GEOTECHNICAL INVESTIGATION FOR CLIFF STABILITY

Jetty Road Foreshore

72 – 100 McDermott Road and
102 – 170 McDermott Road, Curlewis

Report Date

14 April 2023

Prepared for:

Stantec

Reference No:

V220433Report04.1

Revision	Description	Author		Quality Check	
0	Internal Draft	HA	10/02/2023	DBS	
1	Final	HA	14/04/2023	DBS	14/04/2023

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Abbreviations

1H:2V	Slope Ratio of 1 Horizontal to 2 Vertical
AADT	Average Annual Daily Traffic
AHD	Australian Height Datum
AGPT02-17	Austroads Guide to Pavement Technology Part 2 Pavement Structural Design
AGPT05-19	Austroads Guide to Pavement Technology Part 5 Pavement Evaluation
Base Course	Upper granular layer of the pavement
Capping Layer	Lower structural layer of pavement comprising Type A fill designed to minimise moisture movement between the upper pavement and underlying subgrade
CBR	California Bearing Ratio (%)
Construction Layer	Lower structural layer of pavement comprising Type A fill used to facilitate trafficking of the subgrade during construction
CTCR	Cement Treated Crushed Rock
DCP	Dynamic Cone Penetrometer
DF	Direction Factor
DoT	Department of Transport (formerly VicRoads)
DTL	Daily Traffic Loading
EC	Electrical Conductivity
EDCM	Victorian Planning Authority Engineering Design and Construction Manual for Design in Subdivision Growth Areas
ESA	Equivalent Standard Axles
FCR	Fine Crushed Rock
FoS	Factor of Safety
GPS	Global Positioning System
HVAG	Heavy Vehicle Axle Group
HV	Heavy Vehicles (Usually a %)
IDM	Local Government Infrastructure Design Association Infrastructure Design Manual
LF	Loading Factor
MGA	Map Grid of Australia
NATA	National Association of Testing Authorities
NDCR	Non-Descript Crushed Rock
Nominal Diameter	The sieve size in mm in which nearly all of the crushed rock sample will pass through
OMC	Optimum Moisture Content
PMB	Polymer Modified Binder
Prime	Application of a primer to a prepared base

RC500.22	DoT Code of Practice RC500.22 Selection and Design of Pavement and Surfacings
SAMI	Strain Alleviating Membrane Interlayer
Sub-Base Course	Lower granular layer of the pavement
Subgrade	Foundation material for the pavement
TDS	Total Dissolved Solids (salinity of water)
TLD	Traffic Load Distribution
Type A Fill	An engineered fill material defined in accordance with DoT Standard Specification 204
VPD	Vehicles Per Day

1.0 INTRODUCTION

Stantec was engaged to conduct an intrusive geotechnical investigation following on from the geotechnical desktop study (including a site visit) of the foreshore area of the proposed Jetty Road Stage 2 Residential Subdivision located at the north end of 72 – 100 McDermott Road and 102 – 170 McDermott Road, Curlewis. Approval to proceed was provided upon receipt of the signed contract on 1 August 2022.

In accordance with the proposal V220148_Proposal1.1 dated 16 March 2022, the intrusive geotechnical investigation, along with the previous geotechnical desktop study and site inspection, has been undertaken as part of a larger scope of works that will provide an understanding of any rehabilitation and/or prevention works that may be required to protect the foreshore and minimize the impacts of coastal processes on the proposed residential subdivision development, including zoning of areas within the subdivision where construction may be restricted.

2.0 LIMITATIONS OF THE REPORT

The report is limited to the slope stability assessment and landslide risk assessment of the foreshore area, based on information obtained from the desktop study, the site walkover and the intrusive geotechnical investigation of the Jetty Road Stage 2 foreshore site.

This report does not include geotechnical investigation for the subdivision itself.

The limitations of the geotechnical reports are contained in Appendix F.

3.0 SITE DESCRIPTION

The site comprises of two land properties, 102 – 170 McDermott Road (North Property) and 72 – 100 McDermott Road (South Property) that form part of the Jetty Road Stage 2 development which is approximately 2.5 km northwest of Drysdale Village.

At the time of the site investigation, the site area south of the fence line was generally an open paddock, with vegetation and mature trees along the western boundary. North of the fence line the study area was highly vegetated by grass, shrubs and weeds, with numerous small to medium size trees.

Generally, the gradient within the foreshore area was gradual to steep from the fence line to the head scarp, steep to very steep across the head scarp and then becoming gradual within the zone of depletion and approaching the coastal shore. The foreshore area slopes towards the center of the site into a gully and the rest of the site has a slope downwards from the south to the north.

An aerial view of the site is shown in Figure 3-1and a view of the site is shown in Figure 3-2 to Figure 3-5.

Figure 3-1: Aerial Photo of Site Location

Figure 3-2 - Site View looking Northeast from BH02

Figure 3-3 - Site View looking Northwest from BH05

Figure 3-4 – View of Foreshore Area from top of cliff.

Figure 3-5 – View of the cliff from the foreshore

4.0 SITE GEOLOGY

The geological map of the area (Portarlington Sheet 1:63,360) indicates that the site is underlain by residual sandy clays of Brighton Group / Baxter Sandstone Origin (Moorabool Formation). An excerpt from the geological map is shown in Figure 4-1.

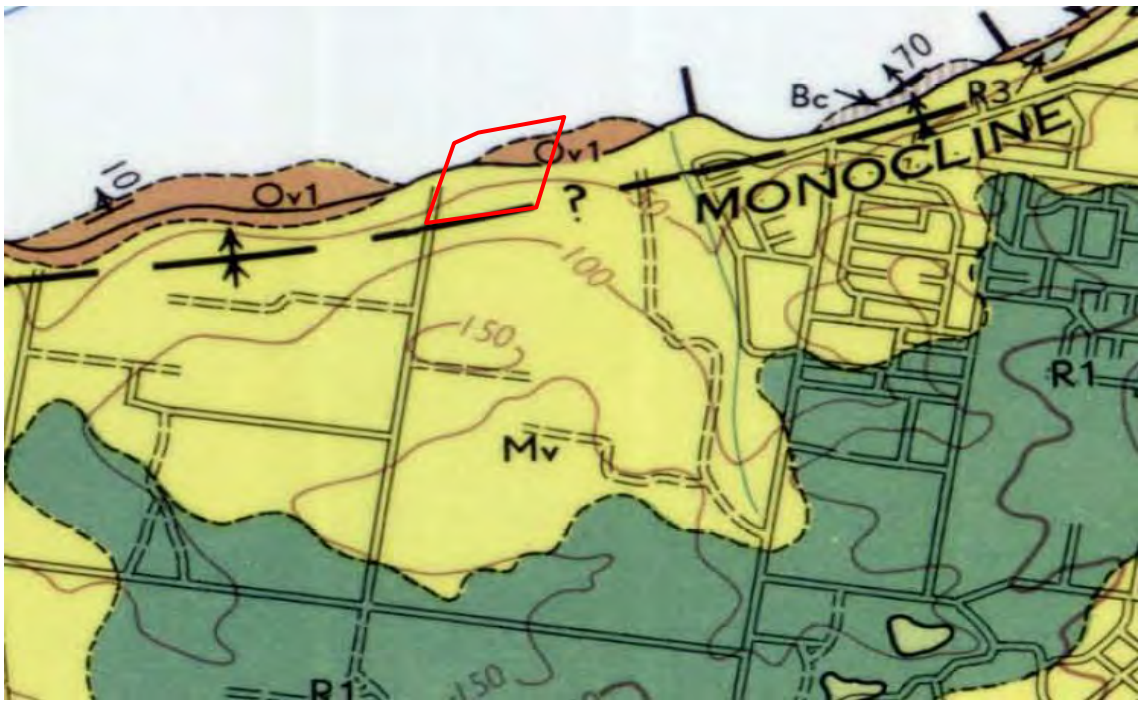


Figure 4-1: Excerpt from Melbourne (1:63,360) Geological Map

The fieldwork observations were consistent with the published geology indications with the sandy clays/clays of the Brighton Group intersected at the surface at all the of the boreholes. The Brighton Group soils were identified to overlie soils of the Fyansford formation. The Older Volcanics basalts were not encountered on site or observed in the foreshore. Outcrops on the foreshore were actually remnant boulders of the cemented soils from the Brighton Group.

5.0 FIELDWORK

The fieldwork was conducted between 26th September 2022 and 21st of October 2022. The fieldwork was conducted by an experienced geotechnical engineer, who conducted the toolbox meetings, supervised the subcontractors, logged the ground encountered and conducted the sampling and in-situ testing.

5.1 SAFE WORK PROCEDURES

Prior to mobilisation and commencement of the fieldwork, a BYDA (Before You Dig Australia, formally known as Dial Before You Dig or DBYD) underground service request was completed to identify utility assets near the proposed borehole locations. A Safe Work Method Statement was prepared to help identify and mitigate potential hazards. The work was conducted in accordance with the documented Safe Work Procedures as set out in Stantec's company Safety Management Plan. Prior to commencement of work each day a Toolbox meeting was held with all site personnel.

5.2 TECHNICAL FIELDWORK

A total number of 6 no. boreholes were drilled using a subcontractor track mounted rig. The boreholes were drilled to depth of between 24.5 m and 32.4 m below ground level. The test locations were located on site using ArcGIS Collector. Disturbed samples were taken from each of the boreholes for laboratory testing. Pocket penetrometer tests were conducted to determine the in–situ shear strength of the cohesive soil.

- 4 Boreholes (BH01, BH03, BH04, BH06) were drilled approximately 3 m to 5 m back from the crest of the cliff and were distributed at approximately 100 m intervals along the cliff.
- 2 Boreholes (BH02 and BH05) were drilled approximately 30 m back from the crest of the cliff, these were located to line up with one of the cliffside boreholes (BH01 and BH04 respectively).

The boreholes were located across the site as shown on the Site Plan, shown in Appendix A. The records of the boreholes accompanied by a Unified Classification System (UCS) are appended in Appendix B.

6.0 LABORATORY TESTING

The testing was undertaken in Stantec's NATA accredited soils laboratory and consisted of:

- Moisture Content Determinations
- Atterberg Limits Tests
- Particle Size Distribution Tests (with Hydrometer)
- Emerson Class Number Tests

The test records are appended in Appendix C**.**

7.0 RESULTS OF THE INVESTIGATION

7.1 SUB-SURFACE STRATIGRAPHICAL PROFILE

The borehole records have been used to develop a generalised stratigraphical profile for the sub-surface conditions on the site. The sub-surface profile and a description of the soil units are shown in Table 7-1.

Table 7-1: Generalised Stratigraphic Profile

Borehole No.	Unit Depth Range (m)		
	Unit 1	Unit 2	Unit 3
BH01	0.00 – 0.80	0.80 – 20.80	20.80 – 22.95
BH02	0.00 – 0.70	0.70 – 32.40	–
BH03	0.00 – 2.70	2.70 – 22.50	22.50 – 24.45
BH04	0.00 – 0.90	0.90 – 25.50	25.50 – 27.45
BH05	0.00 – 0.80	0.80 – 30.50	30.50 – 35.45
BH06	0.00 – 0.80	0.80 – 26.50	26.50 – 28.95

Unit 1 – TOPSOIL/FILL: Clayey SILT (ML), CLAY (CH) / Sandy CLAY (CH) low to medium plasticity

Unit 2 – CLAY (CH) / Sandy CLAY (CH) / Clayey/Silty SAND (SC/SM) / Gravelly SAND (SW-SC) Interbedded layers of clays and medium to coarse sands (Moorabool Formation)

Unit 3 – Sandy Silty CLAY (CH) / Silty CLAY (CH) / Silty SAND (SM) / Silty Clayey SAND (SC-SM), Interbedded layers of clays and fine sands (Fyansford Formation)

7.2 GROUNDWATER

A review of the Visualising Victoria Groundwater (VVG) website indicates the typical groundwater level at this location is expected to be between 5m and 20m at the foreshore area (area of investigation) of the site.

Groundwater was encountered in BH03 but in the other boreholes its was potentially masked by drilling fluids.

Temporary piezometers were installed in four of the boreholes (BH01, BH02, BH04, and BH05). The ground water levels within these boreholes were observed on 21 October 2022 and again on 07 December 2022 to observe the normalised groundwater level. A summary of groundwater readings encountered after the investigation is presented in Table 7-2 below.

Table 7-2: Depth to Groundwater Level

Borehole No.	Elevation (AHD)	Borehole Drill Depth (m)	Depth of Water Encountered During Drilling (AHD)	Groundwater Level (AHD) 21/10/2022	Groundwater Level (AHD) 07/12/02/022
BH01	19.999	22.95	12.0	16.5 (obstruction)	16.5 (obstruction)
BH02	23.100	32.40	14.6	12.4	12.4
BH03	17.406	24.45	11.0	N/A	N/A
BH04	22.316	27.45	13.8	11.5	11.6
BH05	26.278	35.45	15.3	N/A	12.3
BH06	20.458	28.95	14.0	N/A	N/A

7.3 LABORATORY TEST RESULTS

Soil samples were collected from the subsurface profile. The results of the laboratory tests are summarized in Table 7-3. The field moisture contents of the samples taken were between 12.2% and 51.0%. The clays were identified as being between medium to highly expansive with liquid limits in the range of 29% and 77%. The plasticity indices were in the range of 3% and 64%.

Table 7-3: Summary of Laboratory & Field Results

Borehole No.	Depth (m)	Material Description	Field Moisture Content (%)	Emerson Class Number	Liquid Limit (%)	Plasticity Index (%)	Percent Passing 75µm (%)	Percent Passing 425µm (%)
BH01	9.00 – 9.30	Sandy CLAY	15.60	–	–	–	–	–
BH01	21.00	Sandy Silty CLAY	45.40	–	77	57	58	98
BH02	6.00 – 6.40	Clayey Silty SAND	14.30	–	29	7	25	100
BH02	20.00	SAND	26.80	–	–	–	–	–
BH03	3.00	Sandy Silty CLAY with trace gravel	16.50	2	74	52	65	90
BH03	7.00	Sandy CLAY	19.80	–	27	10	35	100
BH03	10.50	Clayey SAND	41.20	2	42	19	28	97
BH03	15.00	Sandy CLAY	43.20	–	54	34	38	99
BH03	18.00	Sandy CLAY with trace gravel	47.30	–	45	22	34	99
BH03	22.50 – 22.90	Silty Clay with sand and gravel	51.00	3	89	64	63	82
BH03	24.00 – 24.50	Silty SAND	31.70	–	31	5	31	100
BH04	24.00 – 24.35	Clayey SAND	30.30	–	–	–	–	–
BH04	25.50	Silty Clayey SAND	31.70	–	32	7	31	100
BH05	3.00	Clayey SAND	12.20	–	–	–	–	–
BH05	30.50	Silty Clayey SAND	28.70	2	28	3	24	100
BH06	18.00 – 18.40	Silty SAND	28.10	–	N/O	N/P	19	100
BH06	27.00 – 27.45	Silty Sandy CLAY	27.10	–	–	–	–	–

N/O denotes a not obtainable result and N/P denotes a non-plastic result

8.0 SEEPAGE-SLOPE STABILITY ANALYSIS

8.1 ANALYSIS METHODOLOGY

A coupled seepage-slope stability analysis was conducted for the existing conditions of two sections of the foreshore within the site. Seepage and slope stability models were developed and analysed using the finite element software SEEP/W and limit equilibrium software SLOPE/W-2021 which are part of the GeoStudio package produced by Geo-Slope International Limited. SLOPE/W analyses non-linear failures using the Morgenstern-Price Method to determine the critical slip surface and minimum Factor of Safety for the slopes. As an initial step, a conventional deterministic slope analysis was conducted to determine the minimum Factor of Safety for the slope and ensure that it was consistent with observed conditions.

A Monte Carlo simulation based probabilistic analysis was then conducted in order to computationally assess the probability of landslides occurring to assist in the risk analysis.

The following is an outline of the adopted methodology for the slope stability analysis:

- Prepare a sub-surface profile based on existing surveying results which represent the existing slope for critical cross sections;
- Develop geotechnical model and determine material parameters for the stratigraphy based on current investigation and historical site-specific data from earlier investigation;
- Run a coupled seepage-slope stability analysis for different seepage scenarios;
- Calibrate the model for deterministic and probabilistic analysis to ensure consistency with the known history of landslides on the site; and
- Extrapolate the probabilistic model to determine zones of different probability for a landslide occurring.

8.2 DESIGN SECTION

Two representative sections were considered for the analysis as depicted in Figure 8-1. Cross Section 1 runs through BH02 and BH01 before continuing down to the shoreline. Cross section 2 runs through BH05 and BH04 before continuing down to the shoreline. Both cross sections were located through areas were landslides have been observed to be occurring.

Cross Section 1 represents a larger scale landslide in a more developed phase of movement while Cross Section 2 represents a smaller scale landslide in an earlier phase of movement.

Figure 8-1: Excerpt from Nearmap (Dec 2022) depicting Extent of the of Current investigation, Approximate Borehole Location and Cross Section Locations

8.3 GEOTECHNICAL MODEL

Geotechnical model has been developed for the cross sections based on the results of this field investigation and subsequent laboratory tests as well as historical data from Engineering Geology of Melbourne (1992), along with other information available online. The geotechnical model includes a defined stratigraphy, material parameters for each of the different layers of the stratigraphy and determination of an initial groundwater profile. This is discussed further in the following sections.

8.3.1 Ground Stratigraphy

The ground stratigraphy for the cross sections was developed based on the results of the borehole records of the historic and current geotechnical investigation. The cross-sections are shown in Figure 8-2 and Figure 8-3.

A brief summary of the units adopted in the model is provided in Table 8-1. When identifying materials within the slip surface it has been conservatively assumed that similar disturbed materials continue off-shore due to historical landslides that have subsequently been eroded.

