pitt&sherry

Landslip Hazard Assessment

Appendix E

Landslip Hazard Report for Proposed Rezoning and Planning Permit Application at Invermay

Introduction

This landslip hazard report demonstrates that a proposal to rezone land at Invermay will not result in an unacceptable risk of landslip hazards. The is rezoning part of a proposed amendment to the Local Provisions Schedule (LPS) of the Tasmanian Planning Scheme (TPS) – Launceston (the planning scheme). This report also demonstrates that the proposed Storage use for the associated planning permit application complies with the requirements of the planning scheme's Landslip Hazard Code.

The requirement for this landslip hazard assessment is derived from the Northern Regional Land Use Strategy 2010-2035 (NRLUS), as amended on 23 June 2021 and the planning scheme. Under the NRLUS, the land to be rezoned is contiguous with an Urban Growth area. Before such land can be rezoned, Part D.2.1.1 of the NRLUS requires that the land should exclude areas with unacceptable risk of landslip hazards, including predicted impact of climate change. This must be demonstrated by way of an assessment of landslip hazards.

As part of the rezoning proposal a planning permit application for a proposed new light industrial building in the proposed Light Industrial Zone. The proposed land use is Storage, and this proposal must comply with the applicable requirements of the planning scheme's Landslip Hazard Code.

No development is proposed on the land which is to be rezoned to General Residential. The proposed plans attached to the planning report which supports proposal shows an indicative 1½ dwellings on this land as part of future staged residential development. However, these 1 ½ dwellings are only indicative and do not form part of the planning permit application.

Landslip Hazard Assessment for the Proposed Rezoning

The Proposed Rezoning

While full details of the proposed rezoning are provided in the Planning Report that supports the rezoning, Image 1 below demonstrates that the proposal is to:

- rezone the following land from General Residential Zone to Light Industrial Zone:
    - southern portion of 69A Mayne Street, Invermay; and
    - 28, 26, 18, 16 and 14 Montagu Street, Invermay;
- rezone the northern portion of 30 Montagu Street from Light Industrial to General Residential.

Landslip Hazard Report for Proposed Rezoning and Planning Permit Application at Invermay

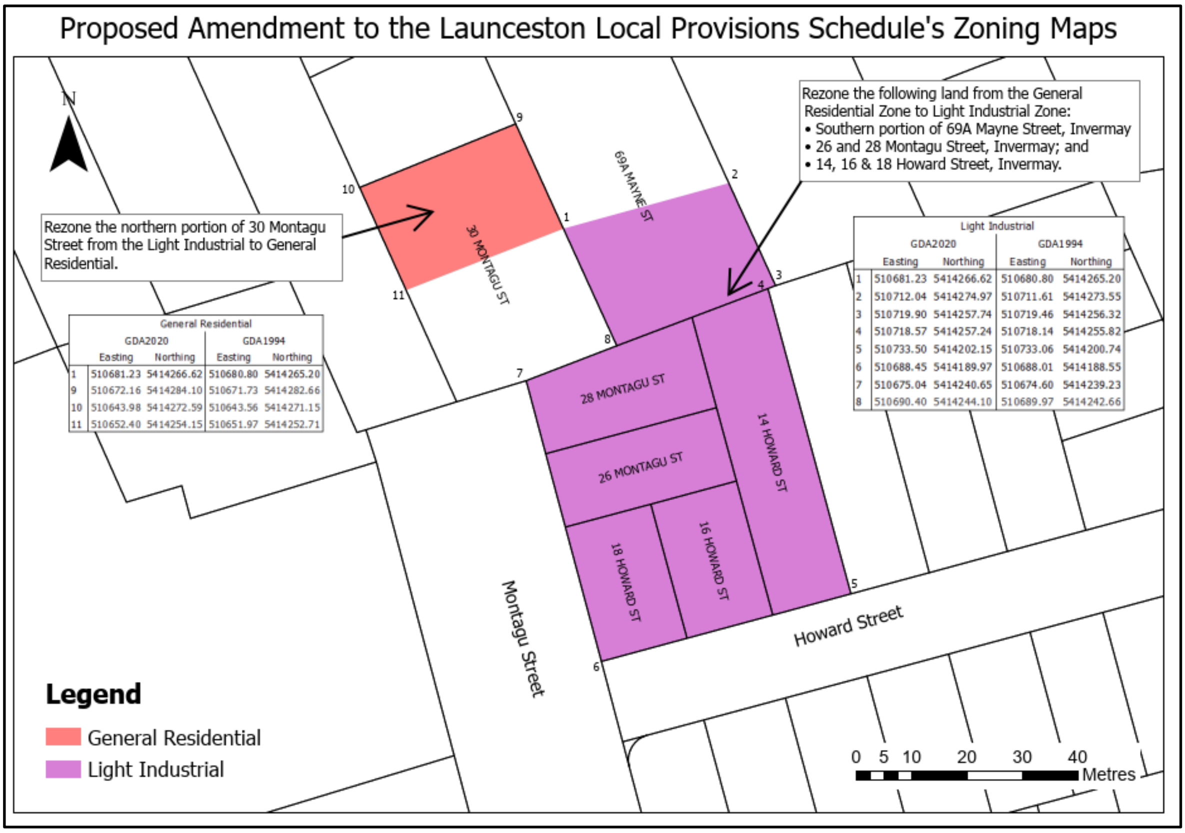

Image 1: Proposed rezoning

The Applicable Landslip Hazard Bands

Image 2 below demonstrates that:

- The northern portion of the land to be rezoned to Light Industrial is partially located in the Low and Medium Landslip Hazard Bands; and
- The portion of land to be rezoned to General Residential is wholly located in the Medium Landslip Hazard Band.

