termination																		
	@ 3.25m																		

10 Attachment D – Geological Cross-Section



Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment I Water I Wastewater I Geotechnical I Civil I Management**	
Drawn:	GMT	**IDEALISED GEOTECHNICAL CROSS SECTION** **62 Hillside Road, Newport, NSW**	Drawing No:
Approved:	GT		**FIGURE 1**
Date:	June, 2016		
Scale:	NA		Job No: P1203617JR04V01

11 Attachment E – Risk Calculation Sheets

Landslide Hazard Evaluation - Risk to Life Assessment

Method based on Walker *et al.* in AGS Vol 42 No. 1 March 2007

Method ST-24 Revised 20.02.08

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PROJECT DETAILS

Project	**Geotechnical Assessment**			Ref. No.	**P1403617**
Author	**GMT**	Reviewed	**GT**	Created	**13.03.15**

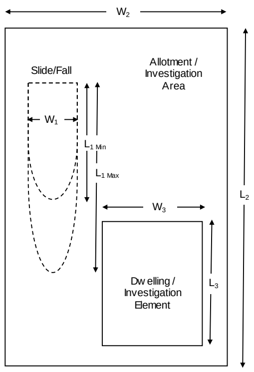
STEP 1 : ENTER SITE AND DESIGN DATA

Hazard Type	**Deep Seated Rotational Slide**

$P_{(H)}$	Annual probability of landslide	**0.0001**

INDICATIVE VALUE	RECURRENCE INTERVAL	DESCRIPTION	DESCRIPTOR	LEVEL
10^{-1}	10 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	100 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	1000 years	The event could occur under tadverse conditions over the design life.	POSSIBLE	C
10^{-4}	10,000 years	The enent might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	100,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}	1,000,000 years	The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

$P_{(S:H)}$	Probablity of spatial impact impacting building location taking into account travel distance and travel direction	**0.27**



FACTOR	DESCRIPTION	UNITS	VALUE
W_1	Likely slide/fall width	m	**30**
W_2	Width of allotment / investigation area	m	**60**
W_3	Width of dwelling / investigation element	m	**15**
L_{1Min}	Minimum run-out length	m	**1**
L_{1Max}	Maximum run-out length	m	**20**
L_2	Length of allotment / investigation area	m	**70**
L_3	Length of dwelling / investigation element	m	**12**
L_{PMin}	Probability of runout being 0 - 1 m long	(0 - 1)	**0.70**
L_{PMax}	Probability of runout being 0 - 20 m long	(0 - 1)	0.30
W_F	Likelihood of across slope strike on risk element	(0 - 1)	**1.00**
$L_{F\ Min}$	Likelihood of downslope strike on risk element for minimum run-out distance	(0 - 1)	0.19
$L_{F\ Max}$	Likelihood of downslope strike on risk element for maximum run-out distance	(0 - 1)	0.46
$L_{F\ Design}$	Likelihood of downslope strike (integrated) on risk element run-out distance	(0 - 1)	**0.27**

$P_{(T:S)}$	Temporal spatial probability given the spatial impact	**0.10**

FACTOR	DESCRIPTION	UNITS	VALUE
T_1	Percentage of time person(s) are on-site	m	50%
T_2	Percentage of dwelling / element that person(s) occupy	m	20%

$V_{(V:D)}$	Vulnerability of the individual (ie. probability of loss of life given the impact)	**0.1000**

CASE	DESCRIPTION	RANGE IN DATA	RECOMMENDED VALUE	COMMENTS
Person in open space	If struck by a rockfall	0.1 - 0.7	0.50	May be injured but unlikely to cause death
	If buried by debris	0.8 - 1.0	1.00	Death by asphyxia almost certain
	If not buried	0.1 - 0.5	0.10	High chance of survival
Person in a vehicle	If vehicle is buried / crushed	0.9 - 1.0	1.00	Death is almost certain
	If the vehicle is damaged only	0.0 - 0.3	0.30	High chance of survival
Persons in building	If the building collapses	0.9 - 1.0	1.00	Dealth is almost certain
	If the building is inundated with debris and the person is buried	0.8 - 1.0	1.00	Death is highly likely
	If the debris strikes the building only	0.0 - 0.1	0.05	Very high chance of survival

STEP 2 : RISK EVALUATION

$V_{(D:T)}$	Risk (annual probability of loss of life of an individual)	**2.67E-07**

Risk Assessment	**Acceptable risk for loss of life for the person(s). Risk level suitable for new developments.**

Landslide Hazard Evaluation - Risk to Life Assessment

Method based on Walker *et al,* in AGS Vol 42 No. 1 March 2007

Method ST-24 Revised 20.02.08

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PROJECT DETAILS

Project	**Geotechnical Assessment**			Ref. No.	**P1403617**
Author	**GMT**	Reviewed	**GT**	Created	**13.03.15**

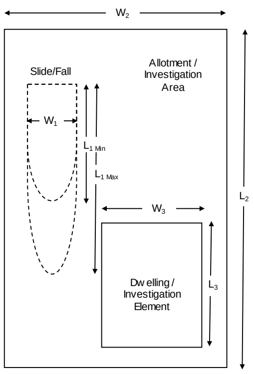
STEP 1 : ENTER SITE AND DESIGN DATA

Hazard Type	**Shallow Rotational Slide**

$P_{(H)}$	Annual probability of landslide	**0.0001**

INDICATIVE VALUE	RECURRENCE INTERVAL	DESCRIPTION	DESCRIPTOR	LEVEL
10^{-1}	10 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	100 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	1000 years	The event could occur under tadverse conditions over the design life.	POSSIBLE	C
10^{-4}	10,000 years	The enent might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	100,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}	1,000,000 years	The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