Table 8-1: Stratigraphy Description

Unit	Description
01	Sandy Clay
01a	Sandy Clay (inside slip surface)
02	Clayey Sand
02a	Clayey Sand (inside slip surface)
03	Fyansford Formation
03a	Fyansford Formation (inside slip surface)

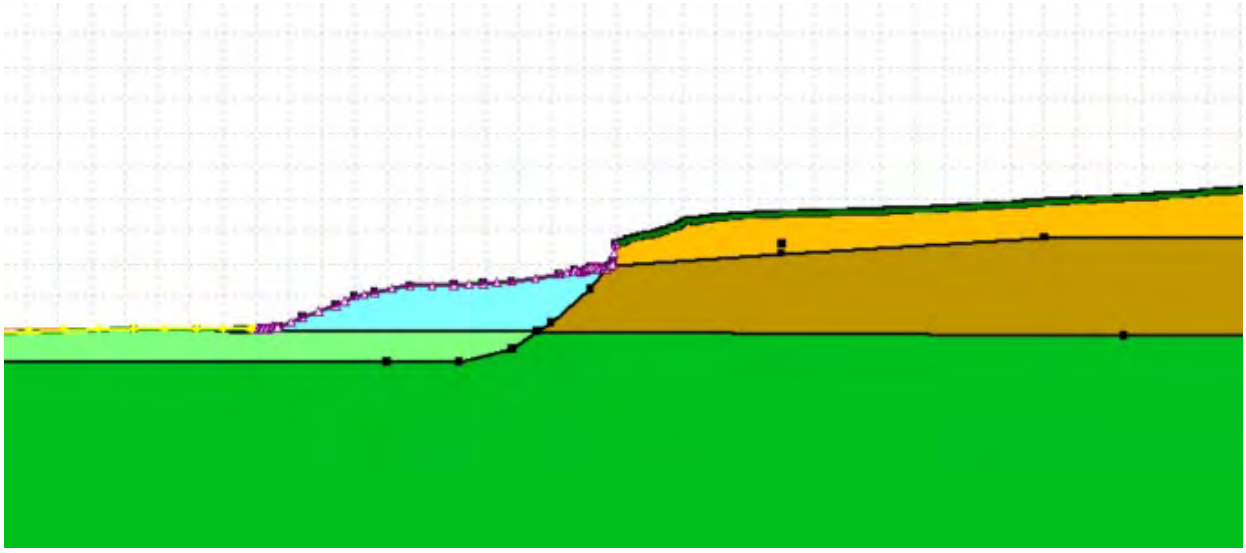


Figure 8-2: Stratigraphy - Cross Section 1

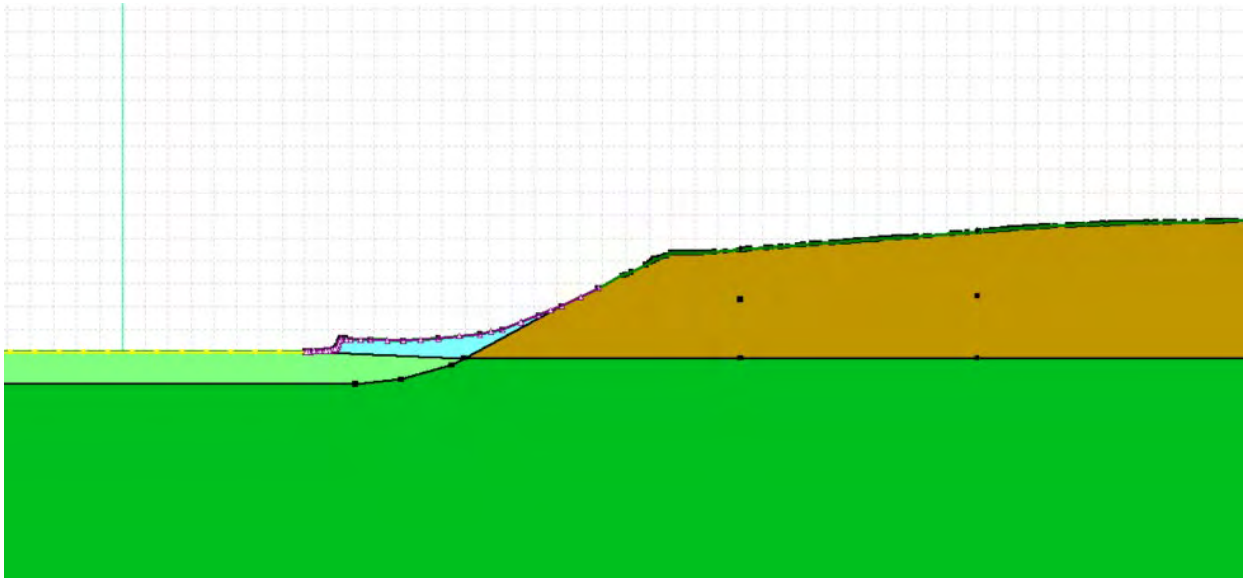


Figure 8-3: Stratigraphy - Cross Section 2

8.3.2 Ground Water Profile

The ground water profile for the cross section was developed based on the results of the borehole records from the current geotechnical investigation. During fieldwork, groundwater was encountered between 11.0 mAHD and 15.3 mAHD, with subsequent groundwater well observations indicating the groundwater level ranging between 11.6 mAHD and 12.4 mAHD.

Based on these observations it is considered that the most likely scenario for the site is that beneath the main Jetty Road site, a permanent groundwater table is present at approximately 12 mAHD, but in the foreshore zone this gradually lowers towards sea level in the vicinity of the beach.

Evidence of subsurface erosion was observed on site, with tunnels identified towards the western end of the foreshore. It is thought that during prolonged rain events, the upper soils become saturated whilst the soils at depth remain at equilibrium condition. The upper soils then drain towards the cliff via the observed gullies and tunnels along the cliff.

The seepage model has been developed based on a long-term groundwater profile based on the observed groundwater levels as described in this section.

8.4 ADOPTED DESIGN PARAMETERS

8.4.1 Geotechnical Parameters

Six boreholes were drilled in relation to this geotechnical investigation. Fields tests and laboratory tests on collected soil and rock samples were conducted. The Engineering Geology of Melbourne (1992) provides soil parameters for the profile encountered in the Jetty Road Foreshore Area.

Due to the amount of information available with regard to the shear strength and other soil parameters for the site it was possible to adopt a statistical method to establish the design parameters for the site. The Bayesian statistics approach of data analysis and parameter estimation based on Baye's Theorem updates current knowledge based on prior knowledge.

The Bayesian approach was applied to establish the values of soil strength parameters to be used in the probabilistic slope stability analysis conducted on two stratigraphic sections as presented in Figure 8-2 and Figure 8-3.

Using the Bayesian approach, a probability distribution is assigned for every parameter by computing its mean (μ) and corresponding standard deviation (σ) value and those are summarized in Table 8-2 and Table 8-3.

Table 8-2: Geotechnical Parameters for Slope Stability Models

Unit Description	Effective Cohesion (kPa)		Effective Friction Angle (°)	
	Mean μ	Std. Dev. σ	Mean μ	Std. Dev. σ
Sandy Clay (1)	9.4	5.9	27.3	1.1
Sandy Clay (1a)	7.5	-	24.3	-
Clayey Sand (2)	9.4	5.9	27.0	0.7
Clayey Sand (2a)	7.5	-	25.0	-
Fyansford Formation (3)	7.0	2.0	19.5	0.4
Fyansford Formation (3a)	3.0	-	10.0	-

Where insufficient data was available to complete a Bayesian analysis of a material's geotechnical parameters, design parameters were assessed based on the laboratory test results obtained, field observations and published correlations such as that presented by *Stark & Choi*.

Material parameters for seepage analysis are presented in Table 8-3.

Table 8-3: Geotechnical Parameters for Seepage Models

Unit Description	Hydraulic Conductivity (Kx) (m/s)	Compressibility (/kPa)
Unit 01 - Sandy Clay	1×10^{-9}	5×10^{-4}
Unit 01a - Sandy Clay	1×10^{-9}	5×10^{-4}
Unit 02 - Clayey Sand	1×10^{-7}	5×10^{-4}
Unit 02a - Clayey Sand	1×10^{-7}	5×10^{-4}
Unit 03 - Fyansford Formation	1×10^{-9}	5×10^{-4}
Unit 03a - Fyansford Formation	1×10^{-9}	5×10^{-4}

8.4.2 Design Groundwater Level

Groundwater profiles were developed for the site based on the results of the current and historic investigation reports as shown in Figure 8-2 and Figure 8-3. For the probabilistic analysis, the groundwater height was assigned standard deviation value of 3.0m to represent seasonal variations in the groundwater profile and other influences due to potential increased run-off from the proposed estate.

8.5 CALIBRATION ANALYSIS

In order to confirm the parameters adopted for the geotechnical model were consistent with the observed site conditions, a calibration analysis was conducted for both sections.

It is important that the model reflects observable conditions for the site. Table 8-4 provides a range of different Factors of Safety to represent different likely conditions. For example, a Factor of Safety of less than 1.0 represents that a failure can occur and therefore the slope should be observed to be unstable.

Between a Factor of Safety of 1.0 and 1.3 the slope will most likely show signs of instability such as tension cracks and creep whereas beyond 1.3 there may be minimal signs of instability. In general, a Factor of Safety of greater than 1.5 is considered stable.

Table 8-4: Factors of Safety for Typical Slope Conditions

Factor of Safety Range	Stability
< 1.0	Unstable
1.0 to 1.1	Marginally unstable and tension cracks are likely
1.1 to 1.3	Quasi-stable with surface creep for shallow failures
1.3 to 1.5	Moderately stable with creep unlikely to occur
> 1.5	Stable

Considering that landslide movement is observed to be occurring it is appropriate for the site to have a Factor of Safety of less than 1.0 under adverse conditions but greater than 1.0 under more favourable conditions. That is, when factors such as a rise in groundwater occur the site becomes unstable and movement occurs but when the groundwater levels fall the movement stabilizes.

The advantage of using both a deterministic and probabilistic approach is that the deterministic model can be used to assess the current condition while the probabilistic model can be used to assess the adverse conditions and also assign a probability of failure. The Monte-Carlo analysis was conducted using 10,000 iterations to assess a significant number of different scenarios within the range of the model.

Table 8-5 provides a summary of the results of the analysis of seepage scenario for both sections.

Table 8-5: Results of Slope Stability Analysis

Analysis Result	Model Type	Seepage Section 1 (Steady state)	Seepage Section 2 (Steady state)
Current Factor of Safety	Deterministic	1.017	1.034
Maximum Probability of Failure	Probabilistic	21.3%	2.4%
Minimum Factor of Safety	Probabilistic	1.05	1.10

Figure 8-4 and Figure 8-5 show the modelled Factor of Safety for the current condition for Seepage Section 1 and Seepage Section 2 respectively.

Figure 8-6 shows the probabilistic distribution of the Factor of Safety for both Sections 1 and 2 respectively, with maximum probability of failure for both seepage scenarios.

The analysis as presented in Table 8-5 has shown that both sections are marginally unstable. It is anticipated that under adverse conditions the slopes becomes unstable. This is consistent with the observed conditions.

The model was therefore considered appropriate to extrapolate the probabilistic extent of landslides along the sections indicated.

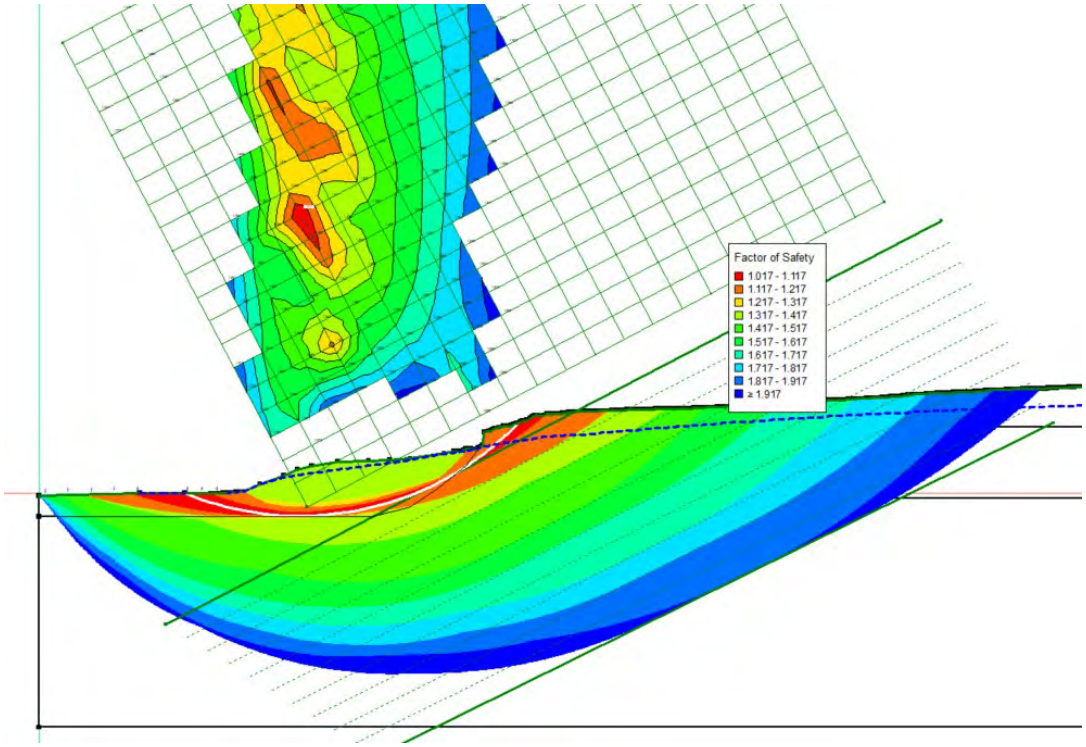


Figure 8-4: Critical Slip Circle for Seepage, Section 1 from Calibration Analysis using Deterministic Approach

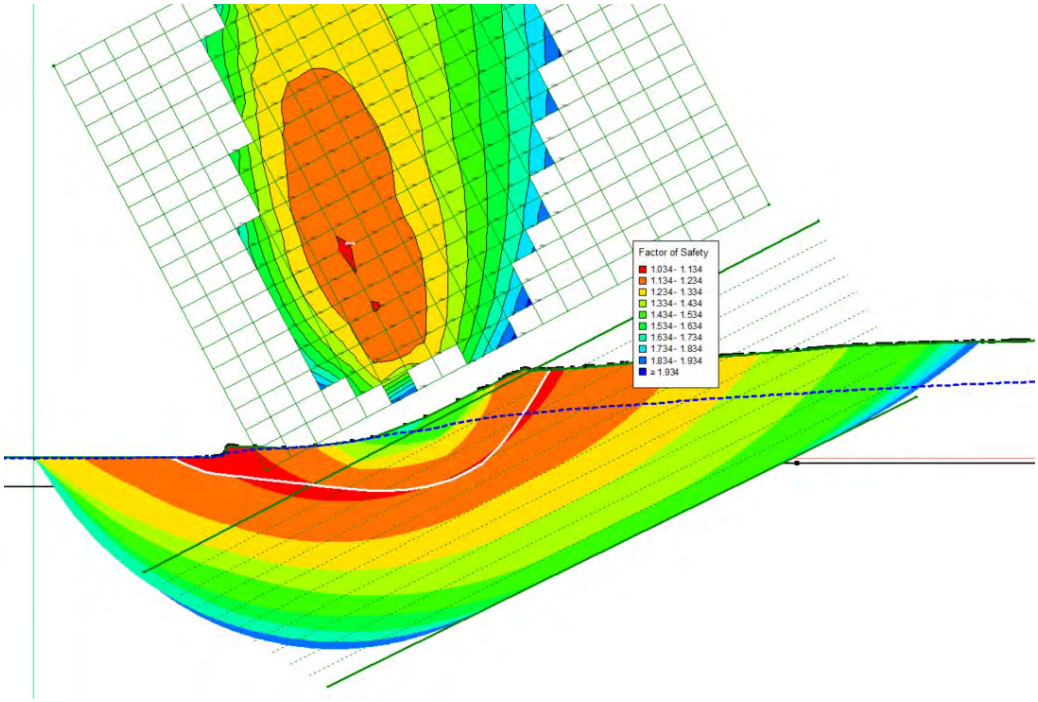


Figure 8-5: Critical Slip Circle for Seepage, Section 2 from Calibration Analysis using Deterministic Approach

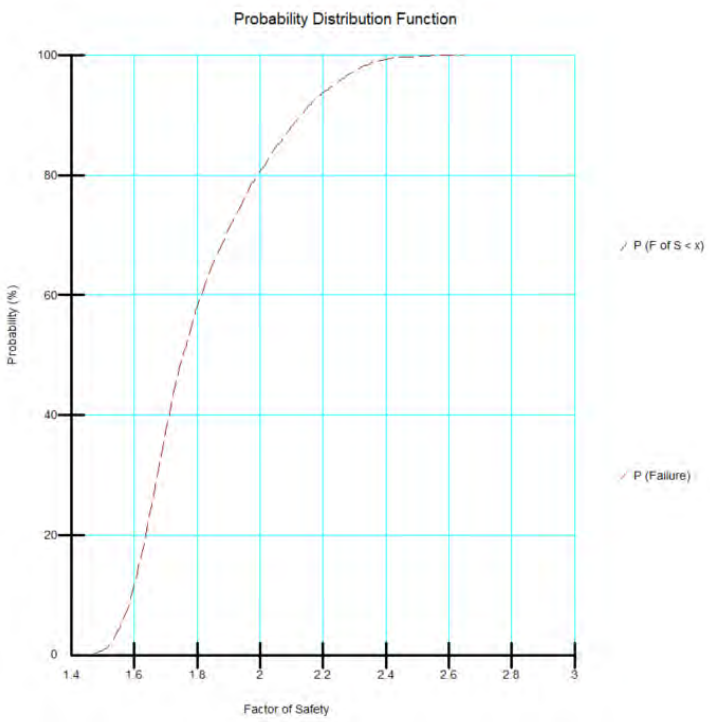
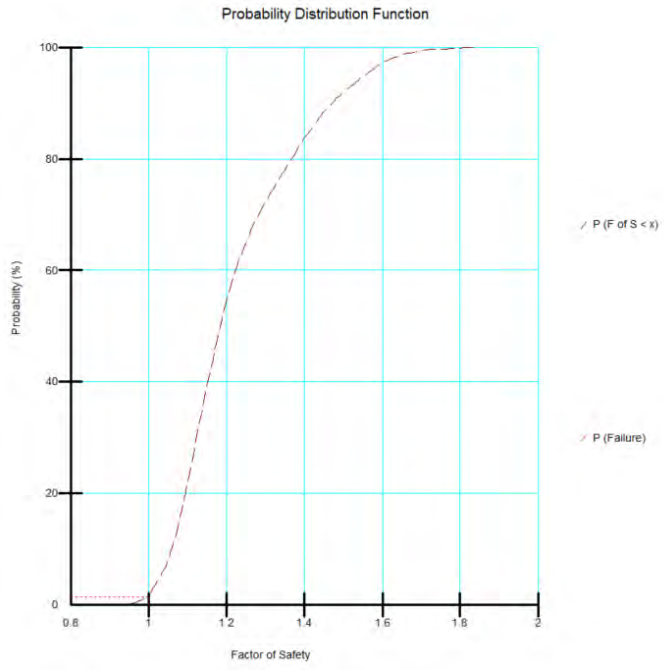
Secion	Probabilistic Distribution Function
Section 1	
Section 2	

Figure 8-6: Calibration Analysis using Probabilistic Approach

8.6 PROBABILITY LANDSLIDE MAP

Once the probabilistic model was appropriately calibrated it was then used to determine the extent of landslides of different probabilities for each section. The annual probability of slope failures has been estimated based on steady state seepage slope stability analysis.