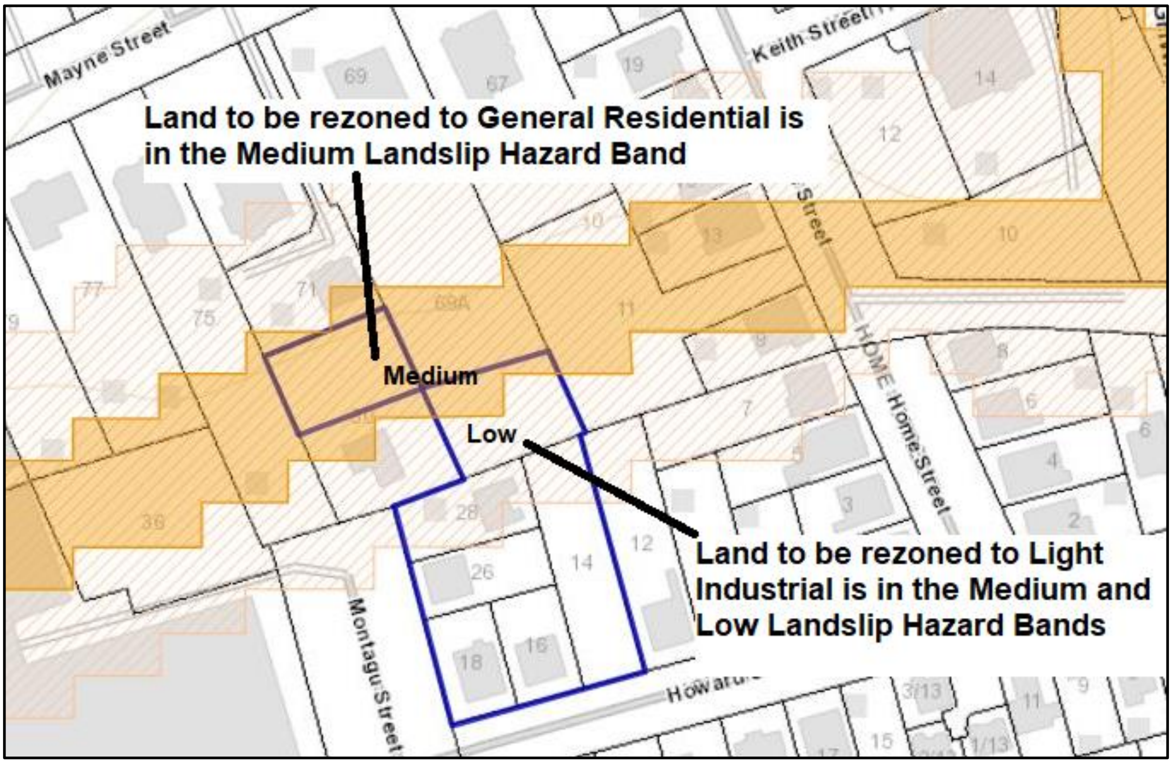

Image 2: Landslip Hazard Bands (source: LISTmap)

Land to be Rezoned from General Residential to Light Industrial

As shown in Image 3 below, the land to be rezoned Light Industrial is generally flat, and begins rising to the north in the low and medium landslip hazard bands to the rear of 14 Howard Street.

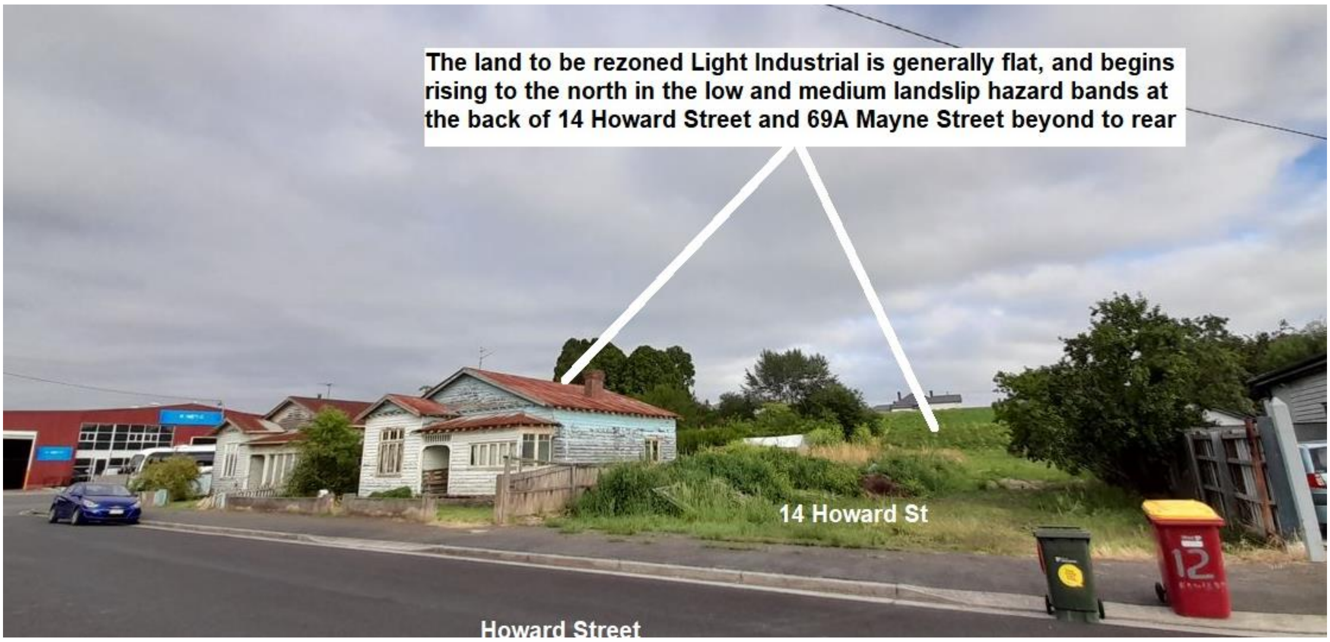

Image 3: Looking north-west onto the rezoning site from Howard Street

The geotechnical report presented in Appendix A of this landslip hazard report has been prepared to assist with building approval of the proposed new light industrial building, which will be partially located in the low and medium landslip hazard bands and the proposed Light Industrial Zone.

The area of interest is underlain by flood plain deposits in the lower sections and river terrace deposits forming the higher areas.

The geotechnical report shows that the flood plain deposits are soft to very soft from approximately one metre below surface; this appears to correspond approximately to the level of water in the Tamar River.

The river terrace deposits that comprise the ridge forming the higher part of the area is mapped as loose to poorly consolidated or cemented, upward fining, cobbles, pebbles, sand, silt and clay. This is an extremely broad definition, but being more elevated this material is very likely to be much dryer than the flood plain materials.

Assessment of site imagery and hillshade data indicates no evidence of landslide activity in the investigation area, nor is there any clear evidence of instability in these units in the surrounding areas. The classification of medium or low hazard band in this area is due to a combination of mapped material type and slope angle, rather than any site specific details.

The predicted impact of climate change that is relevant to slope stability is increased rainfall and rainfall intensity, and associated increase of flooding likelihood and depth in the area. This does have the potential to increase the likelihood of landslide to a small degree, particularly in the event of a very severe flood causing erosion to the base of the ridge to the north of the area of interest, or during the period where floodwaters are receding. In both these scenarios people are likely to be absent from the lower lying areas that are to be rezoned to light industrial, reducing the risk posed by landslides.

A final point is that rezoning to light industrial will typically reduce the number of people in the area classified as low to medium hazard band; even given the predicted impacts of climate change the overall risk to life from landslide is assessed to be reduced, and the land in the low and medium landslip hazard bands and in the proposed Light Industrial Zone will have no unacceptable risk of landslip hazards.