$P_{(S:H)}$	Probablity of spatial impact impacting building location taking into account travel distance and travel direction	**0.22**



FACTOR	DESCRIPTION	UNITS	VALUE
W_1	Likely slide/fall width	m	**30**
W_2	Width of allotment / investigation area	m	**60**
W_3	Width of dwelling / investigation element	m	**15**
L_{1Min}	Minimum run-out length	m	**1**
L_{1Max}	Maximum run-out length	m	**10**
L_2	Length of allotment / investigation area	m	**70**
L_3	Length of dwelling / investigation element	m	**12**
L_{PMin}	Probability of runout being 0 - 1 m long	(0 - 1)	**0.70**
L_{PMax}	Probability of runout being 0 - 10 m long	(0 - 1)	0.30
W_F	Likelihood of across slope strike on risk element	(0 - 1)	**1.00**
$L_{F\ Min}$	Likelihood of downslope strike on risk element for minimum run-out distance	(0 - 1)	0.19
$L_{F\ Max}$	Likelihood of downslope strike on risk element for maximum run-out distance	(0 - 1)	0.31
$L_{F\ Design}$	Likelihood of downslope strike (integrated) on risk element run-out distance	(0 - 1)	**0.22**

$P_{(T:S)}$	Temporal spatial probability given the spatial impact	**0.10**

FACTOR	DESCRIPTION	UNITS	VALUE
T_1	Percentage of time person(s) are on-site	m	50%
T_2	Percentage of dwelling / element that person(s) occupy	m	20%

$V_{(V:D)}$	Vulnerability of the individual (ie. probability of loss of life given the impact)	**0.1000**

CASE	DESCRIPTION	RANGE IN DATA	RECOMMENDED VALUE	COMMENTS
Person in open space	If struck by a rockfall	0.1 - 0.7	0.50	May be injured but unlikely to cause death
	If buried by debris	0.8 - 1.0	1.00	Death by asphyxia almost certain
	If not buried	0.1 - 0.5	0.10	High chance of survival
Person in a vehicle	If vehicle is buried / crushed	0.9 - 1.0	1.00	Death is almost certain
	If the vehicle is damaged only	0.0 - 0.3	0.30	High chance of survival
Persons in building	If the building collapses	0.9 - 1.0	1.00	Dealth is almost certain
	If the building is inundated with debris and the person is buried	0.8 - 1.0	1.00	Death is highly likely
	If the debris strikes the building only	0.0 - 0.1	0.05	Very high chance of survival

STEP 2 : RISK EVALUATION

$V_{(D:T)}$	Risk (annual probability of loss of life of an individual)	**2.24E-07**

Risk Assessment	**Acceptable risk for loss of life for the person(s). Risk level suitable for new developments.**

Landslide Hazard Evaluation - Risk to Life Assessment

Method based on Walker *et al.* in AGS Vol 42 No. 1 March 2007

Method ST-24 Revised 20.02.08

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PROJECT DETAILS

Project	**Geotechnical Assessment**			Ref. No.	**P1403617**
Author	**GMT**	Reviewed	**GT**	Created	**13.03.15**

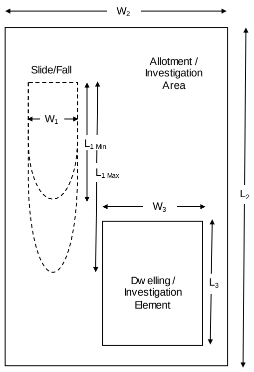
STEP 1 : ENTER SITE AND DESIGN DATA

Hazard Type	**Soil Creep**

$P_{(H)}$	Annual probability of landslide	**0.1**

INDICATIVE VALUE	RECURRENCE INTERVAL	DESCRIPTION	DESCRIPTOR	LEVEL
10^{-1}	10 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	100 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	1000 years	The event could occur under tadverse conditions over the design life.	POSSIBLE	C
10^{-4}	10,000 years	The enent might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	100,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}	1,000,000 years	The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

$P_{(S:H)}$	Probablity of spatial impact impacting building location taking into account travel distance and travel direction	**0.19**



FACTOR	DESCRIPTION	UNITS	VALUE
W_1	Likely slide/fall width	m	**50**
W_2	Width of allotment / investigation area	m	**60**
W_3	Width of dwelling / investigation element	m	**15**
L_{1Min}	Minimum run-out length	m	**1**
L_{1Max}	Maximum run-out length	m	**2**
L_2	Length of allotment / investigation area	m	**70**
L_3	Length of dwelling / investigation element	m	**12**
L_{PMin}	Probability of runout being 0 - 1 m long	(0 - 1)	**0.60**
L_{PMax}	Probability of runout being 0 - 2 m long	(0 - 1)	0.40
W_F	Likelihood of across slope strike on risk element	(0 - 1)	**1.00**
$L_{F\ Min}$	Likelihood of downslope strike on risk element for minimum run-out distance	(0 - 1)	0.19
$L_{F\ Max}$	Likelihood of downslope strike on risk element for maximum run-out distance	(0 - 1)	0.20
$L_{F\ Design}$	Likelihood of downslope strike (integrated) on risk element run-out distance	(0 - 1)	**0.19**

$P_{(T:S)}$	Temporal spatial probability given the spatial impact	**0.10**

FACTOR	DESCRIPTION	UNITS	VALUE
T_1	Percentage of time person(s) are on-site	m	50%
T_2	Percentage of dwelling / element that person(s) occupy	m	20%