The landslides were categorized into Hazards of different probabilities and their extents for that probability. Five different hazards based on the characteristics of the landslides are identified in Table 8-6.

It should be noted that Hazard 1 is only present in the areas represented by Section 1.

Table 8-6: Hazards and Probability of Failure

Hazards	Probability of Failure	Corresponding Annual Probability of Failure	Description
Hazard 1	0.1 and higher	1 in 10 years	This type of landslide would typically involve a large landslide of up to 1,000m^3 of material that moves slowly. The width of the landslide could be as wide as 120m. As part of the landslide process, material is expected to slump from the existing crest level to a point where equilibrium is achieved. Coastal erosion is expected to remove material from the toe of the cliff and restart the process.
Hazard 2	0.01 and higher	1 in 100 years	This type of landslide would typically involve a large landslide of up to 1,000m^3 of material that moves slowly. The width of the landslide could be as wide as 120m. As part of the landslide process, material is expected to slump from the existing crest level to a point where equilibrium is achieved. Coastal erosion is expected to remove material from the toe of the cliff and restart the process.
Hazard 3	0.001 and higher	1 in 1,000 years	This type of landslide would typically involve a large landslide of up to 1,000m^3 of material that moves slowly. The width of the landslide could be as wide as 120m. As part of the landslide process, material is expected to slump from the existing crest level to a point where equilibrium is achieved. Coastal erosion is expected to remove material from the toe of the cliff and restart the process.
Hazard 4	0.0001 and higher	1 in 10,000 years	This type of landslide would typically involve a large landslide of up to 1,000m^3 of material that moves slowly. The width of the landslide could be as wide as 120m. As part of the landslide process, material is expected to slump from the existing crest level to a point where equilibrium is achieved. Coastal erosion is expected to remove material from the toe of the cliff and restart the process.
Hazard 5	0.00001 and higher	1 in 100,000 years	This type of landslide would typically involve a large landslide of up to 1,000m^3 of material that moves slowly. The width of the landslide could be as wide as 120m. As part of the landslide process, material is expected to slump from the existing crest level to a point where equilibrium is achieved. Coastal erosion is expected to remove material from the toe of the cliff and restart the process.

Where one potential landslide with a lower probability overlaps an area with a different potential landslide with a higher probability then the higher probability landslide was adopted for the overlapping area. A general surface map on the probability of landslide occurring based on the extent of these hazards was produced for the area under investigation. The map is presented as Figure 1 in Appendix D.

9.0 LANDSLIDE RISK ASSESSMENT

A geotechnical risk assessment of the site has been undertaken to determine the Risk to Life and Risk to Property from a landslide. The assessment has been conducted in accordance with the methodologies outlined in the Australian Geomechanics Society (AGS) Landslide Risk Assessment and Management (Australian Geomechanics, Volume 42, No. 1, March 2007). The results of the risk assessment are included in Appendix E.

The following points outline the adopted methodology for the slope stability risk assessment:

- Assess quantitatively the Risk to Life based on the AGS 2007 guidelines for the different landslide hazards
- Assess qualitatively the Risk to Property based on the AGS 2007 guidelines for the different landslide hazards;
- Prepare two separate landslide risk maps of the site - one for Risk to Life and another for Risk to Property.

The risk assessments have initially been conducted for the risk considering present day (i.e. 2023) conditions. The risk assessments were then extrapolated to potential future conditions based on predicted cliff recession rates due to sea level rise for conditions in 2030, 2070 and 2100.

9.1 QUANTITATIVE RISK ASSESSMENT – RISK TO LIFE

Following the AGS guidelines, for loss of life the individual risk can be calculated as:

$R_{(LOL)} = P_{(H)} \times P_{(S:H)} \times P_{(T:S)} \times V_{(D:T)}$

Where

R(LOL) is the risk (annual probability) of loss of life (death) of an individual.

P(H) is the annual probability of the landslide.

P(S:H) is the probability of spatial impact of the landslide impacting a location or person taking into account the travel distance and travel direction.

P(T:S) is the temporal spatial probability given the spatial impact and allowing for the possibility of evacuation given there is warning of the landslide occurrence.

V(D:T) is the vulnerability of the individual (probability of life of the individual given the impact).

9.1.1 Landslide Hazards Under Assessment

The geotechnical investigation has identified that the dominant form of landslide on the site is a slow failure of the cliff face that occurs due to a combination of factors including undermining of the toe, surface erosion, tunnel erosion and groundwater seepage. The probability analysis has shown that the extent of these types of landslides varies based on the probability of the landslide occurring with landslides of higher probability generally having a smaller extent and landslides of lower probability generally having a larger extent.

Therefore, it is appropriate to consider the different sized landslides of different probabilities as separate landslide hazards when considering landslide risk. Five different landslide hazards of different probabilities have been considered as previously identified in Table 9-1. Where two hazards overlap the hazard of higher probability is considered to occupy the area. The following table summarises these landslide hazards.

Table 9-1: Summary of Landslide Hazards

Hazard	Annual Probability	Section 1: Upslope Extent from Existing Fence Line (m)	Section 2: Upslope Extent from Existing Fence Line (m)
1	0.1	1.1	*
2	0.01	13.5	14.7
3	0.001	14.5	18.0
4	0.0001	15.5	19.9
5	0.00001	16.5	21.9

* This landslide hazard does not extend beyond the fence line under current conditions

The following Figure 9-1 provides an explanation of the different dimensions shown in the table above.

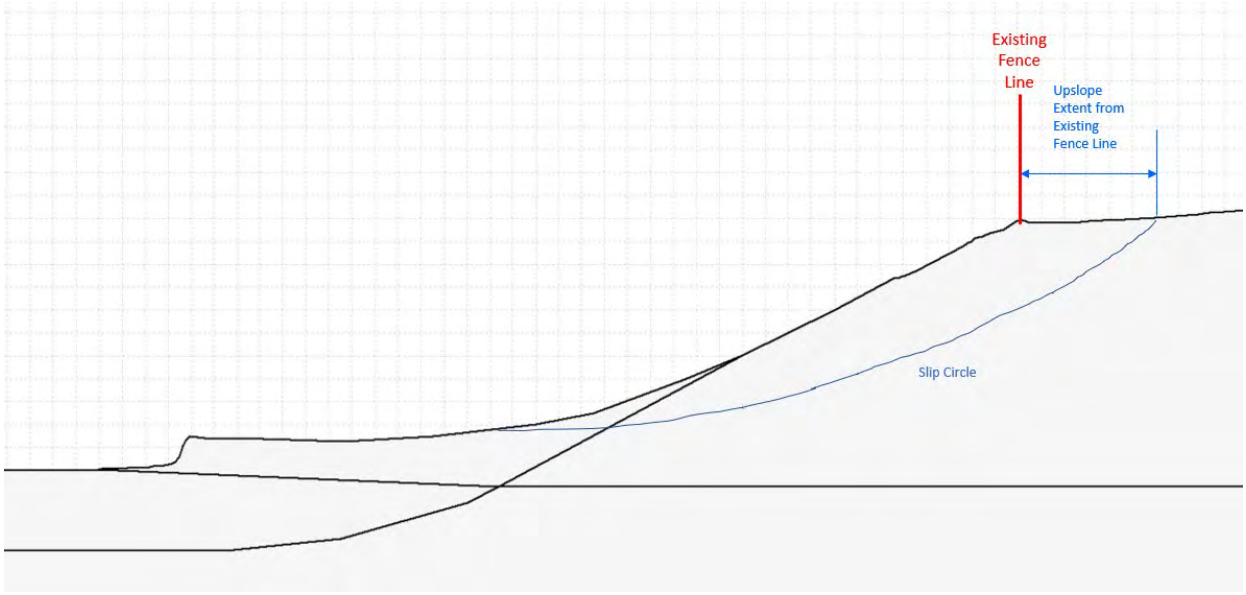


Figure 9-1: Typical Slip Circle and Definition of Different Dimensions

9.1.2 Elements at Risk

The risk assessment has considered a number of elements at risk that represent the people who may use the areas in the vicinity of the site. In this instance, most of the cases represent people who walk through an area (i.e. a transient case).

The following transient cases were evaluated in analysing the risk to life:

Transient Case:

- **Scenario A:** Person/s walking through the buffer or exclusion zone immediately adjacent to the crest of the cliff
- **Scenario B**: Person/s walking through the public reserve behind the exclusion zone
- **Scenario C**: Person/s walking along the road reserve located behind the public reserve
- **Scenario D**: Person/s located within properties constructed beyond the road reserve

The analysis has not considered the risk to a person who jumps the fence and explores the vegetated area on the cliff face itself. This is considered to be an unlikely event and there is insufficient information to assess how often this type of event may occur. However, should the Council wish an assessment of such a situation it could be considered on request.

In addition, the analysis has not considered the risk to a person walking along the beach. While it is possible that people may walk along the beach at times it is considered that the combination of low frequency of use and low vulnerability due to the slow movement will result in an 'Acceptable' risk without needing the analysis.

9.1.3 Probability of Spatial Impact ($P_{(S:H)}$)

The probability of spatial impact of a landslide involves the proportion of the site under assessment that would be affected by the landslide. It is a function of the area of the landslide compared to the area of section under assessment. When discussing length vs width, length refers to the distance running parallel to the direction of the cliff (i.e. east-west) while width refers to the distance running perpendicular to the cliff (i.e. north-south).

For the area up slope of the cliff the spatial probability is dependent on the landslide extending up slope of the lower boundary of the zone being considered. Where the landslide does not extend up slope of the lower boundary of the zone being considered, the spatial probability will be zero. Where the landslide extends beyond the lower boundary of the zone being considered, the spatial probability is dependent on the distance that the landslide extends beyond the boundary of the zone compared to the width of the zone considered. The spatial probability is also further affected by the size of the landslide laterally (i.e. its length along the foreshore) vs the length of the foreshore under investigation.

It has been indicated by the Council that the intention is to implement a 70m buffer or exclusion zone, measured perpendicularly to the existing fence line. Beyond the exclusion zone, a further 30m strip of land has been designated as public space or reserve. It has been assumed that the road reserve upslope of the public space will be a minimum of 10m wide and that the first row of residential properties will extend a minimum of 25m upslope of the road reserve.

The spatial probabilities determined for the different landslide hazards up slope of the existing fence line of the cliff for different areas and for both Section 1 and Section 2 are presented in the following tables.

Table 9-2: Section 1: Calculation of Probability of Spatial Impact for Each Hazard for the Exclusion Zone

Hazards	Length of the Area at Risk, m	Length of Area Affected by Landslide, m	Width of Area at Risk (m)	Width of Area Affected (m)	Spatial Probability
Hazard 1	180.0	86.0	70.0	1.1	0.01
Hazard 2	180.0	86.0	70.0	13.5	0.09
Hazard 3	180.0	86.0	70.0	14.5	0.10
Hazard 4	180.0	86.0	70.0	15.5	0.11
Hazard 5	180.0	86.0	70.0	16.5	0.11

Table 9-3: Section 1: Calculation of Probability of Spatial Impact for Each Hazard for the Public Reserve

Hazards	Length of the Area at Risk, m	Length of Area Affected by Landslide, m	Width of Area at Risk (m)	Width of Area Affected (m)	Spatial Probability
Hazard 1	180.0	86.0	30.0	0.0	0.00
Hazard 2	180.0	86.0	30.0	0.0	0.00
Hazard 3	180.0	86.0	30.0	0.0	0.00
Hazard 4	180.0	86.0	30.0	0.0	0.00
Hazard 5	180.0	86.0	30.0	0.0	0.00

Table 9-4: Section 1: Calculation of Probability of Spatial Impact for Each Hazard for the Road Reserve

Hazards	Length of the Area at Risk, m	Length of Area Affected by Landslide, m	Width of Area at Risk (m)	Width of Area Affected (m)	Spatial Probability
Hazard 1	180.0	86.0	10.0	0.0	0.00
Hazard 2	180.0	86.0	10.0	0.0	0.00
Hazard 3	180.0	86.0	10.0	0.0	0.00
Hazard 4	180.0	86.0	10.0	0.0	0.00
Hazard 5	180.0	86.0	10.0	0.0	0.00

Table 9-5: Section 1: Calculation of Probability of Spatial Impact for Each Hazard for the Residential Properties

Hazards	Length of the Area at Risk, m	Length of Area Affected by Landslide, m	Width of Area at Risk (m)	Width of Area Affected (m)	Spatial Probability
Hazard 1	180.0	86.0	25.0	0.0	0.00
Hazard 2	180.0	86.0	25.0	0.0	0.00
Hazard 3	180.0	86.0	25.0	0.0	0.00
Hazard 4	180.0	86.0	25.0	0.0	0.00
Hazard 5	180.0	86.0	25.0	0.0	0.00

Table 9-6: Section 2: Calculation of Probability of Spatial Impact for Each Hazard for the Exclusion Zone

Hazards	Length of the Area at Risk, m	Length of Area Affected by Landslide, m	Width of Area at Risk (m)	Width of Area Affected (m)	Spatial Probability
Hazard 1	240.0	119.0	70.0	0.0	0.00
Hazard 2	240.0	119.0	70.0	14.7	0.10
Hazard 3	240.0	119.0	70.0	18.0	0.13
Hazard 4	240.0	119.0	70.0	19.9	0.14
Hazard 5	240.0	119.0	70.0	21.9	0.16

Table 9-7: Section 2: Calculation of Probability of Spatial Impact for Each Hazard for the Public Reserve

Hazards	Length of the Area at Risk, m	Length of Area Affected by Landslide, m	Width of Area at Risk (m)	Width of Area Affected (m)	Spatial Probability
Hazard 1	240.0	119.0	30.0	0.0	0.00
Hazard 2	240.0	119.0	30.0	0.0	0.00
Hazard 3	240.0	119.0	30.0	0.0	0.00
Hazard 4	240.0	119.0	30.0	0.0	0.00
Hazard 5	240.0	119.0	30.0	0.0	0.00

Table 9-8: Section 2: Calculation of Probability of Spatial Impact for Each Hazard for the Road Reserve

Hazards	Length of the Area at Risk, m	Length of Area Affected by Landslide, m	Width of Area at Risk (m)	Width of Area Affected (m)	Spatial Probability
Hazard 1	240.0	119.0	10.0	0.0	0.00
Hazard 2	240.0	119.0	10.0	0.0	0.00
Hazard 3	240.0	119.0	10.0	0.0	0.00
Hazard 4	240.0	119.0	10.0	0.0	0.00
Hazard 5	240.0	119.0	10.0	0.0	0.00

Table 9-9: Section 2: Calculation of Probability of Spatial Impact for Each Hazard for the Residential Properties

Hazards	Length of the Area at Risk, m	Length of Area Affected by Landslide, m	Width of Area at Risk (m)	Width of Area Affected (m)	Spatial Probability
Hazard 1	240.0	119.0	25.0	0.0	0.00
Hazard 2	240.0	119.0	25.0	0.0	0.00
Hazard 3	240.0	119.0	25.0	0.0	0.00
Hazard 4	240.0	119.0	25.0	0.0	0.00
Hazard 5	240.0	119.0	25.0	0.0	0.00

9.1.4 Temporal Probability

The temporal probability is the likelihood that the person most at risk will actually be on the site at the time the landslide occurs. For a transient person it is the length of time it takes the person to transit the site compared to the number of hours in a year. The analysis has been based on reasonable estimates for the duration of stay.

For the person most at risk it is considered that the person visits the site once in a year. Multiple visits by the same person would then be taken into account when the societal risk calculations are conducted.

Based on the assumptions above, the estimated temporal spatial probability is summarized below in Table 9-10 and Table 9-11 for Section 1 and Section 2 respectively.

Table 9-10: Section 1 Calculation of Temporal Spatial Probability – Transient Cases

Scenarios	Element Speed (km/hr)	Path Length (m)	Length of Stay (hr)	Temporal Spatial Probability, $P_{(T:S)}$
Scenario A	3.0	86	0.060	6.8×10^{-6}
Scenario B	3.0	86	0.060	6.8×10^{-6}
Scenario C	3.0	86	0.060	6.8×10^{-6}
Scenario D	0.01	86	25.00	2.9×10^{-3}

Table 9-11: Section 2 Calculation of Temporal Spatial Probability – Transient Cases

Scenarios	Element Speed (km/hr)	Path Length (m)	Length of Stay (hr)	Temporal Spatial Probability, $P_{(T:S)}$
Scenario A	3.0	119	0.080	9.1×10^{-6}
Scenario B	3.0	119	0.080	9.1×10^{-6}
Scenario C	3.0	119	0.080	9.1×10^{-6}
Scenario D	0.01	119	25.00	2.8×10^{-3}

9.1.5 Vulnerability

According to AGS (2007c), the vulnerability factor represents the chance of survival should a landslide impact a person. The vulnerability of a person to a landslide is dependent on the type of landslide, its size and its potential impact on a person. People are more vulnerable to landslides that fall from upslope (as they tend to be engulfed or impacted by the landslide) than people who are at the crest of the slope where a landslide occurs downslope (as they tend to ride on top of the landslide). In addition, people are more vulnerable to larger landslides due to the larger mass of impact. However, at the same time people are significantly less vulnerable to landslides that are slow moving as they are able to walk away without being affected.

Considering the very slow nature of these landslides the potential for someone to be impacted by the moving landslide is very low, if not zero. However, a conservative value of 0.01 has been adopted.

Table 9-12 shows the vulnerability determined for each element at risk for each hazard.

Table 9-12: Vulnerability for each Scenario for each Hazard

Scenarios	Hazard 1	Hazard 2	Hazard 3	Hazard 4	Hazard 5
Scenario A/B/C/D	0.01	0.01	0.01	0.01	0.01

9.1.6 Assessment Criteria

AGS (2007c) indicates that different levels of risk are appropriate when considering existing slopes or developments and new developments.

For existing slopes AGS (2007c) suggests that 'tolerable' risk should be less than or equal to $1x10^{-4}$. For newly engineered slopes or new developments AGS (2007c) suggests that 'tolerable' risk should be less than or equal to $1x10^{-5}$.

Therefore for this site a tolerable risk of not greater than $1x10^{-5}$ needs to be achieved for the slope in the scope of the proposed development.