Land to be Rezoned from Light Industrial to General Residential

As shown in Image 4 below, the land to be rezoned General Residential, and wholly within the medium landslip hazard band, is located behind the dwelling on 30 Montagu Street, and rises to the north.

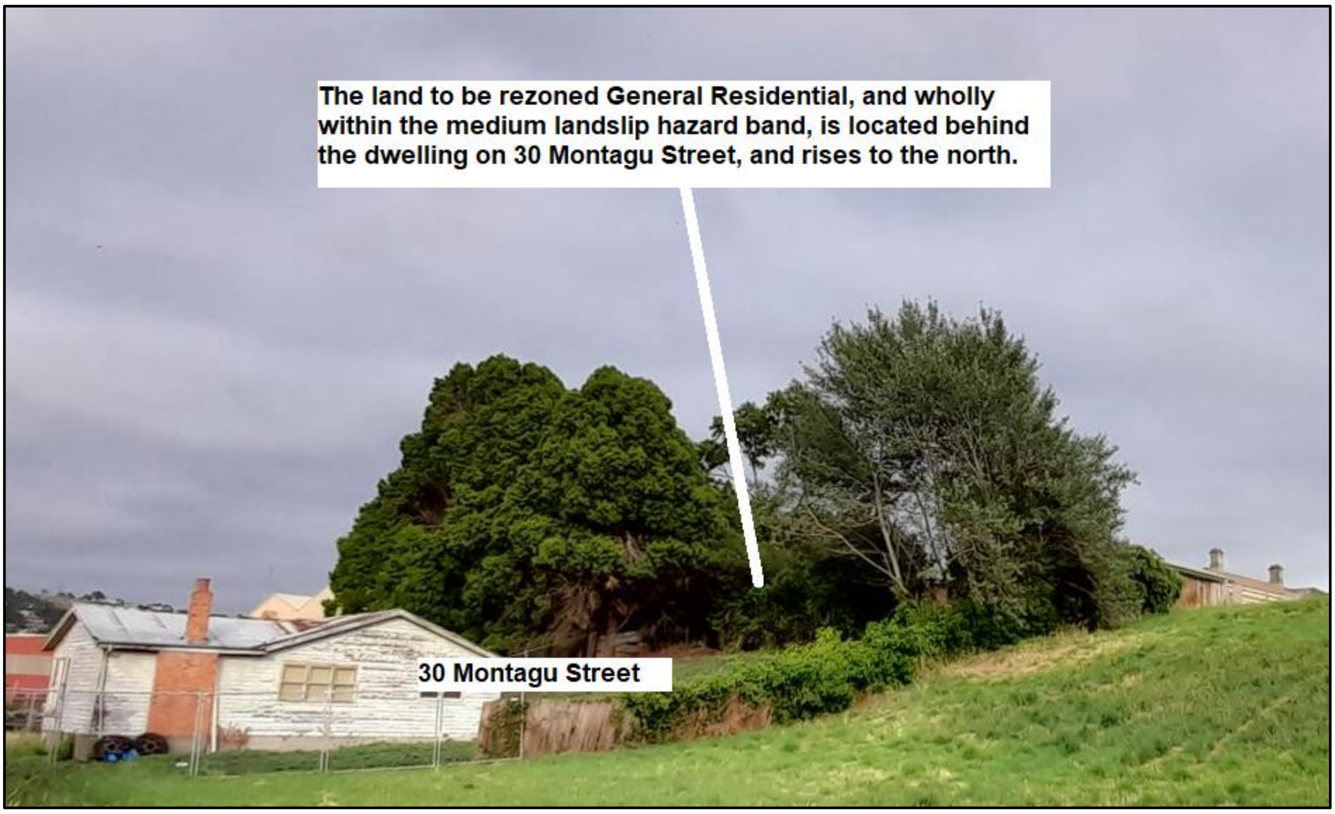

Image 4: Looking towards 30 Montagu Street from the rear of 14 Howard Street

The river terrace deposits that comprise this slope is mapped as loose to poorly consolidated or cemented, upward fining, cobbles, pebbles, sand, silt and clay. This is an extremely broad definition, but being more elevated this material is very likely to be much dryer than the flood plain materials.

Assessment of site imagery and hillshade data indicates no evidence of landslide activity in the investigation area, nor is there any clear evidence of instability in this material in the surrounding areas. The classification of medium hazard band in this area is due to a combination of mapped material type and slope angle, rather than any site specific details.

The predicted impact of climate change that is relevant to slope stability is increased rainfall and rainfall intensity, and associated increase of flooding likelihood and depth in the area. This does have the potential to increase the likelihood of landslide to a small degree, particularly in the event of a very severe flood causing erosion to the base of the ridge to the north of the area of interest, or during the period where floodwaters are receding.

As the block of land currently stands, taking into consideration the predicted impact of climate change, the land in the proposed general residential zone will not have unacceptable risk of landslip. This will remain the case if a building is constructed on the block and occupied, so long as suitable design and construction techniques are applied during development. In order for future developments in the proposed residential area to comply with the landslip code the primary considerations that will need to be made include:

- The site will need to be appropriately investigated prior to any works occurring on site and the results of such investigations will need to be taken into account during design works.
- Any cutting and filling will need to be properly engineered and retained as appropriate.
- All design for works on the site should consider the predicted impact of climate change, and where slope stability may be impacted by the works the effect of elevated groundwater should be considered during assessments, particularly at the point immediately following a flooding event when floodwaters have receded from the base of the slope but water levels in the slope are still high.
- Stormwater and runoff will need to be well controlled from this site given the slopes and properties downslope, and particularly considering the expected increases in rainfall intensity with climate change.
- The block currently has several large trees growing on it. If these trees are to be removed prior to development then it should be taken into account that groundwater will rise as a result of trees being removed, and some swelling of the ground may occur.

Taking into consideration the predicted impact of climate change, the findings in the geotechnical report, and the points made above, the proposed General Residential Zone will have no unacceptable risk of landslip hazards if appropriately developed.

The Proposed Storage Use Complies the Landslip Hazard Code

With regard to the planning permit application for the proposed Storage use and development and the planning scheme's Landslip Hazard Code, the use must comply with Clause C15.5.1 (use within a landslip area). However, the development is exempt under Clause C15.4.1 (d) because it requires authorisation under the *Building Act 2016*.

The proposed Storage use will occur in the proposed light industrial building's development area (building, access and parking areas), as shown in Image 5 below. Only the northern portion of the development area is in the low and medium landslip hazard bands.

Image 5: Development area for the proposed Storage use

The table below demonstrates that the proposed storage use complies with Clause C15.5.1.