$V_{(V:D)}$	Vulnerability of the individual (ie. probability of loss of life given the impact)	**0.0001**

CASE	DESCRIPTION	RANGE IN DATA	RECOMMENDED VALUE	COMMENTS
Person in open space	If struck by a rockfall	0.1 - 0.7	0.50	May be injured but unlikely to cause death
	If buried by debris	0.8 - 1.0	1.00	Death by asphyxia almost certain
	If not buried	0.1 - 0.5	0.10	High chance of survival
Person in a vehicle	If vehicle is buried / crushed	0.9 - 1.0	1.00	Death is almost certain
	If the vehicle is damaged only	0.0 - 0.3	0.30	High chance of survival
Persons in building	If the building collapses	0.9 - 1.0	1.00	Death is almost certain
	If the building is inundated with debris and the person is buried	0.8 - 1.0	1.00	Death is highly likely
	If the debris strikes the building only	0.0 - 0.1	0.05	Very high chance of survival

STEP 2 : RISK EVALUATION

$V_{(D:T)}$	Risk (annual probability of loss of life of an individual)	**1.91E-07**
Risk Assessment		**Acceptable risk for loss of life for the person(s). Risk level suitable for new developments.**

Landslide Hazard Evaluation - Risk to Life Assessment

Method based on Walker *et al.* in AGS Vol 42 No. 1 March 2007

Method ST-24 Revised 20.02.08

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PROJECT DETAILS

Project	Geotechnical Assessment			Ref. No.	P1403617
Author	GMT	Reviewed	GT	Created	13.03.15

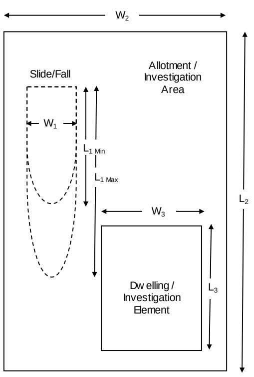
STEP 1 : ENTER SITE AND DESIGN DATA

Hazard Type — **Rock Fall**

$P_{(H)}$ Annual probability of landslide — **0.0001**

INDICATIVE VALUE	RECURRENCE INTERVAL	DESCRIPTION	DESCRIPTOR	LEVEL
10^{-1}	10 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	100 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	1000 years	The event could occur under tadverse conditions over the design life.	POSSIBLE	C
10^{-4}	10,000 years	The enent might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	100,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}	1,000,000 years	The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

$P_{(S:H)}$ Probablity of spatial impact impacting building location taking into account travel distance and travel direction — **0.18**



FACTOR	DESCRIPTION	UNITS	VALUE
W_1	Likely slide/fall width	m	**3**
W_2	Width of allotment / investigation area	m	**60**
W_3	Width of dwelling / investigation element	m	**15**
L_{1Min}	Minimum run-out length	m	**2**
L_{1Max}	Maximum run-out length	m	**50**
L_2	Length of allotment / investigation area	m	**70**
L_3	Length of dwelling / investigation element	m	**12**
L_{PMin}	Probability of runout being 0 - 2 m long	(0 - 1)	**0.50**
L_{PMax}	Probability of runout being 0 - 50 m long	(0 - 1)	0.50
W_F	Likelihood of across slope strike on risk element	(0 - 1)	**0.30**
$L_{F\ Min}$	Likelihood of downslope strike on risk element for minimum run-out distance	(0 - 1)	0.20
$L_{F\ Max}$	Likelihood of downslope strike on risk element for maximum run-out distance	(0 - 1)	1.00
$L_{F\ Design}$	Likelihood of downslope strike (integrated) on risk element run-out distance	(0 - 1)	**0.60**

$P_{(T:S)}$ Temporal spatial probability given the spatial impact — **0.10**

FACTOR	DESCRIPTION	UNITS	VALUE
T_1	Percentage of time person(s) are on-site	m	50%
T_2	Percentage of dwelling / element that person(s) occupy	m	20%

$V_{(V:D)}$ Vulnerability of the individual (ie. probability of loss of life given the impact) — **0.1000**

CASE	DESCRIPTION	RANGE IN DATA	RECOMMENDED VALUE	COMMENTS
Person in open space	If struck by a rockfall	0.1 - 0.7	0.50	May be injured but unlikely to cause death
	If buried by debris	0.8 - 1.0	1.00	Death by asphyxia almost certain
	If not buried	0.1 - 0.5	0.10	High chance of survival
Person in a vehicle	If vehicle is buried / crushed	0.9 - 1.0	1.00	Death is almost certain
	If the vehicle is damaged only	0.0 - 0.3	0.30	High chance of survival
Persons in building	If the building collapses	0.9 - 1.0	1.00	Dealth is almost certain
	If the building is inundated with debris and the person is buried	0.8 - 1.0	1.00	Death is highly likely
	If the debris strikes the building only	0.0 - 0.1	0.05	Very high chance of survival

STEP 2 : RISK EVALUATION

$V_{(D:T)}$ Risk (annual probability of loss of life of an individual) — **1.80E-07**

Risk Assessment — **Acceptable risk for loss of life for the person(s). Risk level suitable for new developments.**

12 Attachment F – Summary of previous borehole investigations

Table 8: Summary of previous borehole investigations.