It is important to understand that a risk assessment does not state that a death or serious injury will or will not occur. It is a statistical likelihood based on a number of factors that is then compared against a pre-defined level of tolerability.

A brief discussion on the limitations of geotechnical reports is appended to this report.

9.1.7 Analysis Results – Risk to Life

The level of Risk to Life is based on the proximity of a person to a particular hazard, the likelihood of that hazard occurring, the temporal probability of the person being in the location at the time and how vulnerable the person is to the failure.

A summary of the results of the assessment for landslide Risk to Life is included in Table 9-13 and ____ for Section 1 and Section 2 respectively, with the analysis results included in Appendix E.

Table 9-13: Section 1 - Summary of Landslide Risk to Life – Person Most at Risk (2023)

Hazard	Risk, $R_{(LOL)}$			
-	Scenario A	Scenario B	Scenario C	Scenario D
Hazard 1	5.1×10^{-11}	0.0	0.0	0.0
Hazard 2	6.3×10^{-11}	0.0	0.0	0.0
Hazard 3	6.8×10^{-12}	0.0	0.0	0.0
Hazard 4	7.2×10^{-13}	0.0	0.0	0.0
Hazard 5	7.7×10^{-14}	0.0	0.0	0.0

Table 9-14: Section 2 - Summary of Landslide Risk to Life – Person Most at Risk (2023)

Hazard	Risk, $R_{(LOL)}$			
-	Scenario A	Scenario B	Scenario C	Scenario D
Hazard 1	0.0	0.0	0.0	0.0
Hazard 2	9.5×10^{-11}	0.0	0.0	0.0
Hazard 3	1.2×10^{-11}	0.0	0.0	0.0
Hazard 4	1.3×10^{-12}	0.0	0.0	0.0
Hazard 5	1.4×10^{-13}	0.0	0.0	0.0

The analysis shows that in its existing condition the risk to the individual most at risk from a failure of the cliff is 'Acceptable' for all the scenarios and hazards.

9.1.8 Analysis Results – Risk to Life – Societal Risk

While the risk to the person most at risk has been identified to be acceptable for this site, it is also important to consider the societal risk from a landslide. In simplified terms, the societal risk is the cumulative risk that builds up over time as each person uses the area under study. For areas which are regularly used it is often the societal risk that dominates whether the risk is tolerable.

AGS(2007c) briefly covered the analysis of Societal Risk, but significant improvements have been made on the analysis methodologies since the issue of that document. Training sessions run but the Australian Geomechanics Society provide the report prepared by Golder Associates for the New South Wales National Parks and Wildlife Service, *Guidelines for Quantitative Risk to Life Calculations for Landslides* (NSWNPWS (2020)) as a good example of assessing the Societal Risk associated with landslides.

The current report has adopted the methods from NSWNPWS (2020) for determining the Societal Risk.

In order to assess whether the societal risk is 'tolerable' a F-N chart is used where the probability of the landslide occurring (F) is compared to the number of people likely to be killed by the landslide (N). Where a large number of people have the potential to be killed by a single landslide is higher, the probability value that determines a 'tolerable' risk is lower. That is, society is less willing to accept a large amount of people being killed at once compared to a smaller amount of people. However, for sites where the amount of people visiting at once is small, such as the subject site, it is appropriate to assume that only one or two people would be killed by any of the landslide hazards in one instance.

Considering that and reviewing the F-N charts provided in Figure 3 of NSWNPWS (2020) it is appropriate for a 'tolerable' societal risk to be less than 1×10^{-3} and an 'acceptable' societal risk to be less than 1×10^{-5}.

To determine the Societal Risk based on the risk determined for the Person Most at Risk it is also necessary to know the amount of people that will use the area under assessment for each Hazard.

Table 9-15 provides details of the frequency of use for each Element at Risk.

Table 9-15: Site Usage for Each Element at Risk

Hazard	Description / Reference
Scenario A	For all the identified hazards, it is assumed that an average of 1 people per day walk through the exclusion zone upslope of the existing fenceline.
Scenario B	For all the identified hazards, it is assumed that an average of 10 groups of 3 people per day visit the public reserve, including play area, located upslope of the exclusion zone.
Scenario C	For all the identified hazards, it is assumed that an average of 15 groups of 3 people per day walk through the road reserve up slope of the public space.
Scenario D	For all the identified hazards, it is assumed that an average of 25 groups of 4 people per day occupy residential properties up slope of the road reserve.

Considering the site usage for each scenario, the Societal Risk for each Hazard of the cliff has been determined. The values are provided in Table 9-16 and Table 9-17 for Section 1 and Section 2 respectively. The detailed calculations are appended.

Table 9-16: Section 1 Summary of Landslide Risk to Life – Societal Risk (2023)

Hazards	Risk, $R_{(LOL)}$			
-	Scenario A	Scenario B	Scenario C	Scenario D
Hazard 1	5.6×10^{-8}	0.0	0.0	0.0
Hazard 2	6.9×10^{-8}	0.0	0.0	0.0
Hazard 3	7.4×10^{-9}	0.0	0.0	0.0
Hazard 4	7.9×10^{-10}	0.0	0.0	0.0
Hazard 5	8.4×10^{-11}	0.0	0.0	0.0

Table 9-17: Section 2 Summary of Landslide Risk to Life – Societal Risk (2023)

Hazards	Risk, $R_{(LOL)}$			
-	Scenario A	Scenario B	Scenario C	Scenario D
Hazard 1	0.0	0.0	0.0	0.0
Hazard 2	1.0×10^{-7}	0.0	0.0	0.0
Hazard 3	1.3×10^{-8}	0.0	0.0	0.0
Hazard 4	1.4×10^{-9}	0.0	0.0	0.0
Hazard 5	1.6×10^{-10}	0.0	0.0	0.0

It is then important to consider the overall societal risk for a person either within the public space, road reserve and within properties up slope of the cliff. The overall societal risk is determined by summing the risks for each of the scenarios for people using the area. The overall societal risk for each of the areas up slope and down slope for each hazard are provided in Table 9-18.

Table 9-18: Summary of Overall Societal Risk to Life (2023)

Hazards	Risk, $R_{(LOL)}$
Hazard 1	5.60×10^{-8}
Hazard 2	1.69×10^{-7}
Hazard 3	2.04×10^{-8}
Hazard 4	9.30×10^{-9}
Hazard 5	2.44×10^{-10}

The analysis has shown that at the current time, the overall societal risk for both Section 1 and Section 2 is ‘acceptable’ for all hazards.

9.2 QUALITATIVE RISK ASSESSMENT – RISK TO PROPERTY

Following the AGS guidelines, a qualitative risk analysis to property was undertaken to assess the risk of damage or loss in the event that a geotechnical hazard occurs.

The infrastructure items that were considered were the exclusion zone, the public space or reserve area, the road reserve and residential properties, all located upslope of the cliff.

The qualitative risk assessment is based on the likelihood of failure as well as the consequence of the failure to the infrastructure.

9.2.1 Likelihood

When conducting a qualitative assessment, annual probability is described with a descriptive term of Likelihood rather than the numerical probability value. However, the Likelihood is directly related to the probability of the hazard occurring.

The likelihood determined for each identified hazard based on the annual probability is presented in Table 9-17.

Table 9-19: Likelihood of Occurrence of Identified Hazards

Hazards	Probability of Failure	Likelihood
Hazard 1	0.1 and higher	Almost Certain
Hazard 2	0.01 and higher	Likely
Hazard 3	0.001 and higher	Possible
Hazard 4	0.0001 and higher	Unlikely
Hazard 5	0.00001 and higher	Rare

9.2.2 Consequence

The consequence to property is assessed based on a combination of factors including the size of the landslide, the rate of slide movement, the position of the property relative to the landslide e.g. on the slide or immediately downslope, the portion of the property that would be affected and the likely impact of damage to the property (i.e. cost of remediation).

For the risk to the public space it is generally loss of amenity that is at risk, should a landslide occur. That is, there is unlikely to be little financial cost but the area will be less useable.

For the risk to the road reserve it is loss of the use of the road and footpath or shared user path that is at risk, should a landslide occur. There is likely to be a financial cost associated with remediating and damage that may have occurred to restore usability to the infrastructure.

For the risk to residential properties, it is loss of the use of houses located that is at risk, should a landslide occur. There is likely to be a significant financial cost associated with remediating and damage that may have occurred to restore usability to the infrastructure.

We note that the analysis has indicated that no landslides can reach the public space, road reserve or residential properties, the consequence of landslide on the properties is considered 'Not Credible'.

Where the landslide hazard has been assessed that it cannot reach the property under assessment the consequence has been identified to be 'Not Credible'.

The potential consequence for each of the identified hazards for each section and for each property type are presented in Table 9-20, Table 9-21 and Table 9-22.

Table 9-20: Consequence to Property – Public Reserve

Hazards	Probability of Failure	Consequence	
		Section 1	Section 2
Hazard 1	0.1 and higher	Not Credible	Not Credible
Hazard 2	0.01 and higher	Not Credible	Not Credible
Hazard 3	0.001 and higher	Not Credible	Not Credible
Hazard 4	0.0001 and higher	Not Credible	Not Credible
Hazard 5	0.00001 and higher	Not Credible	Not Credible

Table 9-21: Consequence to Property – Road Reserve

Hazards	Probability of Failure	Consequence	
		Section 1	Section 2
Hazard 1	0.1 and higher	Not Credible	Not Credible
Hazard 2	0.01 and higher	Not Credible	Not Credible
Hazard 3	0.001 and higher	Not Credible	Not Credible
Hazard 4	0.0001 and higher	Not Credible	Not Credible
Hazard 5	0.00001 and higher	Not Credible	Not Credible

Table 9-22: Consequence to Property – Residential Properties

Hazards	Probability of Failure	Consequence	
		Section 1	Section 2
Hazard 1	0.1 and higher	Not Credible	Not Credible
Hazard 2	0.01 and higher	Not Credible	Not Credible
Hazard 3	0.001 and higher	Not Credible	Not Credible
Hazard 4	0.0001 and higher	Not Credible	Not Credible
Hazard 5	0.00001 and higher	Not Credible	Not Credible

9.2.3 Analysis Results – Risk to Property

The Risk to Property for each of the hazards for each of the sections was determined by adopting the risk matrix provided in AGS (2007), the likelihood of occurrence and consequence to property. The results of the assessment of landslide Risk to Property are presented in Table 9-23 and Table 9-24 for Section 1 and Section 2 respectively. The analysis is included in Appendix E.

Table 9-23: Section 1 Summary of Landslide Risk to Property

Hazards	Risk		
	Reserve	**Road Reserve**	**Residential Properties**
Hazard 1	LOW	LOW	LOW
Hazard 2	LOW – VERY LOW	LOW-VERY LOW	LOW-VERY LOW
Hazard 3	VERY LOW	VERY LOW	VERY LOW
Hazard 4	VERY LOW	VERY LOW	VERY LOW
Hazard 5	VERY LOW	VERY LOW	VERY LOW
Green shading indicates that the risk was very low			
Blue shading indicates that the risk is low			
Yellow shading indicates that the risk was moderate			
Pink shading indicates that the risk is high			
Red shading indicates that the risk very high			

Table 9-24: Section 2 Summary of Landslide Risk to Property

Hazards	Risk		
	Reserve	**Road Reserve**	**Residential Properties**
Hazard 1	LOW	LOW	LOW
Hazard 2	LOW – VERY LOW	LOW-VERY LOW	LOW-VERY LOW
Hazard 3	VERY LOW	VERY LOW	VERY LOW
Hazard 4	VERY LOW	VERY LOW	VERY LOW
Hazard 5	VERY LOW	VERY LOW	VERY LOW
Green shading indicates that the risk was very low			
Blue shading indicates that the risk is low			
Yellow shading indicates that the risk was moderate			
Pink shading indicates that the risk is high			
Red shading indicates that the risk very high			

9.3 IMPACTS OF SEA LEVEL RISE ON FORESHORE

Earlier Stantec has conducted a separate coastal and adaptation assessment (Ref. 20230223 Jetty Road Stage 2 Foreshore CHVA Rev A). The assessment identified that recession of the toe of the cliff due to sea level rise is likely to occur at the following rates up until 2100 as presented in Table 9-25.

Table 9-25: Predicted Recession of Cliffs over Time

Scenario Year	Mean Sea Level Rise (m)	Long Term Shoreline Recession in meters (Δx)
2030	0.15	2.5
2070	0.47	7.8
2100	0.82	13.7

Review of the historical aerial photography over the past 75 years has identified that minimal recession of the foreshore has occurred during this period.

The rate of recession at the toe and head scarp of landslides in this area is complex due to a combination of the movement of the landslide and erosion features such as gullies and tunnels. In the long term (over 1,000 years) the recession of the toe and crest may be similar, but over the lifetime of the project the recession rates of the toe and crest may vary as the varying processes occur. For the purposes of this assessment it has been conservatively assumed that the recession of the toe and the crest will be similar in the short term.

Using this approach, based on the predicted recession and the size of the proposed exclusion zone for the planned subdivision it is not expected that any of the hazards would cross the boundary between the exclusion zone and the public reserve by 2100. Therefore, based on the assessment as presented in this report, the risk to the public space, the road reserve and residential properties will remain unchanged in 2100 compared to that assessed in 2023.

The figures in Appendix D show the predicted changes to the hazard distribution on the site over time due to the recession of the cliff.

9.4 GULLY AND TUNNEL EROSION

A review of historical imagery of the site and the surrounding coastline combined with observations made during the site walkover indicates that the formation of tunnels and gullies along the cliff is likely. It is anticipated that the erosion is likely to be contained within the exclusion zone. Based on the observations made, while the processes are generally independent of each other, it is anticipated that the rate of erosion is likely to occur at a similar order of magnitude as is predicted as a result of sea level rise.

10.0 CONCLUSIONS AND RECOMMENDATIONS

A landslide risk assessment has been conducted for the section of foreshore relevant to the proposed Jetty Road Stage 2 subdivision. The risk assessment considered both the risk to life and the risk to property.

The risk assessment has shown that the overall societal risk to life from a landslide within the foreshore area for people accessing the exclusion zone, the public space, the road reserve and the residential properties adjacent to the road reserve is ‘Acceptable’.

The analysis has also shown that while recession of the cliffs is likely to occur over time, the risk for people up slope of the cliffs is expected to remain ‘Acceptable’ by 2100.

When regarding the risk to property up slope of the cliffs, the risk assessment has shown that the risk to the public space, the road reserve and residential properties is ‘Very Low’ to ‘Low’ up until 2100.

The potential impacts of the above risk assessment and any recommendations for works required to mitigate the risk are provided in the following sections.

The risk assessment has been based on the indication from Council that a 70m buffer zone, or exclusion zone, will be implemented immediately upslope of the existing fence line. Beyond that, a 30m wide zone designated as a public space or reserve, will be constructed. A road reserve is considered to be a minimum of 10m wide, immediately upslope of the public space. The first row of residential properties has been assumed to be positioned immediately upslope of the road reserve. We note that some work will be required to interface with the road reserve and property line observed on the existing subdivision immediately to the east of the site.

Should any of the items that form the basis of the risk assessment carried out differ from those noted in this report, now or in the future, the risk assessment would need to be revisited and updated if necessary.

10.1 DISCUSSION ON RISK TO LIFE

The risk assessment has shown that total societal risk to life for the area up slope of the cliff is ‘Acceptable’ for any time up until 2100. It is therefore considered that minimal mitigation measures are required with regard to landslide risk in this area.

10.2 DISCUSSION ON RISK TO PROPERTY

The risk assessment identified that the risk to the property up slope of the cliff, i.e. the public space or reserve, the road reserve and the residential properties, will be ‘Low’ to ‘Very Low’ and no further maintenance or protection measures would be required by the council up until 2100.

The analysis presented in this report indicates that the proposed 70m exclusion zone is sufficiently large that even with the conservatively expected cliff regression up until 2100, the hazards are not expected to cross the boundary between the exclusion zone and the public space. It should be noted that the public space is likely to comprise grassed areas, tracks and play ground facilities. As the landslides in this area

have been identified as slow moving, any that do reach the public spaces after 2100 would only likely result in minor cracking which would only require minimal work to repair or reinstate. In light of this, the recommendations for each area are as follows:

Exclusion Zone:

- No infrastructure of any sort is to be constructed within the exclusion zone
- Tunnel erosion or gullies may form in this area towards the crest of the cliff. It is anticipated that the effects of this erosion are likely to be contained within the exclusion zone. However, it should be monitored and if erosion is encroaching into the exclusion zone at a faster rate than expected, mitigation measures may be implemented to slow the progression of the erosion. Mitigation measures could include excavating a trench parallel to the crest of the cliff, positioned up slope of the erosion feature and backfilled with compacted lime stabilised material to prevent the up slope progression of the gully and/or tunnel.

Public Space or Reserve:

- No buried infrastructure (such as services) is to be constructed within the public space. This is especially critical as broken water pipes have the potential to introduce water to the slope and exacerbate the slope stability issues.
- Unsealed pavements are adopted for any paths within this area due to their lower maintenance costs.
- Stormwater pits and other subsurface water bearing structures should be avoided where possible, and where required should be lined to prevent leakage.
- Any stormwater pipework should preferably divert water away from the cliff. No stormwater discharge should be allowed over the surface of the site. Where stormwater is to be diverted towards the cliff rather than off-site it should be delivered via an above surface pipe to the toe of the cliffs rather than discharging at the top of the cliffs. The pipe should include appropriate flexible and extendable joints to tolerate the slope movement that will occur across the cliff area.
- Lighting and power poles should be constructed with joints that allow the pole to be readjusted to vertical should ground movement occur.

Road Reserve:

- Any stormwater pipework should divert water away from the cliff. No stormwater discharge should be allowed over the surface of the site.
- See above with regard to the discharge of stormwater.

Residential Properties:

- Minimal restriction on residential development is required considering the offsets.

11.0 REFERENCES

AGS, 2007c. Practice Note Guidelines for Landslide Risk Management, Australian Geomechanics.

AS 1289 *Methods of Testing Soils for Engineering Purposes*

AS 1726 - 2011 *Geotechnical Site Investigations*

Geological Survey of Victoria, *Portarlington Geological Map* 1:63,360, 1977.

Guidelines for Quantitative Risk to Life Calculations for Landslides (NSWNPWS (2020))

McInnes, KL., O'Grady, J., and Macadam, I., 2009. *The Effect of Climate Change on Extreme Sea Levels along Victoria's Coast*. Report prepared for the Department of Sustainability and Environment, Victoria. CSIRO.