C15.5.1 Use within a landslip hazard area	
Objective: That uses, including critical, hazardous or vulnerable use, can achieve and maintain a tolerable risk from exposure to a landslip for the nature and intended duration of the use.	
Acceptable Solution	**Performance Criteria**
A1 No Acceptable Solution.	P1.1 A use, including a critical use, hazardous use, or vulnerable use, within a landslip hazard area achieve and maintain a tolerable risk from exposure to landslip, having regard to: (a) the type, form and duration of the use; and (b) a landslip hazard report that demonstrates that: i. any increase in the level of risk from landslip does not require any specific hazard reduction or protection measure; or ii. the use can achieve and maintain a tolerable risk for the intended life of the use.

	P1.2 If landslip reduction or protection measures are required on land beyond the boundary of the site, the consent in writing of the owner of that land must be provided for that land to be managed in accordance with the landslip reduction or protection measures.

Assessment

This assessment draws on the information presented in the Geotechnical report at Appendix A.

The proposed storage use complies with P1.1 the following reasons:

(a) The proposed use is for Storage, which will enable a range of light industrial-type businesses to operate from the five tenancies in the proposed building. The duration of use is permanent.

(b) The proposed use of the site will not increase the level of risk from landslip; conversely, it will reduce the risk by reducing both the impact and likelihood of landslide events. The proposed use of the site as storage rather than residential will reduce the average number of people present in the area that could be affected by landslide, particularly given the intended use of the area at the bottom of the slope as a pavement. The intended construction of an engineered retaining wall at the base of the slope on the northern boundary of the area will reduce the likelihood of any landslip if designed and constructed appropriately.

As there is no need for landslip reduction or protection measures beyond the boundaries of the site, P1.2 does not apply to the proposal.

Conclusion

The above landslip hazard assessment demonstrates that:

- the land which is to be rezoned will not result in an unacceptable risk of landslip hazards, which is consistent with the requirements of Part D.2.1.1 of the NRLUS; and
- the proposed Storage use for the Light Industrial development complies with Clause C15.5.1 of the Landslip Hazard Code.

Name: Andrew Tyson	**Senior Engineering Geologist: 17 years consulting experience in Tasmania; focusing on slope instability for the last ten years. Accredited to the Roads and Maritime Services (NSW) Slope Risk Analysis (V4) methodology.**	**Date: 25/1/2023**

Appendix A – Geotech Investigation for Proposed Commercial Development Montagu Street, Invermay

GEOTECHNICAL INVESTIGATION

PROPOSED COMMERCIAL DEVELOPMENT

MONTAGU STREET, INVERMAY

Prepared for:	**Cataract Designs**
Date:	4 November 2022
Document Reference:	TG22172/1 - 01report

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Appendices

Version	Date	Prepared by	Reviewed by	Distribution
Original	4 November 2022	Eileen Ooi	Dr Wayne Griffioen	Electronic

1 INTRODUCTION

Tasman Geotechnics was commissioned by Cataract Designs to carry out a geotechnical investigation at the Montagu Street, Invermay (title references 62242/8 and 175261/2).

The proposed commercial development includes a commercial tenancy and car parking facilities. A mass bloc wall is proposed along the northern edge of the development. The wall is to be about 1.8m high.

The aim of the investigation is to:

- Assess subsurface conditions at the site,
- Provide recommendations of footing design based on AS2870, and
- Provide recommendations for allowable bearing capacity.

2 FIELD INVESTIGATION

The field investigation was conducted on two separate days by two Geotechnicians from Tasman Geotechnics.

- On 19 September 2022,
  - Probing of three boreholes using a 4WD mounted Eziprobe rig:
    - BH1 and BH2 at 14 Howard Street, to the depth of 9.9m,
    - BH3 at 69a Mayne Street, to the depth of 5.1m.
- On 23 September 2022,
  - Carrying out PANDA probe to a depth of 8.7m below ground level adjacent to BH2,
- Collecting of soil samples for laboratory testing.

The engineering borehole logs are presented in Appendix A and the locations of the boreholes are shown on Figure 1. The tip resistance from the PANDA probe is shown in Appendix B.

Fourteen soil samples were selected for laboratory testing. The laboratory results are discussed in Section 3.4.

3 RESULTS

3.1 Geology

The Mineral Resources Tasmania Digital Geological Atlas, 1:25,000 Series, Launceston sheet, shows majority of the site to be mapped as Quaternary aged sediment, described as *"Estuarine deposits of clayey silt, silt, sand and subordinate gravel, supra-estuarine swamp and laterally derived alluvial, deposits, unmapped man-made deposits including silt dredgings; in environments inferred to lie above frequent tidal influence"* while the northern majority of 69a Mayne Street is mapped on Cretaceous – Quaternary aged sediments, described as *"TQa unit <5m to ~10m above sea level, loose to poorly-consolidated, clast composition poorly known, dominantly siliceous clasts in some areas, of probable Pleistocene age".*

3.2 Site Conditions

The circa 3330m^2 site (total area of both lots) is approximately 565m northeast of the Tamar River. The site is adjacent to a well-established residential area. The site is vegetated with grass. There are piles of fill located at the southern end of the block, along Howard Street.

The site is relatively flat, with a steep slope of approximate 16° along the centre of 69a Mayne Street. The site appears to be well drained.

3.3 Subsurface Conditions

The boreholes encountered similar subsurface conditions across the site, mainly consisting of high liquid limit clayey/sandy SILT, to termination depth.

BH1 and BH2 terminated at the target depth of 9.9m below ground level whereas BH3 terminated at the target depth of 5.1m below ground level.

The consistency of the soil is classified to be Soft to Firm. The soil became Stiff from 8m below ground level in BH2. The PANDA tip resistance shows a steady increase from about 5m below ground level, near BH2 which is consistent with a normally consolidated silt. The silt is firm from 1m to 5.5m below ground level, gradually becoming stiff (Cu > 100kPa) after that.

No groundwater was observed in the boreholes. However, the soil was observed to be wet from at least 1.1m below ground level.

Soils on the slope to the north of the site are characterized as (very) stiff clays with interbedded (silty) sand or clayey silt.

3.4 Laboratory Testing

Laboratory testing was carried out by Tasman Geotechnics on a number of soil samples. Although not a NATA accredited laboratory, the tests were carried out in accordance with relevant Australian Standards. Two soil samples were tested for Atterberg Limits while six soil samples were tested for particle size distribution. A total of eight soil samples from BH1 and BH2 were also tested for soil moisture content. The Atterberg Limits and particle size grading results are summarised in the following table.