Layer[1]	Depth (mBGL)[5]									
	BH-P0802169-1[3, 7]	BH-P0802169-2[3, 6]	BH-P0601384-1[2, 6]	BH-P0601384-2[2, 7]	BH-P0601384-3[2, 6]	BH1[1, 6]	BH2[1, 7]	BH7[1. 6]	BH-P1002719-2[4. 7]	BH-P1002719-3[4, 7]
Silty SAND	-	0.0 – 0.1	-	-	-	-	0.0 – 0.8	0.0 – 0.6	0.0 – 0.3	-
Loamy SAND	-	-	0.0 – 0.7	0.0 – 0.2	0.0 – 0.7	-	-	-	-	-
FILL: Silty SAND	-	-	-	-	-	0.0 – 0.5	-	-	-	-
Fine SAND	-	-	-	-	-	-	-	-	0.3 – 0.5	0.0 – 0.5
FILL: Clayey SAND	-	-	-	-	-	0.5 – 1.0	-	-	-	-
Clayey SAND	-	-	-	-	-	-	-	-	0.5 – 0.9	0.5 – 1.3
Silty CLAY	-	-	-	-	-	1.0 – 1.2	-	-	-	-
Sandy CLAY	-	-	0.7 – 1.0	0.2 – 0.4	0.7 – 1.8	-	-	-	0.9 – 1.5	-
CLAY	-	0.1 – 1.1	-	-	-	-	-	-	1.5 – 2.0	1.3 – 1.5
FILL: CLAY	0.0 – 0.3	-	-	-	-	-	-	-	-	-
Sandy CLAY	-	-	-	-	-	-	-	-	2.0 – 2.1	-
Light CLAY	-	-	1.0 – 3.1	0.4 – 1.5	-	-	-	-	-	-
Medium CLAY	-	-	-	1.5 – 2.0	1.8 – 2.9	-	-	-	-	-
Heavy CLAY	-	-	-	2.0 – 3.4	-	-	-	-	-	-
Extremely weathered siltstone/shale	-	-	3.1 – 3.4	-	2.9 – 3.9	-	-	-	-	-
Moderately weathered siltstone/shale	-	-	3.4 – 4.05	-	-	-	-	-	-	-

Notes:

[1] Boreholes excavated by Environmental Investigation Services (EIS) (20/03/2002).

[2] Boreholes excavated by Martens and Associates (15/02/2007).

[3] Boreholes excavated by Martens and Associates (19/11/2008).

[4] Boreholes excavated by Martens and Associates (01/10/2010).

[5] Approximate depths in meters below ground level.

[6] Undertaken within Lot 1 DP 408800 No 62 Hillside Road, Newport, NSW.

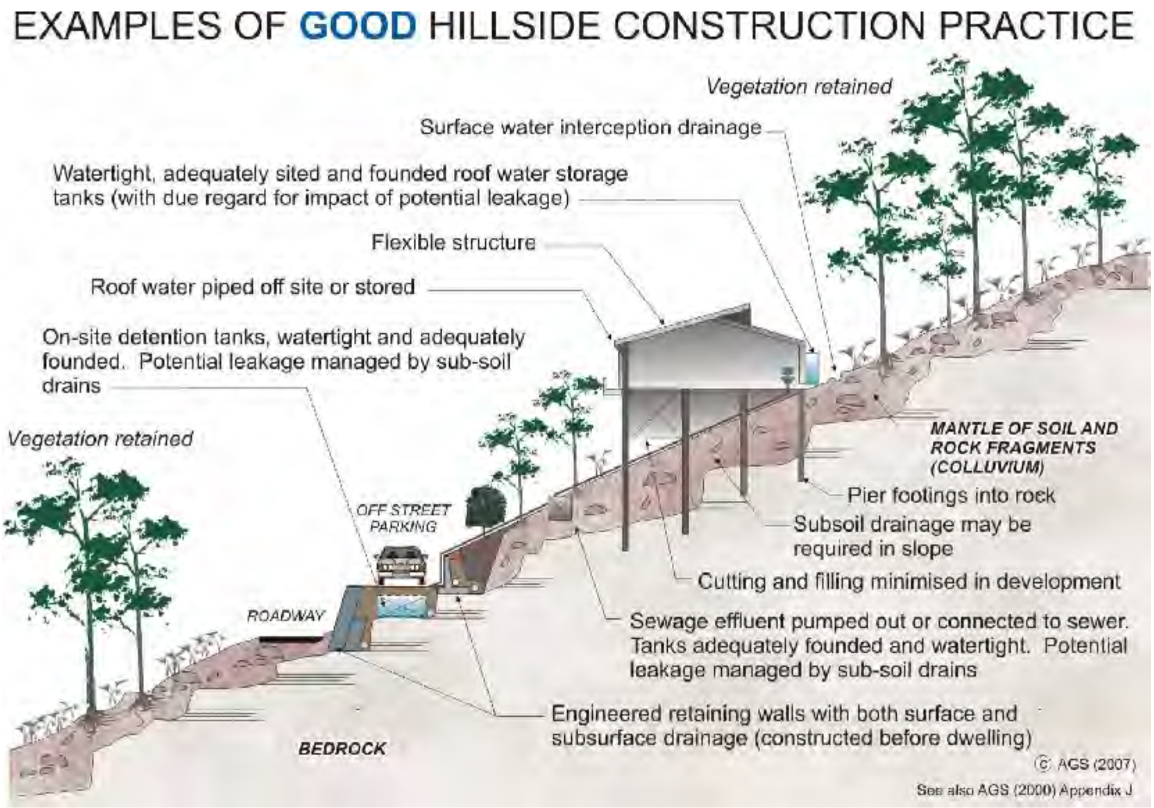
[7] Undertaken within Lot 2 DP 1036400 No 85 Hillside Road, Newport, NSW.