Visualising Victoria's Groundwater website

APPENDICES

Appendix A – SITE PLAN

FIGURE 1

1:2,000 Scale at A3

Metres

0 30 60

Site Plan

72 – 100 MCDERMOTT ROAD AND 102 – 170 MCDERMOTT ROAD, CURLEWIS, VIC

N

Cardno now Stantec

Map Produced by Cardno now Stantec
Date: 2022-10-17 | Project: V220433
Coordinate System: GDA2020 MGA Zone 55
Map: V220433-GS-004-SitePlan.mxd 01
Aerial Imagery Supplied by Nearmap (April, 2022)

Appendix B – BOREHOLE RECORDS

Borehole Record: BH01

Project: Jetty's Road Foreshore

Location: 102 - 170 McDermott Road, Curlewis, VIC, 3222

Job No.: V220433 / 304400703

Position: 55H E: 284597 N: 5773804

Surface Level: 19.999 AHD

Stickup: 1.15 m

Inclination: Vertical

Date St.: 10/10/2022 **Date Comp.:** 10/10/2022

Drill Rig: Hanjin D&B - 8D

Drilling Method: 100mm Dia. Solid Auger Washbore

Logged/Checked: SK / SE

Depth (m)	Description of Strata	Graphic Log	Depth (m)	Sample	In Situ Testing	Well Graph	Remarks
0.0	TOPSOIL, Clayey SILT (ML) low plasticity, brown black, soft to firm, moist, near plastic limit		0.0				
	Becoming stiff at 0.5m			0.50/D	PP=200		
1.0	Sandy CLAY (CH) high plasticity, brown yellow with red brown, stiff to very stiff, moist, dry of plastic limit, (Moorabool Formation)		1.0	1.00/D	PP=400		
	Becoming brown red at 1.5m			1.50/D	PP=200		
2.0	Becoming brown red with brown yellow at 2.0m		2.0	2.00/D	PP=250		
	Becoming brown yellow with grey at 2.5m			2.50/D	PP=400		
3.0	Clayey SAND (SC) fine to medium grained, poorly graded, grey white, very dense, moist, (Moorabool Formation)		3.0	2.99/D 3.00-3.3/SPT	SPT@3m 8/24 refusal, hammer double bounce N>50		
				3.50/D			
4.0			4.0	4.00/D			
				4.50/D			
5.0			5.0				
6.0	Becoming moist to wet at 6.0m		6.0	5.99/D 6.00-6.3/SPT	SPT@6m 15/21/30 N=51		
7.0			7.0				Backfill (0 - 13.95m bgl)
							Comenced washboring at 7.5m
8.0			8.0				
9.0	Sandy CLAY (CH) high plasticity, brown yellow with grey white, stiff to very stiff, moist, dry of plastic limit, (Moorabool Formation)		9.0	9.00-9.3/U63	PP=300		

Key:
For explanation of abbreviations and symbols, refer to Cardno UCS or Rock Notes

Notes:
Water loss from 9.0m

Groundwater Observations:
Groundwater observed at 7.0mbgl

(Continued Next Page)

Borehole Record: BH01

Cardno Shaping the Future

Project: Jetty's Road Foreshore

Location: 102 - 170 McDermott Road, Curlewis, VIC, 3222

Job No.: V220433 / 304400703

Position: 55H E: 284597 N: 5773804

Surface Level: 19.999 AHD

Stickup: 1.15 m

Inclination: Vertical

Date St.: 10/10/2022 **Date Comp.:** 10/10/2022

Drill Rig: Hanjin D&B - 8D

Drilling Method: 100mm Dia. Solid Auger Washbore

Logged/Checked: SK / SE

Depth (m)	Description of Strata	Graphic Log	Depth (m)	Sample	In Situ Testing	Well Graph	Remarks
10.0	Sandy CLAY (CH) high plasticity, brown yellow with grey white, stiff to very stiff, moist, dry of plastic limit, (Moorabool Formation) *(continued)*		10.0				
11.0			11.0				
12.0			12.0	12.00/SPT	SPT@12m 4/5/7 N=12		
13.0			13.0				
14.0			14.0				
15.0			15.0	15.00-15.5/U63	PP=350		Bentonite (13.95 - 15.95m bgl)
16.0			16.0				
17.0			17.0				
18.0			18.0	18.00/SPT	SPT@18m 4/6/7 N=13		
19.0			19.0				
				19.50-20.0/U63	PP=300		Sand (15.95 - 22.95m bgl)
							Screen (16.95 - 22.95m

Key:
For explanation of abbreviations and symbols, refer to Cardno UCS or Rock Notes

Notes:
Water loss from 9.0m

Groundwater Observations:
Groundwater observed at 7.0mbgl

(Continued Next Page)

Borehole Record: BH01

Project: Jetty's Road Foreshore

Location: 102 - 170 McDermott Road, Curlewis, VIC, 3222

Job No.: V220433 / 304400703

Position: 55H E: 284597 N: 5773804

Surface Level: 19.999 AHD

Stickup: 1.15 m

Inclination: Vertical

Date St.: 10/10/2022 **Date Comp.:** 10/10/2022

Drill Rig: Hanjin D&B - 8D

Drilling Method: 100mm Dia. Solid Auger Washbore

Logged/Checked: SK / SE

Depth (m)	Description of Strata	Graphic Log	Depth (m)	Sample	In Situ Testing	Well Graph	Remarks
20.0	Sandy CLAY (CH) high plasticity, brown yellow with grey white, stiff to very stiff, moist, dry of plastic limit, (Moorabool Formation) *(continued)*		20.0				bgl)
21.0	Sandy Silty CLAY (CH) high plasticity, grey, stiff, moist, dry of plastic limit, (Fyansford Formation)		21.0	21.00/SPT	SPT@21m 5/6/6 N=12		
22.0			22.0	22.50-23.0/U63	PP=250		
	Borehole terminated at target depth at 22.95m						

Key:
For explanation of abbreviations and symbols, refer to Cardno UCS or Rock Notes

Notes:
Water loss from 9.0m

Groundwater Observations:
Groundwater observed at 7.0mbgl

Borehole Record: BH02

Project: Jetty's Road Foreshore

Location: 102 - 170 McDermott Road, Curlewis, VIC, 3222

Job No.: V220433 / 304400703

Position: 55H E: 284600 N: 5773768

Surface Level: 23.100 AHD

Stickup: 1.15 m

Inclination: Vertical

Date St.: 11/10/2022 **Date Comp.:** 11/10/2022

Drill Rig: Hanjin D&B - 8D

Drilling Method: 100mm Dia. Solid Auger Washbore

Logged/Checked: SK / SE

Depth (m)	Description of Strata	Graphic Log	Depth (m)	Sample	In Situ Testing	Well Graph	Remarks
0.0	TOPSOIL, Clayey SILT (ML) low plasticity, brown black, soft to firm, moist, near plastic limit		0.0				
	Becoming brown red and stiff at 0.5m			0.50/D	PP=200		
	Sandy CLAY (CH) high plasticity, brown yellow with red brown, stiff to very stiff, moist, dry of plastic limit, (Moorabool Formation)			1.00/D	PP=300		
1.0	Becoming brown yellow with grey at 1.3m		1.0	1.50/D	PP=300		
2.0	Becoming grey with brown at 1.9m		2.0	2.00/D	PP=350		
	Becomin brown yellow with grey and friable at 2.5m			2.50/D	PP=300		
	Clayey Silty SAND (SC-SM) fine to medium grained, poorly graded, grey white, very dense, moist, (Moorabool Formation)			2.99/D 3.00/SPT	SPT@3m 10/29/5 refusal, double bouncing N>50		
3.0			3.0				
4.0			4.0				
5.0			5.0				
6.0			6.0	6.00-6.4/U63			
7.0			7.0				
8.0	Becoming moist to wet at 8.0m		8.0				
	Sandy CLAY (CH) high plasticity, brown yellow with grey white, very stiff, moist, dry of plastic limit, (Moorabool Formation)			9.00/SPT	SPT@9m 8/11/13 N=24		Comenced washboring at 9.0m
9.0			9.0				

Key:
For explanation of abbreviations and symbols, refer to Cardno UCS or Rock Notes

Notes:
Water loss from 8.5m to 32.4m

Groundwater Observations:
Groundwater observed at 8.5mbgl

(Continued Next Page)

Borehole Record: BH02

Cardno Shaping the Future

Project: Jetty's Road Foreshore

Location: 102 - 170 McDermott Road, Curlewis, VIC, 3222

Job No.: V220433 / 304400703

Position: 55H E: 284600 N: 5773768

Surface Level: 23.100 AHD

Stickup: 1.15 m

Inclination: Vertical

Date St.: 11/10/2022 **Date Comp.:** 11/10/2022

Drill Rig: Hanjin D&B - 8D

Drilling Method: 100mm Dia. Solid Auger Washbore

Logged/Checked: SK / SE

Depth (m)	Description of Strata	Graphic Log	Depth (m)	Sample	In Situ Testing	Well Graph	Remarks
10.0	Sandy CLAY (CH) high plasticity, brown yellow with grey white, very stiff, moist, dry of plastic limit, (Moorabool Formation) *(continued)*		10.0				
11.0			11.0				Backfill (0 - 23.4m bgl)
12.0			12.0	12.00-12.4/U63	PP=450		
13.0			13.0				
14.0			14.0				
15.0			15.0	15.00/SPT	SPT@15m 10/7/8 N=15		
16.0			16.0				
17.0			17.0				
18.0			18.0	18.00-18.4/U63	PP=500		
19.0			19.0				
	Gravelly SAND (SW) fine and coarse grained, well graded, brown red, very dense, very moist						

Key:
For explanation of abbreviations and symbols, refer to Cardno UCS or Rock Notes

Notes:
Water loss from 8.5m to 32.4m

Groundwater Observations:
Groundwater observed at 8.5mbgl

(Continued Next Page)

Borehole Record: BH02

Project: Jetty's Road Foreshore

Location: 102 - 170 McDermott Road, Curlewis, VIC, 3222

Job No.: V220433 / 304400703

Position: 55H E: 284600 N: 5773768

Surface Level: 23.100 AHD

Stickup: 1.15 m

Inclination: Vertical

Date St.: 11/10/2022 **Date Comp.:** 11/10/2022

Drill Rig: Hanjin D&B - 8D

Drilling Method: 100mm Dia. Solid Auger Washbore

Logged/Checked: SK / SE

Depth (m)	Description of Strata	Graphic Log	Depth (m)	Sample	In Situ Testing	Well Graph	Remarks
20.0	Sandy CLAY (CH) high plasticity, brown yellow with grey, stiff, moist, dry of plastic limit, (Moorabool Formation)		20.0	20.00/SPT	SPT@20m 12/15/21 N=36		
21.0			21.0	21.50-21.8/U63	PP=150		
22.0			22.0				
23.0			23.0	23.00/SPT	SPT@23m 11/16/23 N=39		
24.0			24.0	24.50/SPT	SPT@24.5m 4/5/11 N=16		Bentonite (23.4 - 25.4m bgl)
25.0			25.0				
26.0			26.0	26.00/SPT	SPT@26m 26/27/28 N=55		
27.0			27.0				
28.0			28.0	27.50/SPT	SPT@27.5m 10/16/20 N=36		
29.0			29.0	29.00/SPT	SPT@29m 15/24/27 N=51		Sand (25.4 - 32.4m bgl) Screen (26.4 - 32.4m bgl)

Key:
For explanation of abbreviations and symbols, refer to Cardno UCS or Rock Notes

Notes:
Water loss from 8.5m to 32.4m

Groundwater Observations:
Groundwater observed at 8.5mbgl

(Continued Next Page)

Borehole Record: BH02

Cardno Shaping the Future

Project: Jetty's Road Foreshore

Location: 102 - 170 McDermott Road, Curlewis, VIC, 3222

Job No.: V220433 / 304400703

Position: 55H E: 284600 N: 5773768

Surface Level: 23.100 AHD

Stickup: 1.15 m

Inclination: Vertical

Date St.: 11/10/2022 **Date Comp.:** 11/10/2022

Drill Rig: Hanjin D&B - 8D

Drilling Method: 100mm Dia. Solid Auger Washbore

Logged/Checked: SK / SE

Depth (m)	Description of Strata	Graphic Log	Depth (m)	Sample	In Situ Testing	Well Graph	Remarks
30.0	Sandy CLAY (CH) high plasticity, brown yellow with grey, stiff, moist, dry of plastic limit, (Moorabool Formation) *(continued)*		30.0	30.50/SPT	SPT@30.5m 16/5 spt hammer broke down N>50		
31.0			31.0				
32.0			32.0	32.00-32.4/U63	PP=200		
	Borehole terminated at target depth at 32.4m						

Key:
For explanation of abbreviations and symbols, refer to Cardno UCS or Rock Notes

Notes:
Water loss from 8.5m to 32.4m

Groundwater Observations:
Groundwater observed at 8.5mbgl

Borehole Record: BH03

Project: Jetty's Road Foreshore

Location: 102 - 170 McDermott Road, Curlewis, VIC, 3222

Job No.: V220433 / 304400703

Position: 55H E: 284672 N: 5773848

Surface Level: 17.406 AHD

Stickup: N/A

Inclination: Vertical

Date St.: 26/09/2022 **Date Comp.:** 27/09/2022

Drill Rig: Hanjin D&B - 8D

Drilling Method: 100mm Dia. Solid Auger Washbore

Logged/Checked: SK / SE

Depth (m)	Description of Strata	Graphic Log	Depth (m)	Sample	In Situ Testing	Remarks
0.0	FILL, Sandy Clayey SILT (ML) low plasticity, brown, stiff to very stiff, moist, near plastic limit		0.0	0.50/D	PP=400	
1.0			1.0	1.00/D	PP=400	
	FILL, CLAY (CI) medium plasticity, pale brown, very stiff, moist, dry of plastic limit			1.50/D	PP=600	
2.0	FILL, Sandy CLAY (CI) medium plasticity, brown, very stiff, moist, dry of plastic limit		2.0	2.00/D	PP=600	
				2.50/D	PP=600	
3.0	Sandy Silty CLAY (CH) high plasticity, brown yellow, very stiff, moist, dry of plastic limit, trace gravel, (Moorabool Formation)		3.0	2.99/D 3.00-3.2/U63 3.20/D	PP=600	
4.0			4.0			
	Clayey SAND (SC) fine to medium grained, poorly graded, pale brown yellow, medium dense, dry, (Moorabool Formation)			4.49/D 4.50/SPT	SPT@4.5m 1/3/9 N=12	
5.0			5.0			
				5.50/D		
6.0	CLAY (CH) high plasticity, pale brown, very stiff, moist, dry of plastic limit, (Moorabool Formation)		6.0	5.99/D 6.00-6.5/U63	PP=500	
	Sandy CLAY (CL) low plasticity, pale grey white, stiff, moist, near plastic limit to moist, wet of plastic limit, (Moorabool Formation)					
7.0			7.0	7.00/D		
				7.49/D 7.50/SPT	SPT@7.5m 8/12/15 N=27	
8.0			8.0			
9.0			9.0	8.99/D 9.00-9.5/U63	PP=200	

Key:
For explanation of abbreviations and symbols, refer to Cardno UCS or Rock Notes

Notes:
Water loss from 20.0m

Groundwater Observations:
Groundwater observed at 6.4mbgl

(Continued Next Page)

Borehole Record: BH03

Cardno Shaping the Future

Project: Jetty's Road Foreshore

Location: 102 - 170 McDermott Road, Curlewis, VIC, 3222

Job No.: V220433 / 304400703

Position: 55H E: 284672 N: 5773848

Surface Level: 17.406 AHD

Stickup: N/A

Inclination: Vertical

Date St.: 26/09/2022 **Date Comp.:** 27/09/2022

Drill Rig: Hanjin D&B - 8D

Drilling Method: 100mm Dia. Solid Auger Washbore

Logged/Checked: SK / SE

Depth (m)	Description of Strata	Graphic Log	Depth (m)	Sample	In Situ Testing	Remarks
10.0	Sandy CLAY (CL) low plasticity, pale grey white, stiff, moist, near plastic limit to moist, wet of plastic limit, (Moorabool Formation) *(continued)*		10.0	10.50-11.0/U63		
	Clayey SAND (SC) fine to coarse grained, well graded, pale grey with brown, dense, moist, (Moorabool Formation)					
11.0			11.0			
12.0			12.0	11.99/D 12.00/SPT	SPT@12m 5/7/5 N=12	
13.0			13.0	13.49/D 13.50-14.0/U63		
14.0			14.0			
15.0	Sandy CLAY (CH) high plasticity, pale grey with brown, very stiff, moist, dry of plastic limit, (Moorabool Formation)		15.0	14.99/D 15.00/SPT	PP=100 SPT@15m 4/8/12 N=20	
16.0			16.0			
				16.49/D 16.50-17.0/U50	PP=100	
17.0			17.0			
18.0	Trace gravel at 18.0m		18.0	17.99/D 18.00/SPT	SPT@18m 6/9/12 N=21	
19.0			19.0			
				19.49/D 19.50-20.0/U50	PP=150	

Key:
For explanation of abbreviations and symbols, refer to Cardno UCS or Rock Notes

Notes:
Water loss from 20.0m

Groundwater Observations:
Groundwater observed at 6.4mbgl

(Continued Next Page)

Borehole Record: BH03

Project: Jetty's Road Foreshore

Location: 102 - 170 McDermott Road, Curlewis, VIC, 3222

Job No.: V220433 / 304400703

Position: 55H E: 284672 N: 5773848

Surface Level: 17.406 AHD

Stickup: N/A

Inclination: Vertical

Date St.: 26/09/2022 **Date Comp.:** 27/09/2022

Drill Rig: Hanjin D&B - 8D

Drilling Method: 100mm Dia. Solid Auger Washbore

Logged/Checked: SK / SE

Depth (m)	Description of Strata	Graphic Log	Depth (m)	Sample	In Situ Testing	Remarks
20.0	Sandy CLAY (CH) high plasticity, pale grey with brown, very stiff, moist, dry of plastic limit, (Moorabool Formation) *(continued)*		20.0			Comenced washboring at 20.0m
21.0			21.0	21.00/SPT	SPT@21m 5/8/6 N=14	
22.0			22.0			
	Silty CLAY (CH) high plasticity, grey, stiff to very stiff, moist, near plastic limit, with sand, and gravel, (Fyansford Formation)			22.50/SPT	SPT@22.5m 2/3/6 N=9	
23.0			23.0			
24.0	Silty SAND (SM) fine to medium grained, poorly graded, grey, dense, moist, (Fyansford Formation)		24.0	24.00/SPT	SPT@24m 11/16/23 N=39	
	Borehole terminated at target depth at 24.45m					