Table 1. Laboratory Results

Sample	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Gravel %	Sand %	Fines %
BH1, 0.7 – 1.0m	82	47	35	17	0	2	98
BH1, 4.0 – 4.2m	–	–	–	–	0	1	99
BH1, 8.5 – 8.6m	–	–	–	–	0	38	62
BH2, 0.7 – 1.0m	–	–	–	–	0	1	99
BH3, 0.7 – 1.0m	83	39	44	18	0	0	100
BH3, 1.3 – 1.5m	–	–	–	–	0	50	50

Thus, the near surface soils in BH1 and BH3 are classified as high liquid limit (clayey/sandy) SILT (symbol MH).

The insitu moisture content ranges from 205% to 33%. Figure 2 shows how the moisture content reduces with depth below ground level. The samples with moisture content over 40% correspond to the soft/firm silt. From 8m below ground level, the moisture content is approximately equal to the plasticity limit of the surface soils. The lower soil moisture content corresponds to higher shear strength.

4 DISCUSSION & RECOMMENDATIONS

4.1 General

The soils at the site are characterised as low strength and compressible. The compressible soils are underlain by stiff silt/clay (encountered from 8m below ground level in BH2, but at least 5m below ground level at BH3).

Based on the geometry, we expect that the proposed retaining wall is to be founded on the (very) stiff clays encountered on the slope to the north.

The investigation depth on the lower elevations was limited to 9.9m below ground level. Therefore, it is not known at what depth “bedrock” is likely to occur. Anecdotal evidence suggests “bedrock” is at least 15m below ground level.

Thus, the bearing capacity of isolated strip footings are limited by the strength of the underlying natural soils.

An alternative is to adopt bored pier or piled foundation for the proposed structure. The bored piers or piles would be founded in stiff silt encountered at least 8m below ground level at BH2. Bored piles may be difficult to construct if groundwater inflows occur.

Recommendations for bearing capacity and estimated settlements for various footing options are provided below.

Recommendations for pile design are provided below. However, to confirm the capacity of the pile, we recommend installing a test pile. The most suitable location for a test pile is the southern end of the property, near Howard Street.

4.2 Site Classification

Strictly speaking, a site classification in accordance with AS2870-2011 is only applicable for buildings or structures similar to houses. The footing designs provided are referenced to AS2870 despite the size of the proposed development is bigger than that of a typical house.

Due to the low bearing capacity and compressible soils, the site classification is:

Class P

Nevertheless, after allowing due consideration of the site geology, drainage and soil conditions, the natural site has been classified as follows:

CLASS H2 (AS2870 – 2011)

Characteristic surface movement, y_s < 65 mm

This site classification assumes that the current natural drainage and infiltration conditions at the site will not be markedly affected by the proposed site development work.

4.3 High Level Footings

The bearing capacity for pad footings founded on <u>clayey silt</u> is a function of the undrained shear strength, C_u, (eg Tomlinson, 2001):

$$q_u \quad = C_u N_C s_c + \gamma \frac{B}{2} N_\gamma s_\gamma + \gamma \quad N_q s_q$$

Where s_c, $s_{\uparrow}$ and s_q are shape factors,

N_c, $N_{\uparrow}$ and N_q are bearing capacity factors,

B is footing width (m),

D is footing embedment, and

$\uparrow$ is the soil bulk density.

Footing size, B, and embedment, D, have very little effect on the bearing capacity of a footing in clay.

For the clayey silt encountered at this site, the undrained shear strength at 1m below ground level was calculated from the PANDA test to be about 20kPa. The ultimate bearing capacity, q_{ult}, for a strip footing, was calculated using the Caquot-Kerisel bearing capacity factors as 110kPa. Assuming a geotechnical reduction factor of 0.4, the allowable bearing capacity is 45kPa.

4.4 Settlement

High-level footings will undergo immediate and consolidation settlements.

The immediate settlement was calculated assuming the stiffness of the compressible silt, E, is 3.0MPa. With a load of 45kPa, the immediate settlement of a 0.5m wide strip footing is approximately 10mm. The consolidation settlement is about 350mm.

Similarly, the consolidation settlement of a raft loaded at 10kPa is estimated to be 450mm.

If these settlements are unacceptable, we recommend adopting a pile foundation.

4.5 Pile Foundation

4.5.1 End Bearing Capacity

The ultimate end bearing capacity of piles driven into a cohesive soil, q_b, can be calculated as (Tomlinson, 2001):

$$q_b = 9C_u$$

Where: C_u is the undrained shear strength.

At this site, the silt/clay from at least 8m is Stiff, and the undrained shear strength is about 100kPa. Therefore, the ultimate bearing capacity of a pile driven at least 8m below ground level is 900kPa.

It should be noted that such piles are to be driven for a capacity, not to “refusal”. If piles are driven to refusal, they likely need to be at least 15m long.

4.5.2 Pile Friction Capacity

For driven piles in cohesive soil, the skin friction, q_s, in compression can be calculated as (Tomlinson, 2001):

$$q_s = F\Im_p C_u$$

Where: F is a length factor, dependent on the pile slenderness ratio,

$\Im_p$ is the adhesion factor, dependent on the shear strength of the soil, and

C_u is the average undrained shear strength of the soil along the pile.

The undrained shear strength, C_u, of the silt varies with depth. The consistency of silt from 1m to 8m is determined to be Firm while it is Stiff after 8m below ground level.

The table below shows the values of pile frictions which vary with the consistency of silt.

Table 2. Pile Friction

Depth	Undrained Shear Strength, C_u (kPa)	Pile Friction (kPa)
1m to 8m	25	12
8m onwards	100	50

4.6 Retaining wall

The bearing capacity of the natural clays encountered on the slope to the north is at least 200kPa.

We recommend a soil friction angle of 30° be adopted for calculation of the earth pressures on the wall from the natural soil.

The retaining wall should be designed to withstand active earth pressures from the backfill, as well as sloping backfill and surcharge loading on the slope.

TASMAN geotechnics

Important information about your report

These notes are provided to help you understand the limitations of your report.

Project Scope

Your report has been developed on the basis of your unique project specific requirements as understood by Tasman Geotechnics at the time, and applies only to the site investigated. Tasman Geotechnics should be consulted if there are subsequent changes to the proposed project, to assess how the changes impact on the report's recommendations.

Subsurface Conditions

Subsurface conditions are created by natural processes and the activity of man.

A site assessment identifies subsurface conditions at discrete locations. Actual conditions at other locations may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time.

Nothing can be done to change the conditions that exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, the services of Tasman Geotechnics should be retained throughout the project, to identify variable conditions, conduct additional investigation or tests if required and recommend solutions to problems encountered on site.