13 Attachment G – Hillside Construction Guidelines (AGS, 2007)

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

HILLSIDE CONSTRUCTION PRACTICE

Sensible development practices are required when building on hillsides, particularly if the hillside has more than a low risk of instability (GeoGuide LR7). Only building techniques intended to maintain, or reduce, the overall level of landslide risk should be considered. Examples of good hillside construction practice are illustrated below.



WHY ARE THESE PRACTICES GOOD?

Roadways and parking areas - are paved and incorporate kerbs which prevent water discharging straight into the hillside (GeoGuide LR5).

Cuttings - are supported by retaining walls (GeoGuide LR6).

Retaining walls - are engineer designed to withstand the lateral earth pressures and surcharges expected, and include drains to prevent water pressures developing in the backfill. Where the ground slopes steeply down towards the high side of a retaining wall, the disturbing force (see GeoGuide LR6) can be two or more times that in level ground. Retaining walls must be designed taking these forces into account.

Sewage - whether treated or not is either taken away in pipes or contained in properly founded tanks so it cannot soak into the ground.

Surface water - from roofs and other hard surfaces is piped away to a suitable discharge point rather than being allowed to infiltrate into the ground. Preferably, the discharge point will be in a natural creek where ground water exits, rather than enters, the ground. Shallow, lined, drains on the surface can fulfil the same purpose (GeoGuide LR5).

Surface loads - are minimised. No fill embankments have been built. The house is a lightweight structure. Foundation loads have been taken down below the level at which a landslide is likely to occur and, preferably, to rock. This sort of construction is probably not applicable to soil slopes (GeoGuide LR3). If you are uncertain whether your site has rock near the surface, or is essentially a soil slope, you should engage a geotechnical practitioner to find out.

Flexible structures - have been used because they can tolerate a certain amount of movement with minimal signs of distress and maintain their functionality.

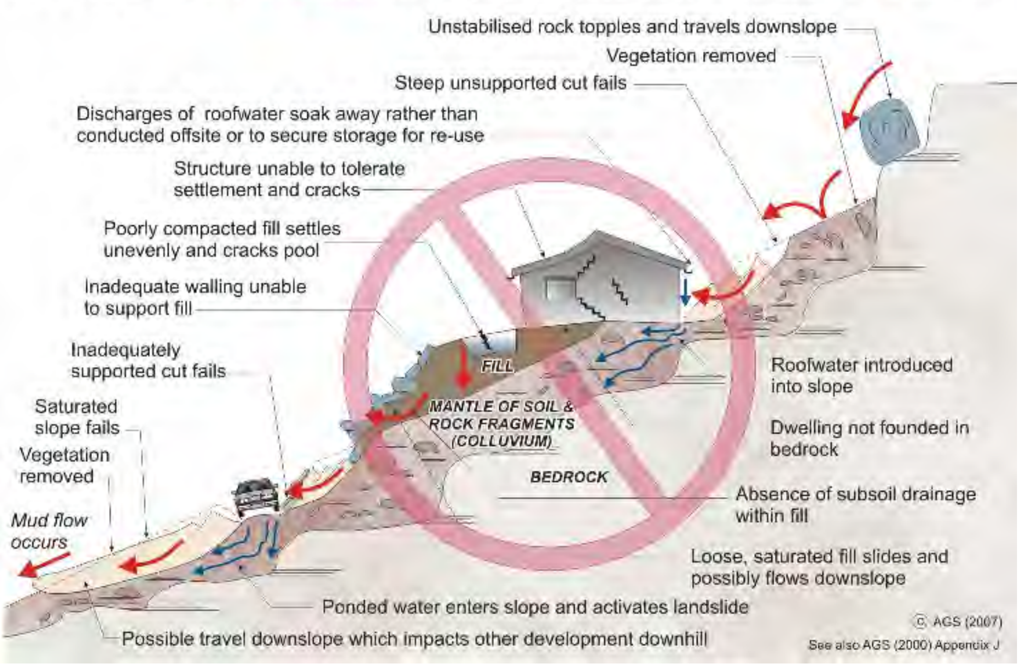
Vegetation clearance - on soil slopes has been kept to a reasonable minimum. Trees, and to a lesser extent smaller vegetation, take large quantities of water out of the ground every day. This lowers the ground water table, which in turn helps to maintain the stability of the slope. Large scale clearing can result in a rise in water table with a consequent increase in the likelihood of a landslide (GeoGuide LR5). An exception may have to be made to this rule on steep rock slopes where trees have little effect on the water table, but their roots pose a landslide hazard by dislodging boulders.

Possible effects of ignoring good construction practices are illustrated on page 2. Unfortunately, these poor construction practices are not as unusual as you might think and are often chosen because, on the face of it, they will save the developer, or owner, money. You should not lose sight of the fact that the cost and anguish associated with any one of the disasters illustrated, is likely to more than wipe out any apparent savings at the outset.

ADOPT GOOD PRACTICE ON HILLSIDE SITES

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

EXAMPLES OF POOR HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES POOR?

Roadways and parking areas - are unsurfaced and lack proper table drains (gutters) causing surface water to pond and soak into the ground.

Cut and fill - has been used to balance earthworks quantities and level the site leaving unstable cut faces and added large surface loads to the ground. Failure to compact the fill properly has led to settlement, which will probably continue for several years after completion. The house and pool have been built on the fill and have settled with it and cracked. Leakage from the cracked pool and the applied surface loads from the fill have combined to cause landslides.

Retaining walls - have been avoided, to minimise cost, and hand placed rock walls used instead. Without applying engineering design principles, the walls have failed to provide the required support to the ground and have failed, creating a very dangerous situation.