Key:
For explanation of abbreviations and symbols, refer to Cardno UCS or Rock Notes

Notes:
Water loss from 20.0m

Groundwater Observations:
Groundwater observed at 6.4mbgl

Borehole Record: BH04

Project: Jetty's Road Foreshore

Location: 102 - 170 McDermott Road, Curlewis, VIC, 3222

Job No.: V220433 / 304400703

Position: 55H E: 284849 N: 5773842

Surface Level: 22.316 AHD

Stickup: 1.1 m

Inclination: Vertical

Date St.: 4/10/2022 **Date Comp.:** 4/10/2022

Drill Rig: Hanjin D&B - 8D

Drilling Method: 100mm Dia. Solid Auger Washbore

Logged/Checked: SK / SE

Depth (m)	Description of Strata	Graphic Log	Depth (m)	Sample	In Situ Testing	Well Graph	Remarks
0.0	TOPSOIL, Clayey SILT (ML) low plasticity, brown black, soft to firm, moist, near plastic limit		0.0	0.50/D	PP=100		
1.0	Sandy CLAY (CH) high plasticity, grey with brown yellow, stiff to very stiff, moist, dry of plastic limit, (Moorabool Formation)		1.0	1.00/D	PP=250		
	Becoming brown yellow at 1.5m			1.50/D	PP=300		
2.0			2.0	2.00/D	PP=200		
				2.50/D	PP=250		
3.0	Becoming friable, brown, yellow with grey white at 3.0m		3.0	2.99/D 3.00/SPT	PP=300 SPT@3m 8/22/34 N=56		
4.0			4.0				
5.0			5.0				
6.0			6.0	6.00-6.2/U63	PP=300		
7.0			7.0				
8.0	Becoming moist, near of plastiic limit at 8.0m		8.0				
9.0			9.0	9.00/SPT	SPT@9m 5/12/16 N=28		Backfill (0 - 18m bgl) Commenced washboring at 9.0m

Key:
For explanation of abbreviations and symbols, refer to Cardno UCS or Rock Notes

Notes:
Water loss from 9.0m to 22.0m

Complete water loss at 22.0m

Groundwater Observations:
Groundwater observed at 8.5mbgl

(Continued Next Page)

Borehole Record: BH04

Project: Jetty's Road Foreshore

Location: 102 - 170 McDermott Road, Curlewis, VIC, 3222

Job No.: V220433 / 304400703

Position: 55H E: 284849 N: 5773842

Surface Level: 22.316 AHD

Stickup: 1.1 m

Inclination: Vertical

Date St.: 4/10/2022 **Date Comp.:** 4/10/2022

Drill Rig: Hanjin D&B - 8D

Drilling Method: 100mm Dia. Solid Auger Washbore

Logged/Checked: SK / SE

Depth (m)	Description of Strata	Graphic Log	Depth (m)	Sample	In Situ Testing	Well Graph	Remarks
10.0	Sandy CLAY (CH) high plasticity, grey with brown yellow, stiff to very stiff, moist, dry of plastic limit, (Moorabool Formation) *(continued)*		10.0				
11.0			11.0				
12.0	Becoming hard at 12.0m		12.0	12.00-12.5/U63	PP=600		
13.0			13.0				
14.0			14.0				
15.0			15.0	15.00/SPT	SPT@15m 4/7/10 N=17		
16.0			16.0				
17.0			17.0				
18.0	Becoming very stiff at 18.0m		18.0	18.00-18.2/U63	PP=300		
19.0			19.0				Bentonite (18 - 20m bgl)
				19.50/SPT	SPT@19.5m		

Key:
For explanation of abbreviations and symbols, refer to Cardno UCS or Rock Notes

Notes:
Water loss from 9.0m to 22.0m

Complete water loss at 22.0m

Groundwater Observations:
Groundwater observed at 8.5mbgl

(Continued Next Page)

Borehole Record: BH04

Project: Jetty's Road Foreshore

Location: 102 - 170 McDermott Road, Curlewis, VIC, 3222

Job No.: V220433 / 304400703

Position: 55H E: 284849 N: 5773842

Surface Level: 22.316 AHD

Stickup: 1.1 m

Inclination: Vertical

Date St.: 4/10/2022 **Date Comp.:** 4/10/2022

Drill Rig: Hanjin D&B - 8D

Drilling Method: 100mm Dia. Solid Auger Washbore

Logged/Checked: SK / SE

Depth (m)	Description of Strata	Graphic Log	Depth (m)	Sample	In Situ Testing	Well Graph	Remarks
20.0	Sandy CLAY (CH) high plasticity, grey with brown yellow, stiff to very stiff, moist, dry of plastic limit, (Moorabool Formation) *(continued)*		20.0				
21.0	Ironstone cobble at 21.0m		21.0	21.00/D			
22.0			22.0	22.50/SPT	SPT@22.5m 9/13/17 N=30		
23.0	Clayey SAND (SC) fine to coarse grained, well graded, brown yellow, very dense, moist, (Moorabool Formation)		23.0				Sand (20 - 27.45m bgl)
24.0			24.0	24.00-24.4/U63			Screen (21 - 27.45m bgl)
25.0			25.0				
	Silty Clayey SAND (SC-SM) fine to medium grained, poorly graded, grey, dense, moist, (Fyansford Formation)			25.50/SPT	SPT@25.5m 7/8/18 N=26		
26.0			26.0				
27.0			27.0	27.00/SPT	SPT@27m 7/9/16 N=25		
	Borehole terminated at target depth at 27.45m						

Key:
For explanation of abbreviations and symbols, refer to Cardno UCS or Rock Notes

Notes:
Water loss from 9.0m to 22.0m

Complete water loss at 22.0m

Groundwater Observations:
Groundwater observed at 8.5mbgl

Borehole Record: BH05

Project: Jetty's Road Foreshore

Location: 102 - 170 McDermott Road, Curlewis, VIC, 3222

Job No.: V220433 / 304400703

Position: 55H E: 284842 N: 5773801

Surface Level: 26.278 AHD

Stickup: 1 m

Inclination: Vertical

Date St.: 21/10/2022 **Date Comp.:** 22/10/2022

Drill Rig: Hanjin D&B - 8D

Drilling Method: 100mm Dia. Solid Auger Washbore

Logged/Checked: SK / SE

Depth (m)	Description of Strata	Graphic Log	Depth (m)	Sample	In Situ Testing	Well Graph	Remarks
0.0	TOPSOIL, Clayey SILT (ML) low plasticity, brown black, soft to firm, moist, near plastic limit		0.0	0.50/D	PP=200		
1.0	Sandy CLAY (CH) high plasticity, grey with brown yellow, stiff to very stiff, moist, dry of plastic limit, (Moorabool Formation)		1.0	1.00/D 1.50/D	PP=350 PP=250		
2.0	Clayey SAND (SC) fine to coarse grained, well graded, grey white with brown yellow, dense, dry, (Moorabool Formation)		2.0	2.00/D 2.50/D			
3.0			3.0	2.99/D 3.00/SPT	SPT@3m 6/15/23 N=38		
4.0			4.0				
5.0			5.0				
6.0			6.0				
				6.50-7.0/U63			
7.0			7.0				
8.0			8.0				
9.0	Sandy CLAY (CH) high plasticity, brown yellow with grey white, stiff, moist, dry of plastic limit, (Moorabool Formation)		9.0	9.50/SPT	SPT@9.5m 2/6/9 N=15		

Key:
For explanation of abbreviations and symbols, refer to Cardno UCS or Rock Notes

Notes:
Complete water loss at 11.5m

Complete water loss at 15.5m

Groundwater Observations:
Groundwater observed at 11.0mbgl

(Continued Next Page)

Borehole Record: BH05

Project: Jetty's Road Foreshore

Location: 102 - 170 McDermott Road, Curlewis, VIC, 3222

Job No.: V220433 / 304400703

Position: 55H E: 284842 N: 5773801

Surface Level: 26.278 AHD

Stickup: 1 m

Inclination: Vertical

Date St.: 21/10/2022 **Date Comp.:** 22/10/2022

Drill Rig: Hanjin D&B - 8D

Drilling Method: 100mm Dia. Solid Auger Washbore

Logged/Checked: SK / SE

Depth (m)	Description of Strata	Graphic Log	Depth (m)	Sample	In Situ Testing	Well Graph	Remarks
10.0	Sandy CLAY (CH) high plasticity, brown yellow with grey white, stiff, moist, dry of plastic limit, (Moorabool Formation) *(continued)* Becoming moist, near of plastiic limit and with gravel at 10.5m		10.0				
11.0			11.0				Commenced washboring at 11.5m
12.0			12.0	12.50-12.6/U63	PP=600		
13.0			13.0				Backfill (0 - 26.45m bgl)
14.0			14.0				
15.0			15.0	15.50-15.6/SPT	SPT@15.5m 14/10/9 N=19		
16.0			16.0				
17.0			17.0				
18.0	Becoming very stiff at 18.5m		18.0	18.50-19.0/U63	PP=500		
19.0			19.0				

Key:
For explanation of abbreviations and symbols, refer to Cardno UCS or Rock Notes

Notes:
Complete water loss at 11.5m

Complete water loss at 15.5m

Groundwater Observations:
Groundwater observed at 11.0mbgl

(Continued Next Page)

Borehole Record: BH05

Project: Jetty's Road Foreshore

Location: 102 - 170 McDermott Road, Curlewis, VIC, 3222

Job No.: V220433 / 304400703

Position: 55H E: 284842 N: 5773801

Surface Level: 26.278 AHD

Stickup: 1 m

Inclination: Vertical

Date St.: 21/10/2022 **Date Comp.:** 22/10/2022

Drill Rig: Hanjin D&B - 8D

Drilling Method: 100mm Dia. Solid Auger Washbore

Logged/Checked: SK / SE

Depth (m)	Description of Strata	Graphic Log	Depth (m)	Sample	In Situ Testing	Well Graph	Remarks
20.0	Clayey SAND (SC) fine to coarse grained, well graded, brown yellow, medium dense to dense, moist, (Moorabool Formation) *(continued)*		20.0	20.00/SPT	SPT@20m 6/8/10 N=18		
21.0			21.0	21.50-21.9/U63			
22.0			22.0				
23.0	Sandy CLAY (CH) high plasticity, brown yellow with grey, very stiff, moist, dry of plastic limit, (Moorabool Formation)		23.0	23.00/SPT	SPT@23m 11/12/15 N=27		
24.0			24.0	24.50-24.8/U63	PP=450		
25.0			25.0				
26.0	Clayey SAND (SC) fine to coarse grained, well graded, brown yellow, medium dense to dense, moist, (Moorabool Formation)		26.0	26.00/SPT	SPT@26m 9/16/23 N=39		
27.0			27.0	27.50-28.0/U63			Bentonite (26.45 - 28.42m bgl)
28.0			28.0				
29.0	Becoming very dense at 29.0m		29.0	29.00/SPT	SPT@29m 11/22/33 N=55		

Key:
For explanation of abbreviations and symbols, refer to Cardno UCS or Rock Notes

Notes:
Complete water loss at 11.5m

Complete water loss at 15.5m

Groundwater Observations:
Groundwater observed at 11.0mbgl

(Continued Next Page)

Borehole Record: BH05

Project: Jetty's Road Foreshore

Location: 102 - 170 McDermott Road, Curlewis, VIC, 3222

Job No.: V220433 / 304400703

Position: 55H E: 284842 N: 5773801

Surface Level: 26.278 AHD

Stickup: 1 m

Inclination: Vertical

Date St.: 21/10/2022 **Date Comp.:** 22/10/2022

Drill Rig: Hanjin D&B - 8D

Drilling Method: 100mm Dia. Solid Auger Washbore

Logged/Checked: SK / SE

Depth (m)	Description of Strata	Graphic Log	Depth (m)	Sample	In Situ Testing	Well Graph	Remarks
30.0	Silty Clayey SAND (SC-SM) fine grained, poorly graded, grey, dense, moist, (Fyansford Formation)		30.0	30.50/SPT	SPT@30.5m 14/13/21 N=34		
31.0			31.0				
32.0			32.0	32.00/SPT	SPT@32m 10/23/26 N=49		Sand (28.45 - 35.45m bgl)
33.0			33.0	33.50/SPT	SPT@33.5m 13/24/28 N=52		Screen (29.45 - 35.45m bgl)
34.0			34.0				
35.0			35.0	35.00-35.5/U63	PP=250		
	Borehole terminated at target depth at 35.45m						

Key:
For explanation of abbreviations and symbols, refer to Cardno UCS or Rock Notes

Notes:
Complete water loss at 11.5m

Complete water loss at 15.5m

Groundwater Observations:
Groundwater observed at 11.0mbgl

Borehole Record: BH06

Project: Jetty's Road Foreshore

Location: 102 - 170 McDermott Road, Curlewis, VIC, 3222

Job No.: V220433 / 304400703

Position: 55H E: 284944 N: 5773830

Surface Level: 20.458 AHD

Stickup: N/A

Inclination: Vertical

Date St.: 27/09/2022 **Date Comp.:** 3/10/2022

Drill Rig: Hanjin D&B - 8D

Drilling Method: 100mm Dia. Solid Auger Washbore

Logged/Checked: SK / SE

Depth (m)	Description of Strata	Graphic Log	Depth (m)	Sample	In Situ Testing	Remarks
0.0	TOPSOIL, Clayey SILT (ML) low plasticity, brown black, soft to firm, moist, near plastic limit		0.0	0.50/D		
1.0	Sandy CLAY (CH) high plasticity, brown with grey white, stiff, moist, dry of plastic limit, (Moorabool Formation)		1.0	1.00/D	PP=200	
				1.50/D	PP=200	
2.0	Becoming very stiff to hard at 2.0m		2.0	2.00/D	PP=400	
				2.50/D	PP=600	
	Becoming pale grey, brown yellow and friable at 2.7m					
3.0			3.0	3.00/D 3.01-3.2/U63	PP=600	
4.0			4.0			
				4.50/SPT	SPT@4.5m 13/16/20 N=36	
5.0			5.0			
6.0	Becoming moist, near of plastiic limit at 6.0m		6.0	6.00-6.5/U63	PP=450	
7.0			7.0			Commenced washboring at 7.0m
				7.50/SPT	SPT@7.5m 4/8/8 N=16	
8.0			8.0			
9.0			9.0	9.00-9.5/U63	PP=600+	
	With gravel at 9.45m					

Key:
For explanation of abbreviations and symbols, refer to Cardno UCS or Rock Notes

Notes:
Complete water loss at 24.5m

Groundwater Observations:
Groundwater observed at 6.5mbgl

(Continued Next Page)

Borehole Record: BH06

Project: Jetty's Road Foreshore

Location: 102 - 170 McDermott Road, Curlewis, VIC, 3222

Job No.: V220433 / 304400703

Position: 55H E: 284944 N: 5773830

Surface Level: 20.458 AHD

Stickup: N/A

Inclination: Vertical

Date St.: 27/09/2022 **Date Comp.:** 3/10/2022

Drill Rig: Hanjin D&B - 8D

Drilling Method: 100mm Dia. Solid Auger Washbore

Logged/Checked: SK / SE

Depth (m)	Description of Strata	Graphic Log	Depth (m)	Sample	In Situ Testing	Remarks
10.0	Sandy CLAY (CH) high plasticity, brown with grey white, stiff, moist, dry of plastic limit, (Moorabool Formation) *(continued)*		10.0	10.50/SPT	SPT@10.5m 7/7/3 N=10	
11.0			11.0			
12.0			12.0	12.00-12.3/U63	PP=600+	
	Becoming hard, possible ironstone at 12.34m					
13.0			13.0	13.50/SPT	SPT@13.5m 8/12/12 N=24	
14.0			14.0			
15.0			15.0	15.00-15.5/U63	PP=400	
16.0			16.0			
	Clayey SAND (SC) fine to coarse grained, well graded, brown yellow, dense, very moist, (Moorabool Formation)			16.50/SPT	SPT@16.5m 12/14/22 N=36	
17.0			17.0			
18.0	Silty SAND (SM) fine to medium grained, poorly graded, brown yellow, dense, dry, (Moorabool Formation)		18.0	18.00-18.4/U63		
19.0			19.0			
	Sandy CLAY (CH) high plasticity, brown yellow, very stiff, moist, dry of plastic limit, (Moorabool Formation)			19.50/SPT	SPT@19.5m 6/18/19 refusal,	

Key:
For explanation of abbreviations and symbols, refer to Cardno UCS or Rock Notes

Notes:
Complete water loss at 24.5m

Groundwater Observations:
Groundwater observed at 6.5mbgl

(Continued Next Page)

Borehole Record: BH06

Project: Jetty's Road Foreshore

Location: 102 - 170 McDermott Road, Curlewis, VIC, 3222

Job No.: V220433 / 304400703

Position: 55H E: 284944 N: 5773830

Surface Level: 20.458 AHD

Stickup: N/A

Inclination: Vertical

Date St.: 27/09/2022 **Date Comp.:** 3/10/2022

Drill Rig: Hanjin D&B - 8D

Drilling Method: 100mm Dia. Solid Auger Washbore

Logged/Checked: SK / SE

Depth (m)	Description of Strata	Graphic Log	Depth (m)	Sample	In Situ Testing	Remarks
20.0	Sandy CLAY (CH) high plasticity, brown yellow, very stiff, moist, dry of plastic limit, (Moorabool Formation) *(continued)*		20.0		double bounce N>50	
21.0	Becoming firm and moist, near plastic limit at 21.0m		21.0	21.00-21.4/U63	PP=100	
22.0			22.0	22.50/SPT	SPT@22.5m 14/19/20 N=39	
23.0			23.0			
24.0	Becoming very stiff and moist, dry of plastic at 24.0m		24.0	24.00-24.5/U63	PP=400	
25.0			25.0			
	Gravelly SAND (SW) fine and coarse grained, well graded, brown red, medium dense, moist			25.50/SPT	SPT@25.5m	
26.0			26.0			
	Sandy Silty CLAY (CH) high plasticity, grey, stiff, moist, dry of plastic limit, (Fyansford Formation)					
27.0			27.0	27.00-27.5/U63	PP=300	
	Silty CLAY (CH) high plasticity, grey, stiff, moist, dry of plastic limit, (Fyansford Formation)			27.50/SPT	SPT@27.5m 16/30/29 N=59	
28.0			28.0			
				28.50/SPT	SPT@28.5m 6/4/11 N=15	
	Borehole terminated at target depth at 28.95m					

Key:
For explanation of abbreviations and symbols, refer to Cardno UCS or Rock Notes