Advice and Recommendations

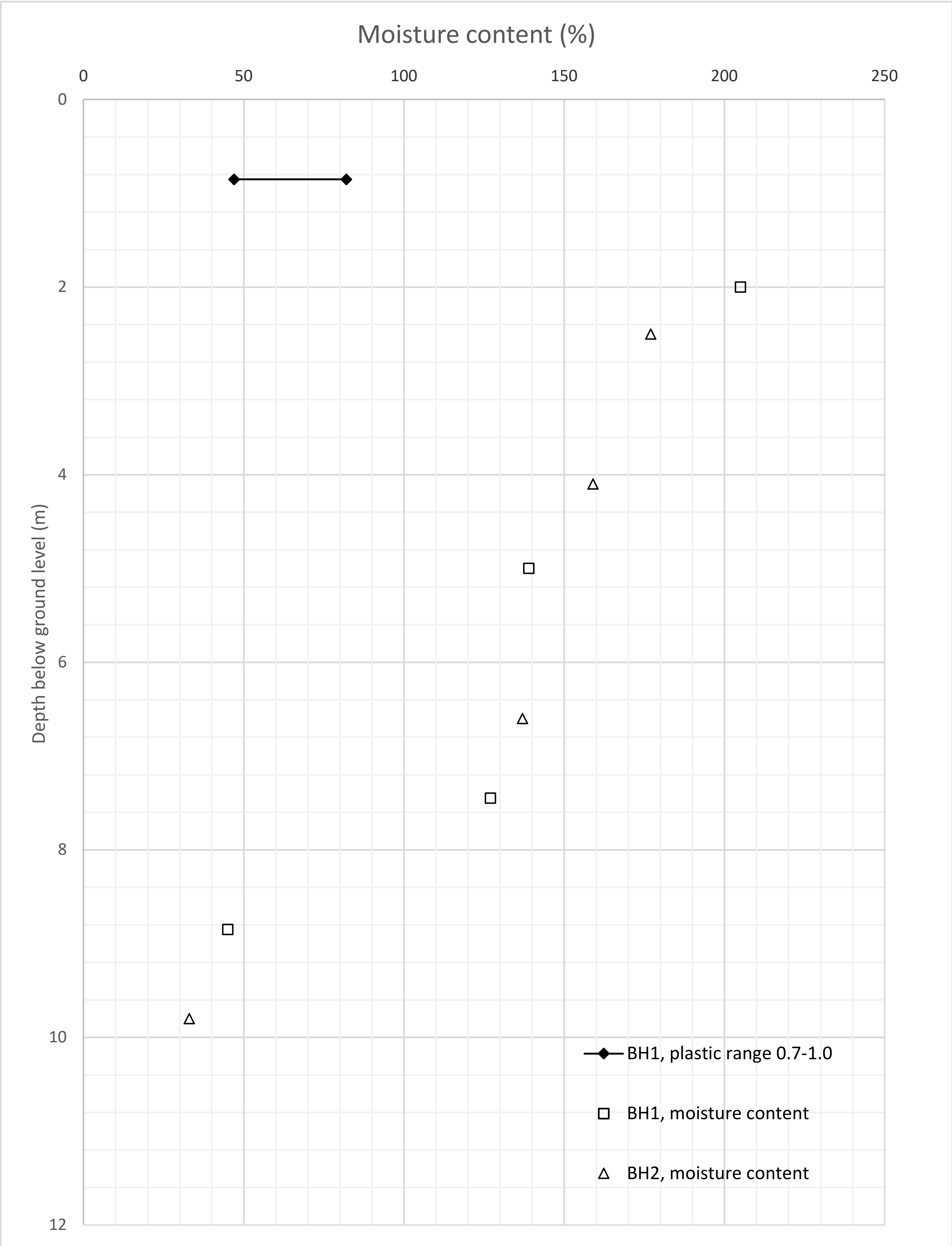
Your report contains advice or recommendations which are based on observations, measurements, calculations and professional interpretation, all of which have a level of uncertainty attached.

The recommendations are based on the assumption that subsurface conditions encountered at the discrete locations are indicative of an area. This can not be substantiated until implementation of the project has commenced. Tasman Geotechnics is familiar with the background information and should be consulted to assess whether or not the report's recommendations are valid, or whether changes should be considered.

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.

Drawn:	EO	TASMAN geotechnics	client: Cataract Designs
Approved:	WG		project: Geotechnical Investigation Montagu Street, Invermay
Date:	17/10/2022		title: Site Layout and Borehole Locations
Scale:	1:1000		project no: TG22172/1 – 01report / figure no: FIGURE 1
Size:	A4		

Note: basemap airphoto and cadastral boundaries are from TheLIST Web Services (http://services.thelist.tas.gov.au) and were retrieved on the date shown above. Current site conditions may differ from this plan. TheLIST data is copyright of TheLIST, and use is subject to terms found at: http://listdata.thelist.tas.gov.au/public/LISTWebServicesTermsConditions.pdf



Drawn	EO	TASMAN geotechnics	**Client**	Cataract Designs
Approved	WG		**Project**	Geotechnical Investigation Montagu Street, Invermay
Date	18/10/2022			
Scale	NTS		**Title**	Moisture Content Profile
Original size	A4		**Project No:** TG22172/1 - 01report	**Figure:** Figure 2

Appendix A

Engineering Borehole Logs

SOIL DESCRIPTION EXPLANATION SHEET

TASMAN geotechnics

Soils are described in accordance with the Unified Soil Classification System (UCS), as shown in the following table.

FIELD IDENTIFICATION

					DRY STRENGTH	DILATANCY	TOUGHNESS
COARSE GRAINED SOILS	more than 65% of material less than 63mm is larger than 0.075mm	GRAVELS	GW	Well graded gravels and gravel-sand mixtures, little or no fines			
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines			
		GRAVELLY SOILS	GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines			
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines			
		SANDS	SW	Well graded sands and gravelly sands, little or no fines			
			SP	Poorly graded sands and gravelly sands, little or no fines			
		SANDY SOILS	SM	Silty sand, sand-silt mixtures, non-plastic fines			
			SC	Clayey sands, sand-clay mixtures, plastic fines			
FINE GRAINED SOILS	more than 35% of material less than 63mm is less than 0.075mm	SILT & CLAY, liquid limit less than 50%	ML	Inorganic silts, very fine sands or clayey fine sands	None to low	Quick to slow	None
			CL	Inorganic clays or low to medium plasticity, gravelly clays, sandy clays and silty clays	Medium to high	None to very slow	Medium
			OL	Organic silts and organic silty clays of low plasticity	Low to medium	Slow	Low
		SILT & CLAY, liquid limit greater than 50%	MH	Inorganic silts, micaceous or diatomaceous fine sands or silts	Low to medium	Slow to none	Low to medium
			CH	Inorganic clays of high plasticity, fat clays	High	None	High
			OH	Organic clays of medium to high plasticity	Medium to high	None to very slow	Low to medium
PEAT			Pt	Peat muck and other highly organic soils			

Particle size descriptive terms

Name	Subdivision	Size
Boulders		>200mm
Cobbles		63mm to 200mm
Gravel	coarse	20mm to 63mm
	medium	6mm to 20mm
	fine	2.36mm to 6mm
Sand	coarse	600µm to 2.36mm
	medium	200µm to 600µm
	fine	75µm to 200µm

Minor Components

Term	Proportions	Observed properties
'Trace of'	Coarse grained: <5% Fine grained: <15%	Presence just detectable by feel or eye. Soil properties little or no different to general properties of primary component.
'With some'	Coarse grained: 5-12% Fine grained: 15-30%	Presence easily detected by feel or eye. Soil properties little different to general properties of primary component.