A heavy, rigid, house - has been built on shallow, conventional, footings. Not only has the brickwork cracked because of the resulting ground movements, but it has also become involved in a man-made landslide.

Soak-away drainage - has been used for sewage and surface water run-off from roofs and pavements. This water soaks into the ground and raises the water table (GeoGuide LR5). Subsoil drains that run along the contours should be avoided for the same reason. If felt necessary, subsoil drains should run steeply downhill in a chevron, or herring bone, pattern. This may conflict with the requirements for effluent and surface water disposal (GeoGuide LR9) and if so, you will need to seek professional advice.

Rock debris - from landslides higher up on the slope seems likely to pass through the site. Such locations are often referred to by geotechnical practitioners as "debris flow paths". Rock is normally even denser than ordinary fill, so even quite modest boulders are likely to weigh many tonnes and do a lot of damage once they start to roll. Boulders have been known to travel hundreds of metres downhill leaving behind a trail of destruction.

Vegetation - has been completely cleared, leading to a possible rise in the water table and increased landslide risk (GeoGuide LR5).

DON'T CUT CORNERS ON HILLSIDE SITES - OBTAIN ADVICE FROM A GEOTECHNICAL PRACTITIONER

More information relevant to your particular situation may be found in other Australian GeoGuides:

- GeoGuide LR1 - Introduction
- GeoGuide LR2 - Landslides
- GeoGuide LR3 - Landslides in Soil
- GeoGuide LR4 - Landslides in Rock
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR7 - Landslide Risk
- GeoGuide LR9 - Effluent & Surface Water Disposal

GeoGuide LR10 - Coastal Landslides

- GeoGuide LR11 - Record Keeping

The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to help you understand why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local council approval (if required) to remove, reduce, or minimise the risk they represent. The GeoGuides have been prepared by the Australian Geomechanics Society, a specialist technical society within Engineers Australia, the national peak body for all engineering disciplines in Australia, whose members are professional geotechnical engineers and engineering geologists with a particular interest in ground engineering. The GeoGuides have been funded under the Australian governments' National Disaster Mitigation Program.

14 Attachment H – Notes About This Report

Information

Important Information About Your Report

Subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Martens to help you interpret and understand the limitations of your report. Not all of course, are necessarily relevant to all reports, but are included as general reference.

Engineering Reports - Limitations

Geotechnical reports are based on information gained from limited sub-surface site testing and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely.

Engineering Reports – Project Specific Criteria

Engineering reports are prepared by qualified personnel and are based on the 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 (eg. a three storey building), the information and interpretation may not be relative if the design proposal is changed (eg. 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 that 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 they are not consulted.

Engineering Reports – Recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption often cannot be substantiated until project implementation has commenced and 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 this investigation 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. Attention is drawn to the document 'Guidelines for the Provision of Geotechnical Information in Tender Documents', published by the Institution of Engineers, Australia.

The Company 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 the site assessment and the report 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) 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 the 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 as it relates 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 for 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 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, the Company will be pleased to assist with investigation or 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.

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, the Company 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 report, retain Martens to work with other project professionals who are 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 - Geoenvironmental 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 the Company's proposal for works.

Specific sampling guidelines and specialist equipment, techniques and personnel are typically used to perform geoenvironmental 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

Geotechnical 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 recognize 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 is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site. Martens is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction.

Soil Data

Explanation of Terms (1 of 3)

Definitions

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

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726 and the S.A.A Site Investigation Code. In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

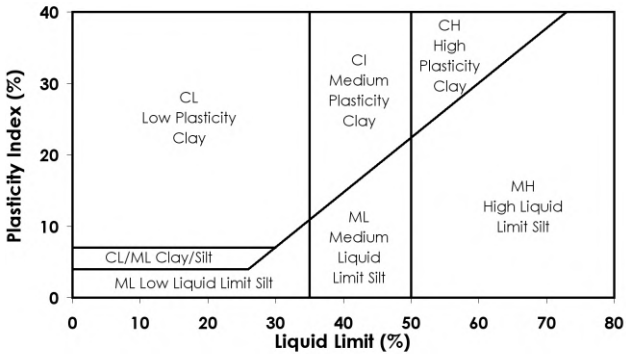
Particle Size

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. sandy clay). Unless otherwise stated, particle size is described in accordance with the following table.

Division	Subdivision	Size
BOULDERS		>200 mm
COBBLES		60 to 200 mm
GRAVEL	Coarse	20 to 60 mm
	Medium	6 to 20 mm
	Fine	2 to 6 mm
SAND	Coarse	0.6 to 2.0 mm
	Medium	0.2 to 0.6 mm
	Fine	0.075 to 0.2 mm
SILT		0.002 to 0.075 mm
CLAY		< 0.002 mm

Plasticity Properties

Plasticity properties can be assessed either in the field by tactile properties, or by laboratory procedures.



Moisture Condition

Dry	Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.
Moist	Soil feels cool and damp and is darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	As for moist but with free water forming on hands when handled.

Consistency of Cohesive Soils

Cohesive soils refer to predominantly clay materials.