Notes:
Complete water loss at 24.5m

Groundwater Observations:
Groundwater observed at 6.5mbgl

PARTICLE SIZES

TERM		SIZE (mm)
BOULDER		>200
COBBLE		60 to 200
GRAVEL		
	Coarse	20 to 60
	Medium	6 to 20
	Fine	2 to 6
SAND		
	Coarse	0.6 to 2
	Medium	0.2 to 0.6
	Fine	0.06 to 0.2
SILT		0.002 to 0.06
CLAY		< 0.002

COHESIVE SOILS

TERM	UNDRAINED SHEAR STRENGTH (kPa)
Very Soft	0 to 12.5
Soft	12.5 to 25
Firm	25 to 50
Stiff	50 to 100
Very Stiff	100 to 200
Hard	≥ 200

COHESIONLESS SOILS

TERM	'N' (SPT) VALUE (blows / 300mm)	RELATIVE DENSITY (%)	ANGLE SHEAR RESISTANCE (degrees)
Very Loose	0 to 4	< 15	25 to 30
Loose	4 to 10	15 to 35	27 to 32
Medium Dense	10 to 30	35 to 65	30 to 35
Dense	30 to 50	65 to 85	35 to 40
Very Dense	> 50	≥ 85	38 to 43

STRUCTURE

TERM	SIZE OF BLOCKS (mm)
Blocky	> 60
Cloddy	20 to 60
Nutty	6 to 20
Granular	0.6 to 6
Prismatic	Stated
Shattered	< 10

SAMPLES

BS = Bulk sample
D = Disturbed sample
U(n) = Undisturbed tube sample ('n' denotes internal dia in mm)
■ = Undisturbed tube recovery
▨ = Undisturbed tube non-recovery
⊠ = SPT Disturbed sample

GROUNDWATER

GW = Groundwater depth (m) or level (RL)
bgl = Below ground level
swl = Standing water level

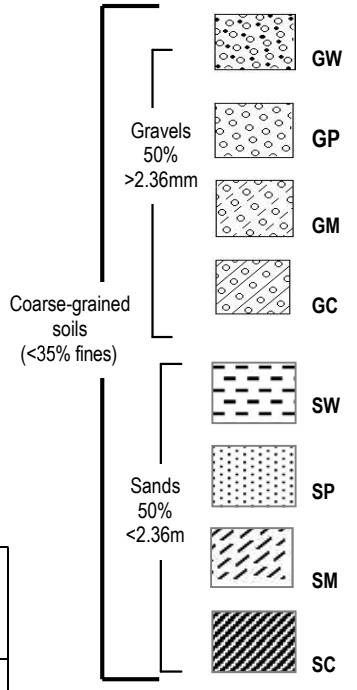
FIELD TESTS

W = Field permeability test
P = Pressuremeter test
ID = Insitu density test
SPT(9) = Standard Penetrometer Test (*blows per 300 mm*) (63.5 kg hammer dropped 760mm)
PP = Pocket Penetrometer (kPa)
DCP = Dynamic Cone Penetrometer Test

IDENTIFICATION OF SOILS

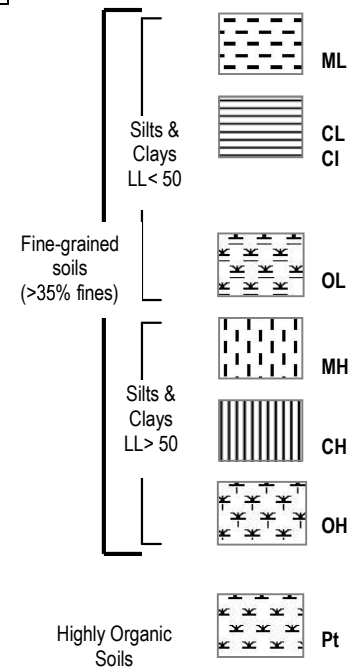
FILL

COARSE GRAINED SOILS



GW	Well graded gravels and gravel-sand mixtures, little or no fines
GP	Poorly graded gravels and gravel-sand mixtures, little or no fines
GM	Silty gravels and gravel- sand-clay mixtures
GC	Clayey gravels, gravel-sand-clay mixture
SW	Well graded sands and gravelly sands, little or no fines
SP	Poorly graded sands and gravelly sands, little or no fines
SM	Silty sand, sandy silt mixture
SC	Clayey sands, sandy clay mixtures

FINE GRAINED SOILS



ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands of low plasticity
CL **CI**	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays
OL	Organic silts and organic silty clays of low plasticity
MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts of high plasticity
CH	Inorganic clays of high plasticity, gravelly clays, sandy clays, silty clays
OH	Organic clays and silts of medium to high plasticity
Pt	Peat and other highly organic soils

MINOR COMPONENTS

Coarse Grained Soils:
Trace: <5% fines
With: >5% and <12% fines
Prefix 'Silty/Clayey': >12% fines
% accessory coarse faction
Trace: <15% sand/gravel
With: >15% and <30% sand/gravel
Prefix 'Sandy/Gravelly': >30% sand/gravel

Fine Grained Soils:
Trace: <15% sand/gravel
With: >15% and <30% sand/gravel
Prefix 'Sandy/Gravelly': >30% sand/gravel

Rock Description Notes & Abbreviations

Sample Types		Field Tests	
U(*n*)	Undisturbed tube sample *('n' denotes the diameter in mm)*	**W**	Field permeability tests over the length shown
D	Disturbed sample	**P**	Pressuremeter test
NMLC	Core obtained in a 52mm dia. triple tube rotary core barrel	**SPT (*N*)**	Standard Penetrometer Test *(no. of blows required by a 63.5 kg hammer dropped 760 mm to drive a sampler 300mm)*
NQ	Core obtained in a 47mm dia. wireline, triple tube rotary core barrel	**pp**	Pocket penetrometer test (kPa)

Structure Details			
J	Joint	**SM**	Smooth surface of the joint
F	Fracture	**R**	Ridged surface of the joint
IJ	Incipient joint	**ST**	Stepped surface of the joint
x.x	Depth of joint at 'x.x' m	**VR**	Very rough surface of the joint
y°	Dip angle of joint in 'y' degrees	**SL**	Slickensided surface of the joint
z mm	Width of joint in 'z' mm	**NI**	Non-intact – recovered in a non-intact state
Fe	Iron oxide staining	**NR**	No recovery from the core run
L	Limonite staining	**CI**	Clay infill
▮	Rock core loss during the coring if the location of the loss is known. Otherwise the recovery is represented as a percentage of the core run.	**DI**	Drill induced fracture
		RQD	Rock Quality Designation (%), defined as: $= \frac{Sum\ of\ sound\ core\ pieces > 100mm}{Total\ length\ of\ the\ section} \times 100$

Joint Spacing Details		Rock Quality Design	
Term	**Spacing**	**RQD (%)**	**Rock Quality**
Very widely spaced	> 2.0m	0 - 25	Very poor
Widely spaced	600mm – 2.0m	25 - 50	Poor
Moderately widely spaced	200mm – 600mm	50 - 75	Fair
Closely spaced	60mm – 200mm	75 - 90	Good
Very closely spaced	20mm – 60mm	90 - 100	Excellent
Extremely closely spaced	< 20mm		

Rock Weathering Classification		
Term	**Abbreviation**	**Features**
Fresh	**FR**	No weathering effects visible to the naked eye. No signs of decomposition.
Slightly Weathered	**SW**	Visible change in appearance, but no significant loss in strength.
Moderately Weathered	**MW**	Visible change in appearance with significant loss in strength. Rock pieces cannot be broken by hand across fabric and material is not friable.
Highly Weathered	**HW**	Considerable change in appearance and loss in strength. Material is still rock but normally very weak. Rock pieces can generally be broken by hand across the rock fabric and the material is partly friable.
Completely Weathered	**CW**	Has soil properties and often shows complete change in appearance.
Altered	**A**	Shows chemical and physical alterations to rock fabric caused by temperature, pressure or injection of other material.

Rock Strength		
Term	**Abbreviation**	**Point Load Strength Index $I_{s(50)}$ (MPa)**
Extremely Low	**EL**	< 0.03
Very Low	**VL**	0.03 – 0.1
Low	**L**	0.1 – 0.3
Medium	**M**	0.3 – 1.0
High	**H**	1.0 – 3.0
Very High	**VH**	3.0 – 10
Extremely High	**EH**	≥ 10

Appendix C – LABORATORY TEST RESULTS

Material Test Report

Cardno Victoria Pty Ltd
501 Swanston Street Melbourne VIC 3000
Phone: (07) 4952 5255
Email: arveendra.gounder@cardno.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

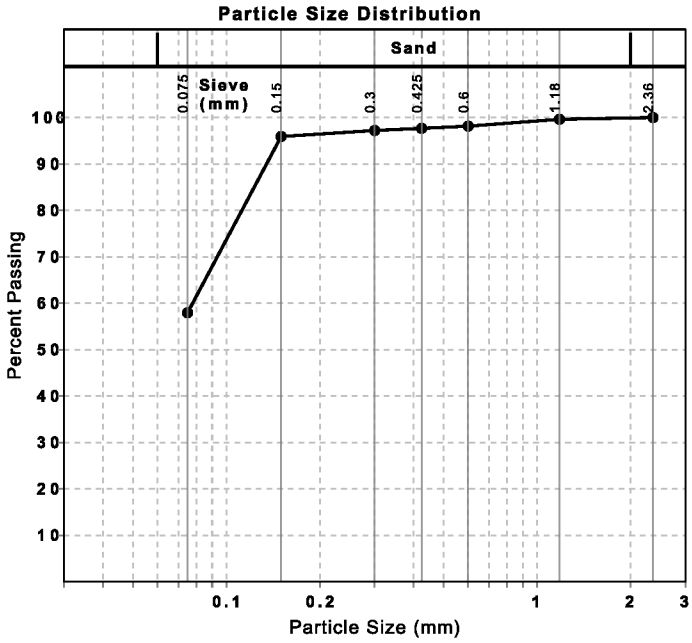
[redacted]

Approved Signator[redacted]
Laboratory Manager
NATA Accredited Laboratory Number: 3145

Report Number: **V220433-2**
Issue Number: 1
Date Issued: 15/11/2022
Client: Developer Consortium
Suite 2, Level 8, 412 St Kilda Rd,, Melbourne VIC 3004
Project Number: V220433
Project Name: Jettys Road Foreshore
Project Location: 102 - 107 McDermott Road, Curlewis, VIC 3222
Work Request: 165
Sample Number: 22-165B
Date Sampled: 10/10/2022
Dates Tested: 02/11/2022 - 08/11/2022
Sampling Method: Sampled by Engineering Department
The results apply to the sample as received
Sample Location: **BH01, Depth: 21.0(m)**
Material: Sandy silty CLAY

Particle Size Distribution (AS1289 3.6.1)			
Sieve	Passed %	Passing Limits	
2.36 mm	**100**		
1.18 mm	**100**		
0.6 mm	**98**		
0.425 mm	**98**		
0.3 mm	**97**		
0.15 mm	**96**		
0.075 mm	**58**		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	77		
Plastic Limit (%)	20		
Plasticity Index (%)	**57**		



Material Test Report

Cardno Victoria Pty Ltd
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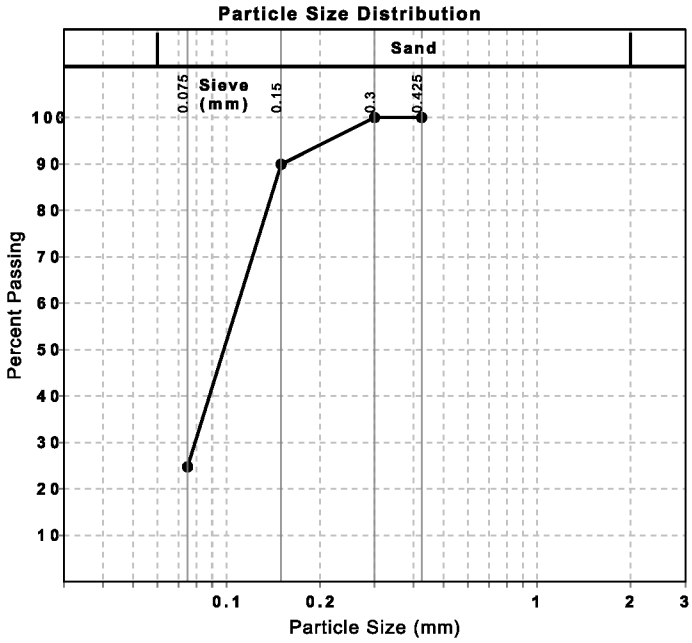
Approved Signatory: [redacted]
Laboratory Manager

NATA Accredited Laboratory Number: 3145

Report Number: V220433-2
Issue Number: 1
Date Issued: 15/11/2022
Client: Developer Consortium
Suite 2, Level 8, 412 St Kilda Rd,, Melbourne VIC 3004
Project Number: V220433
Project Name: Jettys Road Foreshore
Project Location: 102 - 107 McDermott Road, Curlewis, VIC 3222
Work Request: 165
Sample Number: 22-165C
Date Sampled: 10/10/2022
Dates Tested: 02/11/2022 - 09/11/2022
Sampling Method: Sampled by Engineering Department
The results apply to the sample as received
Sample Location: **BH02, Depth: 6.0(m) - 6.4(m)**
Material: Clayey silty SAND

Particle Size Distribution (AS1289 3.6.1)			
Sieve	Passed %	Passing Limits	
0.425 mm	**100**		
0.3 mm	**100**		
0.15 mm	**90**		
0.075 mm	**25**		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	29		
Plastic Limit (%)	22		
Plasticity Index (%)	**7**		



Material Test Report

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Approved Signatory: [redacted]
Laboratory Manager

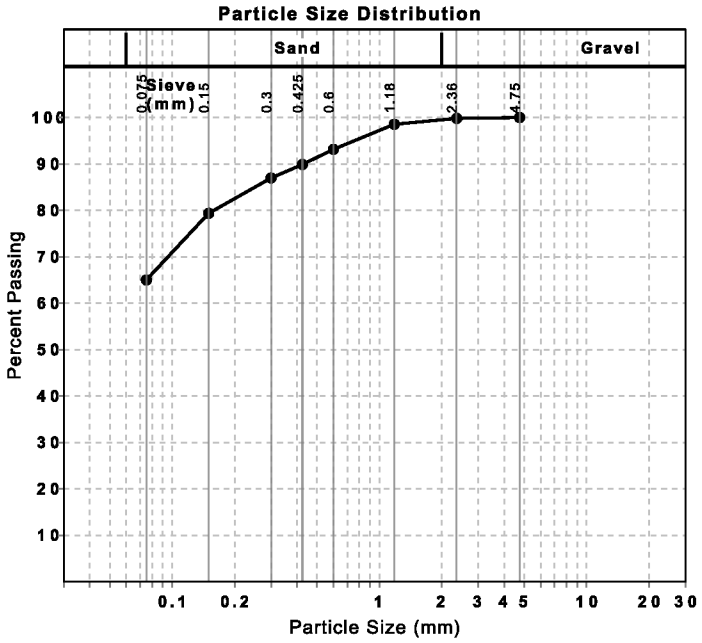
NATA Accredited Laboratory Number: 3145

Report Number: **V220433-1**
Issue Number: 1
Date Issued: 21/10/2022
Client: Developer Consortium
Suite 2, Level 8, 412 St Kilda Rd,, Melbourne VIC 3004
Project Number: V220433
Project Name: Jettys Road Foreshore
Project Location: 102 - 107 McDermott Road, Curlewis, VIC 3222
Work Request: 151
Sample Number: 22-151A
Date Sampled: 26/09/2022
Dates Tested: 03/10/2022 - 12/10/2022
Sampling Method: Sampled by Engineering Department
The results apply to the sample as received
Sample Location: **BH03, Depth: 3.0(m)**
Material: Sandy silty CLAY with trace gravel

Particle Size Distribution (AS1289 3.6.1)						
Sieve	Passed %	Passing Limits		Retained %	Retained Limits	
4.75 mm	**100**			0		
2.36 mm	**100**			0		
1.18 mm	**99**			1		
0.6 mm	**93**			5		
0.425 mm	**90**			3		
0.3 mm	**87**			3		
0.15 mm	**79**			8		
0.075 mm	**65**			14		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	74		
Plastic Limit (%)	22		
Plasticity Index (%)	**52**		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**2**		
Soil Description	Sandy silty CLAY with trace gravel		
Nature of Water	Distilled Water		
Temperature of Water (°C)	22		



Material Test Report

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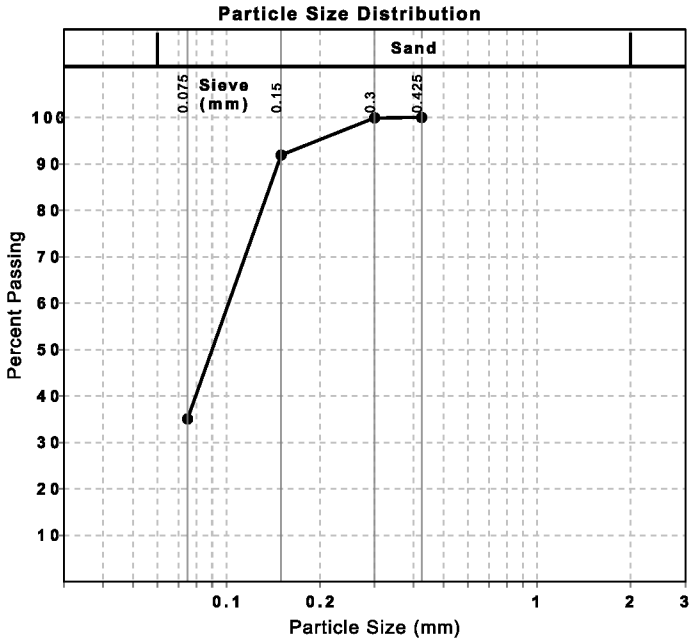
Approved Signatory: [redacted]
Laboratory Manager
NATA Accredited Laboratory Number: 3145

Report Number: **V220433-1**
Issue Number: 1
Date Issued: 21/10/2022
Client: Developer Consortium
Suite 2, Level 8, 412 St Kilda Rd,, Melbourne VIC 3004
Project Number: V220433
Project Name: Jettys Road Foreshore
Project Location: 102 - 107 McDermott Road, Curlewis, VIC 3222
Work Request: 151
Sample Number: 22-151B
Date Sampled: 26/09/2022
Dates Tested: 03/10/2022 - 11/10/2022
Sampling Method: Sampled by Engineering Department
The results apply to the sample as received
Sample Location: **BH03, Depth: 7.0(m)**
Material: Sandy CLAY