Density of granular soils

Term	Density index
Very loose	<15%
Loose	15 to 35%
Medium Dense	35 to 65%
Dense	65 to 85%
Very dense	>85%

Consistency of cohesive soils

Term		Undrained strength	Approximate Pocket Penetrometer Reading	Field guide
Very soft	VS	<12kPa	25kPa	A finger can be pushed well into soil with little effort
Soft	S	12 - 25kPa	25-50kPa	Easily penetrated several cm by fist
Firm	F	25 - 50kPa	50-100kPa	Soil can be indented about 5mm by thumb
Stiff	St	50-100kPa	100-200kPa	Surface can be indented but not penetrated by thumb
Very stiff	VSt	100-200kPa	200-400kPa	Surface can be marked but not indented by thumb
Hard	H	>200kPa	>400kPa	Indented with difficulty by thumb nail
Friable	Fb	-	-	Crumbles or powders when scraped by thumb nail

Moisture Condition

Dry (D)	Looks and feels dry. Cohesive soils are hard, friable or powdery. Granular soils run freely through fingers.
Moist (M)	Soil feels cool, darkened in colour. Cohesive soils are usually weakened by moisture presence, granular soils tend to cohere.
Wet (W)	As for moist soils, but free water forms on hands when sample is handled

Cohesive soils can also be described relative to their plastic limit, ie: <Wp, =Wp, >Wp. The plastic limit is defined as the minimum water content at which the soil can be rolled into a thread 3mm thick.

ENGINEERING BOREHOLE LOG

Client: Cataract Designs
Project: Geotechnical Investigation
Location: Montagu Street, Invermay

Drill model: Eziprobe
Hole diameter: 58mm
Slope: **Bearing:**

TASMAN geotechnics

Borehole no: BH1
Sheet no. 1 of 1
Job no. TG22172/1
Date: 19/09/2022
Logged By: MS
GDA94 Easting: 510722
GDA94 Northing: 5414220
Elevation:

Method	Penetration 1 2 3 4	Notes Samples Tests	Water	Depth	Graphic Log	Classification	Material Description	Moisture Condition	Consistency density, index	Pocket Penetro-meter kPa (100 200 300 400 500)	Structure, additional observations
Push tube				0	X	MH	Clayey SILT, high liquid limit, dark brown, trace fine to medium grained sand, with medium to coarse grained gravel.	D/M	F/Fb		Possibly fill.
				0.5			Becoming dark brown/orange, no gravel.			+	
		D		1						+	
				1.2			Becoming grey.	W	S/VS		
		D		2							
		D		4							
		D		5							
		D		7.5							
				8			Becoming sandy SILT, fine to medium grained sand, no gravel.	M	F		
		D		8.5							
		D		8.8							
				9.9			Terminated at 9.9m, still going.				

method

DT	Diatube
AS	Auger screwing
AH	Auger drilling
RR	Roller/tricone
CB	Claw/blade bit
NMLC	NMLC core
NQ, HQ	Wireline core

water

17/03/18 water level on date shown
water inflow
partial drill fluid loss
complete drill fluid loss

Notes, Samples, Tests

U50	Undisturbed sample 50mm diameter
D	Disturbed sample
N	Standard Penetration Test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	Vane Shear (kPa)
P	Pressure Meter
Bs	Bulk Sample
R	Refusal
E	Environmental Sample
PID	PID Measurement
WS	Water Sample

Moisture Condition
Dry (D)
Moist (M)
Wet (W)

Cohesive soils can also be described relative to their plastic limit, ie:
<Wp
=Wp
>Wp

Consistency

VS	Very soft
S	Soft
F	Firm
St	Stiff
VSt	Very stiff
H	Hard
Fb	Friable
VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense

ENGINEERING BOREHOLE LOG

Client: Cataract Designs
Project: Geotechnical Investigation
Location: Montagu Street, Invermay

Drill model: Eziprobe
Hole diameter: 58mm
Slope: **Bearing:**

TASMAN geotechnics

Borehole no: BH2
Sheet no. 1 of 1
Job no. TG22172/1
Date: 19/09/2022
Logged By: MS
GDA94 Easting: 510714
GDA94 Northing: 5414240
Elevation:

Method	Penetration 1 2 3 4	Notes Samples Tests	Water	Depth	Graphic Log	Classification	Material Description	Moisture Condition	Consistency density, index	Pocket Penetro-meter kPa (100 200 300 400 500)	Structure, additional observations
Push tube				0		MH	Clayey SILT, high liquid limit, dark brown, trace fine to medium grained sand and gravel.	D/M	F/Fb		
		D		0.5			Becoming brown/grey/orange, no gravel.			+	Organics present.
		D		1.2			Becoming grey, trace fine to medium grained sand.	W	S/VS		
				4.5				M	F		
				8				D/M	F/St	+	
				10			Terminated at 9.9m, still going.				

method	
DT	Diatube
AS	Auger screwing
AH	Auger drilling
RR	Roller/tricone
CB	Claw/blade bit
NMLC	NMLC core
NQ, HQ	Wireline core

water
- 17/03/18 water level on date shown
- water inflow
- partial drill fluid loss
- complete drill fluid loss

Notes, Samples, Tests	
U50	Undisturbed sample 50mm diameter
D	Disturbed sample
N	Standard Penetration Test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	Vane Shear (kPa)
P	Pressure Meter
Bs	Bulk Sample
R	Refusal
E	Environmental Sample
PID	PID Measurement
WS	Water Sample

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Dry (D)
Moist (M)
Wet (W)
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VL	Very Loose
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MD	Medium Dense
D	Dense
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ENGINEERING BOREHOLE LOG

Client: Cataract Designs
Project: Geotechnical Investigation
Location: Montagu Street, Invermay

Drill model: Eziprobe
Hole diameter: 58mm
Slope: **Bearing:**

TASMAN geotechnics

Borehole no: BH3
Sheet no. 1 of 1
Job no. TG22172/1
Date: 19/09/2022
Logged By: MS
GDA94 Easting: 510703
GDA94 Northing: 5414260
Elevation:

Method	Penetration 1 2 3 4	Notes Samples Tests	Water	Depth	Graphic Log	Classification	Material Description	Moisture Condition	Consistency density, index	Pocket Penetro-meter kPa 100 200 300 400 500	Structure, additional observations
Push tube				0		MH	Clayey SILT, high liquid limit, dark brown, trace fine to medium grained sand.	D/M	Fb		
				0.5			Becoming brown/grey/orange.				
		D									
				1							
		D					Becoming sandy SILT, fine to medium grained sand.	W	S/VS		
				1.5							
				2							
				2.5							
				3			Trace fine to medium grained sand.	M	F		Some organics present, very smelly anaerobic rotten eggs.
				3.5							
				4							
				4.5			Sandy SILT, fine to medium grained, trace fine to medium grained subrounded quartz gravel.		S		Drilled through log at 4.6-4.9m, red/yellow in colour.
				5							
				5.5			Terminated at 5.1m, still going.				
				6							
				6.5							
				7							
				7.5							
				8							
				8.5							
				9							
				9.5							
				10							
				10.5							

method
DT Diatube
AS Auger screwing
AH Auger drilling
RR Roller/tricone
CB Claw/blade bit
NMLC NMLC core
NQ, HQ Wireline core

water
17/03/18 water level on date shown
water inflow
partial drill fluid loss
complete drill fluid loss

Notes, Samples, Tests
U50 Undisturbed sample 50mm diameter
D Disturbed sample
N Standard Penetration Test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
V Vane Shear (kPa)
P Pressure Meter
Bs Bulk Sample
R Refusal
E Environmental Sample
PID PID Measurement
WS Water Sample

Moisture Condition
Dry (D)
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Cohesive soils can also be described relative to their plastic limit, ie:
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Consistency
VS Very soft
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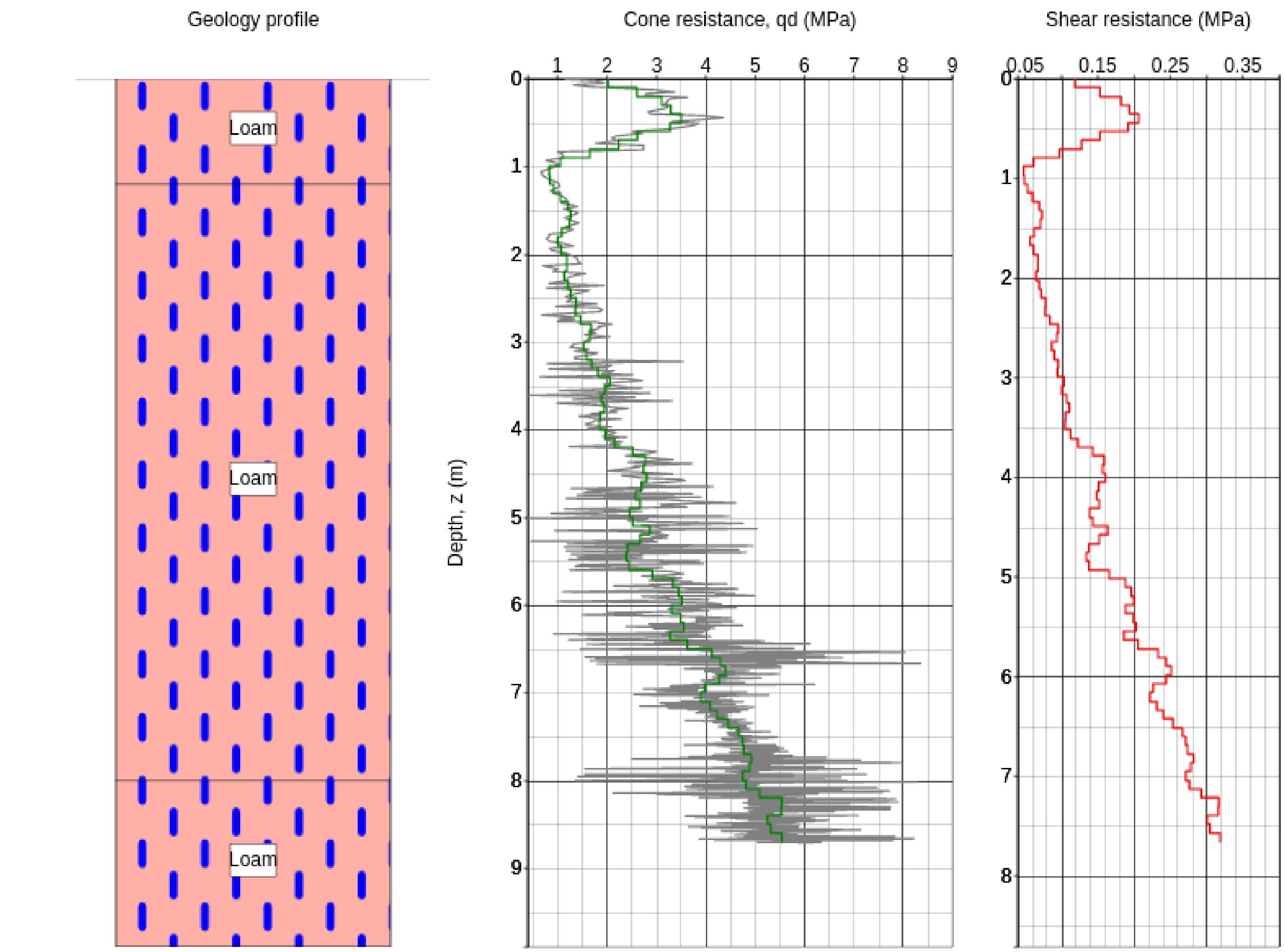
St Stiff
VSt Very stiff
H Hard
Fb Friable
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

Appendix B

PANDA Tip Resistance

Sounding :	Sounding1	Company :		Lat. :	
Site :	Montagu St	User :	wg	Long. :	
Date :	03/10/2022	Supervisor :		Alt. :	
Comments :					

PANDA®



* These estimates are indicative and cannot be considered as a reference

Summary of estimated results from the sounding Sounding1 for the parameter Shear resistance							
Strate ID	Depth (m)	Soil family	Average	Variance	Input	Expression	Source - Author(s)
1	1.2	Loam	0.133	0.055	Qd (Pa)	y = qd - σv0 ÷ Nkt	Escande, 1994; [...]
2	8.0	Loam	0.135	0.07	Qd (Pa)	y = qd - σv0 ÷ Nkt	Escande, 1994; [...]
3	9.9	Loam	0.279	0.029	Qd (Pa)	y = qd - σv0 ÷ Nkt	Escande, 1994; [...]