Term	C_u (kPa)	Apprx SPT "N"	Field Guide
Very Soft	<12	2	A finger can be pushed well into the soil with little effort. Sample extrudes between fingers when squeezed in fist.
Soft	12 - 25	2 to 4	A finger can be pushed into the soil to about 25mm depth. Easily moulded in fingers.
Firm	25 - 50	4 – 8	The soil can be indented about 5mm with the thumb, but not penetrated. Can be moulded by strong pressure in the figures.
Stiff	50 - 100	8 – 15	The surface of the soil can be indented with the thumb, but not penetrated. Cannot be moulded by fingers.
Very Stiff	100 - 200	15 – 30	The surface of the soil can be marked, but not indented with thumb pressure. Difficult to cut with a knife. Thumbnail can readily indent.
Hard	> 200	> 30	The surface of the soil can be marked only with the thumbnail. Brittle. Tends to break into fragments.
Friable	-	-	Crumbles or powders when scraped by thumbnail

Density of Granular Soils

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration test (SPT) or Dutch cone penetrometer tests (CPT) as below:

Relative Density	%	SPT 'N' Value (blows/300mm)	CPT Cone Value (q_c Mpa)
Very loose	< 15	< 5	< 2
Loose	15 – 35	5 - 10	2 -5
Medium dense	35 – 65	10 - 30	5 - 15
Dense	65- 85	30 - 50	15 - 25
Very dense	> 85	> 50	> 25

Minor Components

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

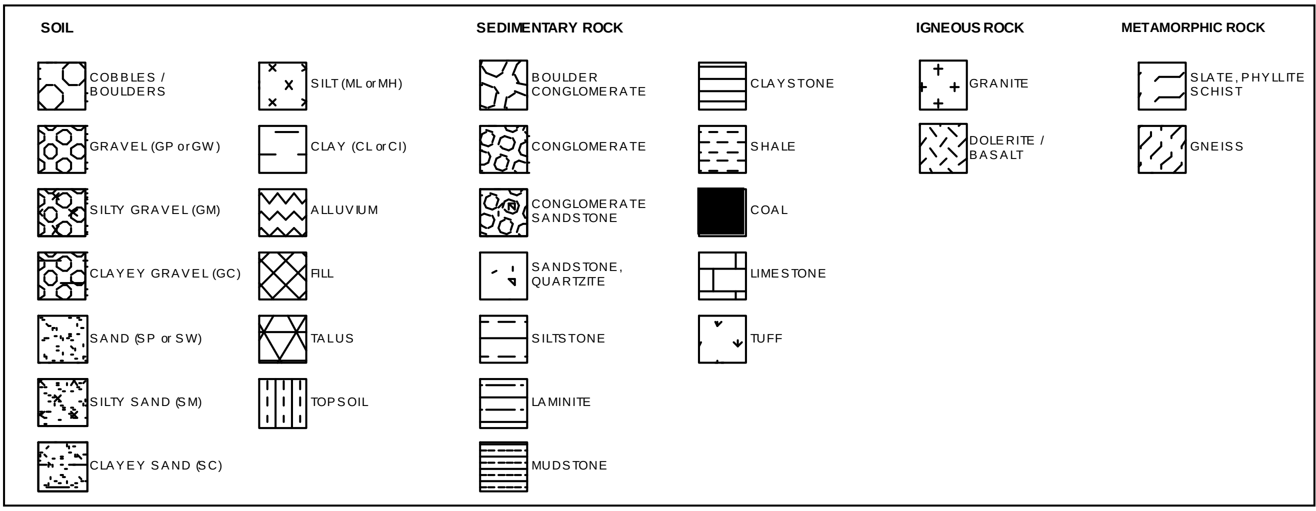
Term	Assessment	Proportion of Minor component In:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: < 5 % Fine grained soils: < 15 %
With some	Presence easily detectable by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 – 12 % Fine grained soils: 15 – 30 %

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 Soil and Rock



Unified Soil Classification Scheme (USCS)

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 63 mm and basing fractions on estimated mass)					USCS	Primary Name
COARSE GRAINED SOILS More than 50 % of material less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.0 mm.	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Gravel
				Predominantly one size or a range of sizes with more intermediate sizes missing	GP	Gravel
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	GM	Silty Gravel
				Plastic fines (for identification procedures see CL below)	GC	Clayey Gravel
		SANDS More than half of coarse fraction is smaller than 2.0 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of intermediate sizes missing.	SW	Sand
				Predominantly one size or a range of sizes with some intermediate sizes missing	SP	Sand
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	SM	Silty Sand
				Plastic fines (for identification procedures see CL below)	SC	Clayey Sand

		IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 MM					
		DRY STRENGTH (Crushing Characteristics)	**DILATANCY**	**TOUGHNESS**	**DESCRIPTION**	**USCS**	**Primary Name**
FINE GRAINED SOILS More than 50 % of material less than 63 mm is smaller than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	None to Low	Quick to Slow	None	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	ML	Silt
		Medium to High	None	Medium	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	CL	Clay
		Low to Medium	Slow to Very Slow	Low	Organic slits and organic silty clays of low plasticity	OL	Organic Silt
		Low to Medium	Slow to Very Slow	Low to Medium	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	MH	Silt
		High	None	High	Inorganic clays of high plasticity, fat clays	CH	Clay
		Medium to High	None	Low to Medium	Organic clays of medium to high plasticity	OH	Organic Silt
HIGHLY ORGANIC SOILS		Readily identified by colour, odour, spongy feel and frequently by fibrous texture				Pt	Peat

Low Plasticity – Liquid Limit W_L < 35 % Medium Plasticity – Liquid limit W_L 35 to 60 % High Plasticity - Liquid limit W_L > 60 %

Rock Data

Explanation of Terms (1 of 2)

martens
consulting engineers

Definitions

Descriptive terms used for Rock by Martens are given below and include rock substance, rock defects and rock mass.

Rock Substance	In geotechnical engineering terms, rock substance is any naturally occurring aggregate of minerals and organic matter which cannot, unless extremely weathered, be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Rock substance is effectively homogeneous and may be isotropic or anisotropic.
Rock Defect	Discontinuity or break in the continuity of a substance or substances.
Rock Mass	Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

Degree of Weathering

Rock weathering is defined as the degree in rock structure and grain property decline and can be readily determined in the field.

Term	Symbol	Definition
Residual Soil	Rs	Soil derived from the weathering of rock. The mass structure and substance fabric are no longer evident. There is a large change in volume but the soil has not been significantly transported.
Extremely weathered	EW	Rock substance affected by weathering to the extent that the rock exhibits soil properties - ie. it can be remoulded and can be classified according to the Unified Classification System, but the texture of the original rock is still evident.
Highly weathered	HW	Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength may be increased or decrease compared to the fresh rock usually as a result of iron leaching or deposition. The colour and strength of the original rock substance is no longer recognisable.
Moderately weathered	MW	Rock substance affected by weathering to the extent that staining extends throughout the whole of the rock substance and the original colour of the fresh rock is no longer recognisable.
Slightly weathered	SW	Rock substance affected by weathering to the extent that partial staining or discolouration of the rock substance usually by limonite has taken place. The colour and texture of the fresh rock is recognisable.
Fresh	Fr	Rock substance unaffected by weathering

Rock Strength

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance is the direction normal to the bedding. The test procedure is described by the International Society of Rock Mechanics.

Term	Is (50) MPa	Field Guide	Symbol
Extremely low	≤0.03	Easily remoulded by hand to a material with soil properties.	EL
Very low	>0.03 ≤0.1	May be crumbled in the hand. Sandstone is 'sugary' and friable.	VL
Low	>0.1 ≤0.3	A piece of core 150mm long x 50mm diameter may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.	L
Medium	>0.3 ≤1.0	A piece of core 150mm long x 50mm diameter can be broken by hand with considerable difficulty. Readily scored with a knife.	M
High	>1 ≤3	A piece of core 150mm long x 50mm diameter cannot be broken by unaided hands, can be slightly scratched or scored with a knife.	H
Very high	>3 ≤10	A piece of core 150mm long x 50mm diameter may be broken readily with hand held hammer. Cannot be scratched with pen knife.	VH
Extremely high	>10	A piece of core 150mm long x 50mm diameter is difficult to break with hand held hammer. Rings when struck with a hammer.	EH

Rock Data

Explanation of Terms (2 of 2)

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 excludes fractures such as drilling breaks.

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

Rock Core Recovery

TCR = Total Core Recovery

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

SCR = Solid Core Recovery

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

RQD = Rock Quality Designation

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

Rock Strength Tests

▼	Point load strength Index (Is50) - axial test (MPa)
▶	Point load strength Index (Is50) - diametrall test (MPa)
●	Unconfined compressive strength (UCS) (MPa)

Defect Type Abbreviations and Descriptions

Defect Type (with inclination given)		**Coating or Filling**		**Roughness**	
BP	Bedding plane parting	Cn	Clean	Po	Polished
X	Foliation	Sn	Stain	Ro	Rough
L	Cleavage	Ct	Coating	Sl	Slickensided
JT	Joint	Fe	Iron Oxide	Sm	Smooth
F	Fracture			Vr	Very rough
SZ	Sheared zone (Fault)	**Planarity**		**Inclination**	
CS	Crushed seam	Cu	Curved	The inclination of defects are measured from perpendicular to the core axis.	
DS	Decomposed seam	Ir	Irregular		
IS	Infilled seam	Pl	Planar		
V	Vein	St	Stepped		
		Un	Undulating		

Test Methods

Explanation of Terms (1 of 2)

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 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 sample tube into the 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 Methods

The following is a brief summary of drilling 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 75-100mm in diameter into the ground. The depth of penetration 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 if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (eg. Pengo) - the hole is advanced by a rotating plate or short spiral auger, generally 300mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5m) 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 - the hole is advanced by pushing a 100mm 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, usually 50mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

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 Methods of Testing Soils for Engineering Purposes - Test F3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

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

as 4, 6, 7
N = 13
(ii) In a case 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 50mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borelogs in brackets.

CONE PENETROMETER TESTING AND INTERPRETATION

Cone penetrometer testing (sometimes referred to as Dutch Cone - abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in AS 1289 - Test F4.1.

In the test, a 35mm 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 separate 130mm long sleeve, immediately behind the cone. Tranducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm 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:
Cone resistance - the actual end bearing force divided by the cross sectional area of the cone - expressed in MPA.
Sleeve friction - the frictional force of the sleeve divided by the surface area - expressed in kPa.
Friction ratio - the ratio of sleeve friction to cone resistance - expressed in percent.

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

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

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

q_c (Mpa) = (0.4 to 0.6) N (blows/300mm)

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

q_c = (12 to 18) c_u

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

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

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 - a 16 mm diameter flat ended rod is driven with a 9kg hammer, dropping 600mm (AS 1289 - Test F 3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
Cone penetrometer (sometimes known as the Scala Penetrometer) - a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS 1289 - Test F 3.2). The test was developed initially for pavement sub-grade investigations, with correlations of the test results with California bearing ratio published by various Road Authorities.

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.

TEST PIT / BORE LOGS

The test pit / bore log(s) presented herein are an engineering and/or geological interpretation of the sub-surface conditions and their reliability will depend to some extent on frequency of sampling and the method 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 boreholes 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 boreholes, the frequency of sampling and the possibility of other than ‘straight line’ variation between the boreholes.

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.