Particle Size Distribution (AS1289 3.6.1)						
Sieve	Passed %	Passing Limits		Retained %	Retained Limits	
0.425 mm	**100**			0		
0.3 mm	**100**			0		
0.15 mm	**92**			8		
0.075 mm	**35**			57		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	27		
Plastic Limit (%)	17		
Plasticity Index (%)	**10**		



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Approved Signatory

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Laboratory Manager

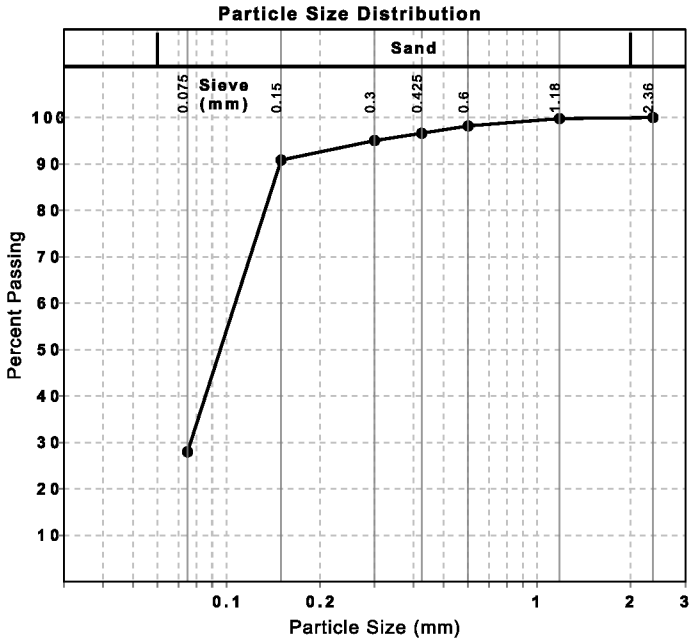
NATA Accredited Laboratory Number: 3145

Report Number: **V220433-1**
Issue Number: 1
Date Issued: 21/10/2022
Client: Developer Consortium
Suite 2, Level 8, 412 St Kilda Rd,, Melbourne VIC 3004
Project Number: V220433
Project Name: Jettys Road Foreshore
Project Location: 102 - 107 McDermott Road, Curlewis, VIC 3222
Work Request: 151
Sample Number: 22-151C
Date Sampled: 26/09/2022
Dates Tested: 03/10/2022 - 12/10/2022
Sampling Method: Sampled by Engineering Department
The results apply to the sample as received
Sample Location: **BH03, Depth: 10.5(m)**
Material: Clayey SAND

Particle Size Distribution (AS1289 3.6.1)						
Sieve	Passed %	Passing Limits		Retained %	Retained Limits	
2.36 mm	**100**			0		
1.18 mm	**100**			0		
0.6 mm	**98**			2		
0.425 mm	**97**			2		
0.3 mm	**95**			2		
0.15 mm	**91**			4		
0.075 mm	**28**			63		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	42		
Plastic Limit (%)	23		
Plasticity Index (%)	**19**		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**2**		
Soil Description	Clayey SAND		
Nature of Water	Distilled Water		
Temperature of Water (°C)	22		



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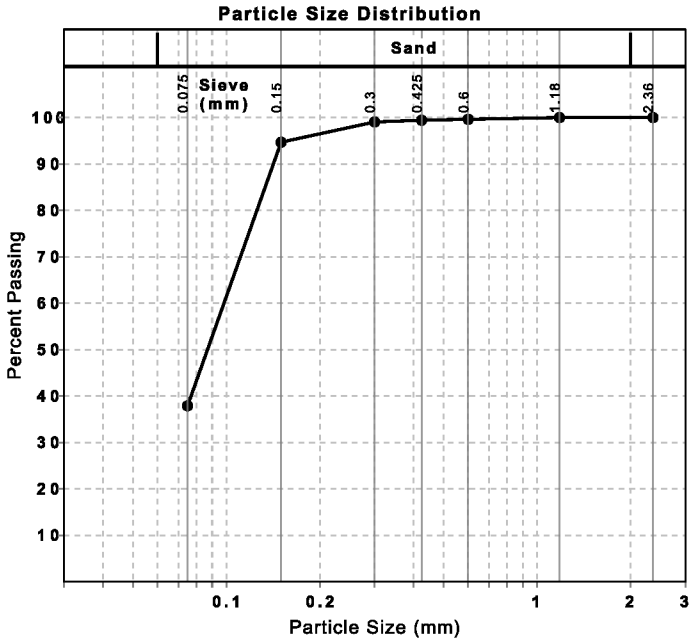
Approved Signatory [redacted]
Laboratory Manager
NATA Accredited Laboratory Number: 3145

Report Number: **V220433-1**
Issue Number: 1
Date Issued: 21/10/2022
Client: Developer Consortium
Suite 2, Level 8, 412 St Kilda Rd,, Melbourne VIC 3004
Project Number: V220433
Project Name: Jettys Road Foreshore
Project Location: 102 - 107 McDermott Road, Curlewis, VIC 3222
Work Request: 151
Sample Number: 22-151D
Date Sampled: 26/09/2022
Dates Tested: 03/10/2022 - 11/10/2022
Sampling Method: Sampled by Engineering Department
The results apply to the sample as received
Sample Location: **BH03, Depth: 15.0(m)**
Material: Sandy CLAY

Particle Size Distribution (AS1289 3.6.1)						
Sieve	Passed %	Passing Limits		Retained %	Retained Limits	
2.36 mm	**100**			0		
1.18 mm	**100**			0		
0.6 mm	**100**			0		
0.425 mm	**99**			0		
0.3 mm	**99**			0		
0.15 mm	**95**			4		
0.075 mm	**38**			57		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	54		
Plastic Limit (%)	20		
Plasticity Index (%)	**34**		



Material Test Report

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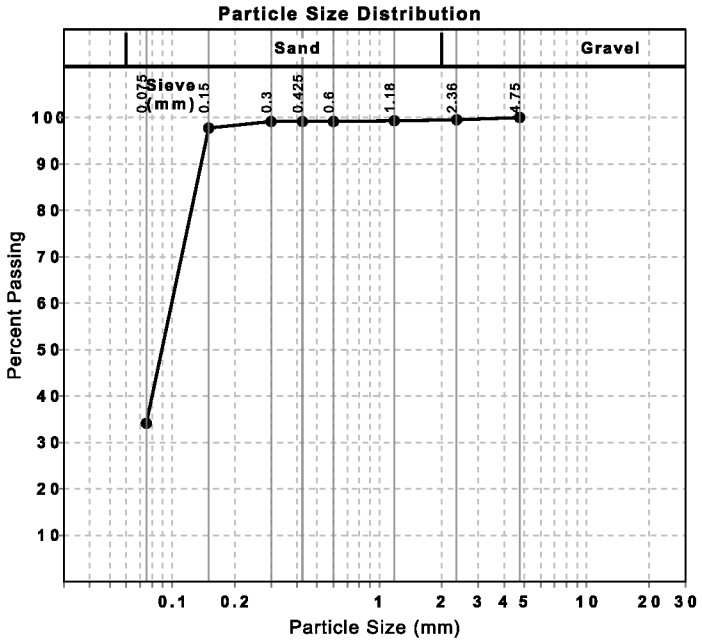
Approved Signatory [redacted]
Laboratory Manager

NATA Accredited Laboratory Number: 3145

Report Number: **V220433-1**
Issue Number: 1
Date Issued: 21/10/2022
Client: Developer Consortium
Suite 2, Level 8, 412 St Kilda Rd,, Melbourne VIC 3004
Project Number: V220433
Project Name: Jettys Road Foreshore
Project Location: 102 - 107 McDermott Road, Curlewis, VIC 3222
Work Request: 151
Sample Number: 22-151E
Date Sampled: 26/09/2022
Dates Tested: 03/10/2022 - 11/10/2022
Sampling Method: Sampled by Engineering Department
The results apply to the sample as received
Sample Location: **BH03, Depth: 18.0(m)**
Material: Sandy CLAY with trace gravel

Particle Size Distribution (AS1289 3.6.1)						
Sieve	Passed %	Passing Limits		Retained %	Retained Limits	
4.75 mm	**100**			0		
2.36 mm	**100**			0		
1.18 mm	**99**			0		
0.6 mm	**99**			0		
0.425 mm	**99**			0		
0.3 mm	**99**			0		
0.15 mm	**98**			1		
0.075 mm	**34**			64		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	45		
Plastic Limit (%)	23		
Plasticity Index (%)	**22**		



Material Test Report

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Approved Signatory [redacted]
Laboratory Manager

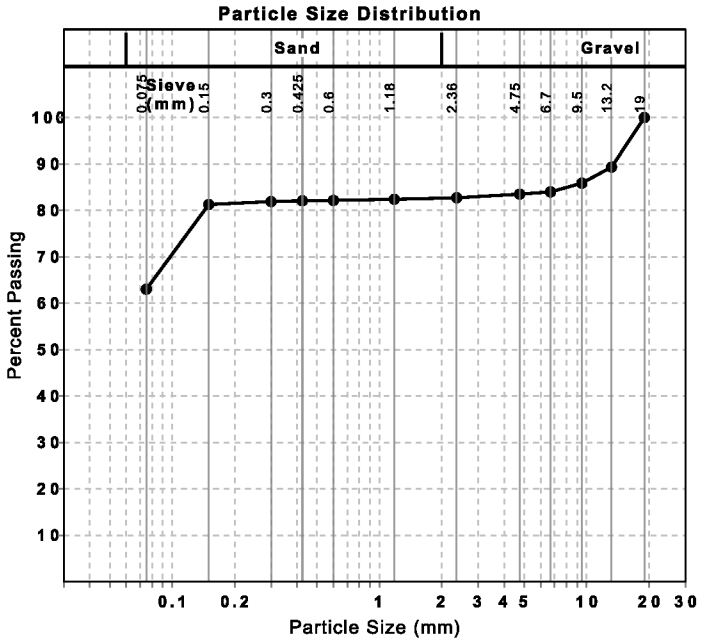
NATA Accredited Laboratory Number: 3145

Report Number: **V220433-1**
Issue Number: 1
Date Issued: 21/10/2022
Client: Developer Consortium
Suite 2, Level 8, 412 St Kilda Rd,, Melbourne VIC 3004
Project Number: V220433
Project Name: Jettys Road Foreshore
Project Location: 102 - 107 McDermott Road, Curlewis, VIC 3222
Work Request: 151
Sample Number: 22-151F
Date Sampled: 26/09/2022
Dates Tested: 03/10/2022 - 12/10/2022
Sampling Method: Sampled by Engineering Department
The results apply to the sample as received
Sample Location: **BH03, Depth: 22.5(m) - 22.9**
Material: Silty CLAY with sand and gravel

Particle Size Distribution (AS1289 3.6.1)						
Sieve	Passed %	Passing Limits		Retained %	Retained Limits	
19 mm	**100**			0		
13.2 mm	**89**			11		
9.5 mm	**86**			3		
6.7 mm	**84**			2		
4.75 mm	**83**			0		
2.36 mm	**83**			1		
1.18 mm	**82**			0		
0.6 mm	**82**			0		
0.425 mm	**82**			0		
0.3 mm	**82**			0		
0.15 mm	**81**			1		
0.075 mm	**63**			18		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	89		
Plastic Limit (%)	25		
Plasticity Index (%)	**64**		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**3**		
Soil Description	Silty CLAY with sand and gravel		
Nature of Water	Distilled Water		
Temperature of Water (°C)	22		



Material Test Report

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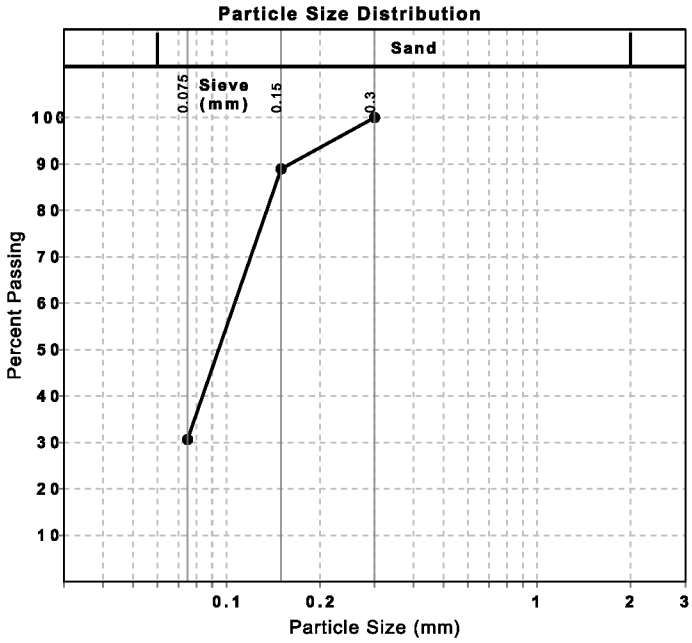
Approved Signatory [redacted]
Laboratory Manager
NATA Accredited Laboratory Number: 3145

Report Number: **V220433-1**
Issue Number: 1
Date Issued: 21/10/2022
Client: Developer Consortium
Suite 2, Level 8, 412 St Kilda Rd,, Melbourne VIC 3004
Project Number: V220433
Project Name: Jettys Road Foreshore
Project Location: 102 - 107 McDermott Road, Curlewis, VIC 3222
Work Request: 151
Sample Number: 22-151G
Date Sampled: 26/09/2022
Dates Tested: 03/10/2022 - 11/10/2022
Sampling Method: Sampled by Engineering Department
The results apply to the sample as received
Sample Location: **BH03, Depth: 24.0(m) - 24.5(m)**
Material: Silty SAND

Particle Size Distribution (AS1289 3.6.1)						
Sieve	Passed %	Passing Limits		Retained %	Retained Limits	
0.3 mm	**100**			0		
0.15 mm	**89**			11		
0.075 mm	**31**			58		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	31		
Plastic Limit (%)	26		
Plasticity Index (%)	**5**		



Material Test Report

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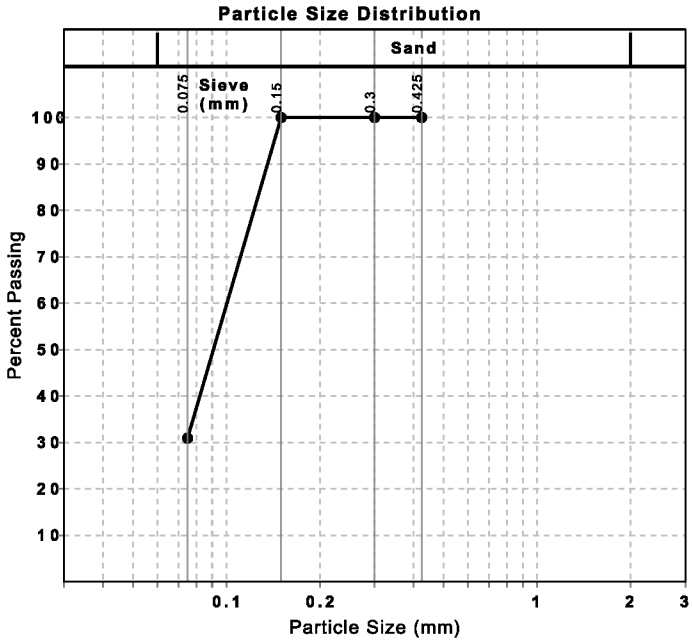
Approved Signatory: [redacted]
Laboratory Manager

NATA Accredited Laboratory Number: 3145

Report Number: V220433-2
Issue Number: 1
Date Issued: 15/11/2022
Client: Developer Consortium
Suite 2, Level 8, 412 St Kilda Rd,, Melbourne VIC 3004
Project Number: V220433
Project Name: Jettys Road Foreshore
Project Location: 102 - 107 McDermott Road, Curlewis, VIC 3222
Work Request: 165
Sample Number: 22-165F
Date Sampled: 10/10/2022
Dates Tested: 02/11/2022 - 09/11/2022
Sampling Method: Sampled by Engineering Department
The results apply to the sample as received
Sample Location: **BH04, Depth: 25.5(m)**
Material: Silty clayey SAND

Particle Size Distribution (AS1289 3.6.1)			
Sieve	Passed %	Passing Limits	
0.425 mm	**100**		
0.3 mm	**100**		
0.15 mm	**100**		
0.075 mm	**31**		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	32		
Plastic Limit (%)	25		
Plasticity Index (%)	**7**		



Material Test Report

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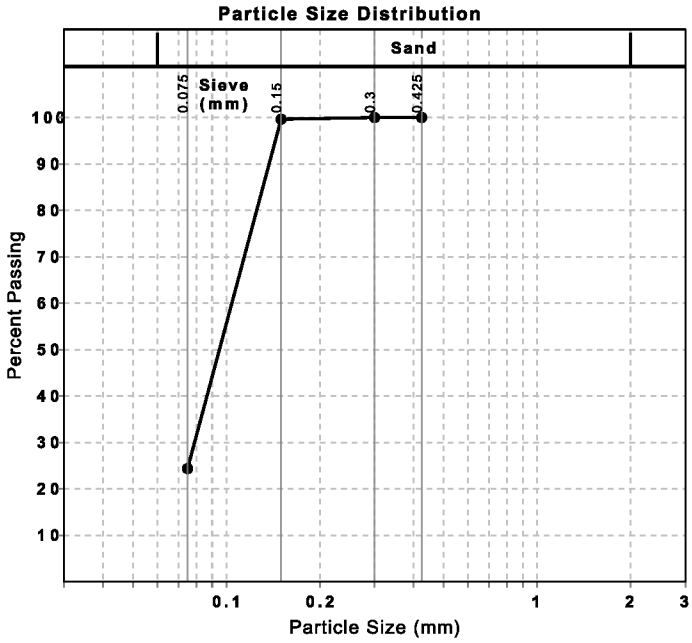
Approved Signatory: [redacted]
Laboratory Manager
NATA Accredited Laboratory Number: 3145

Report Number: V220433-2
Issue Number: 1
Date Issued: 15/11/2022
Client: Developer Consortium
Suite 2, Level 8, 412 St Kilda Rd,, Melbourne VIC 3004
Project Number: V220433
Project Name: Jettys Road Foreshore
Project Location: 102 - 107 McDermott Road, Curlewis, VIC 3222
Work Request: 165
Sample Number: 22-165H
Date Sampled: 10/10/2022
Dates Tested: 02/11/2022 - 09/11/2022
Sampling Method: Sampled by Engineering Department
The results apply to the sample as received
Sample Location: **BH05, Depth: 30.5(m)**
Material: Silty clayey SAND

Particle Size Distribution (AS1289 3.6.1)			
Sieve	Passed %	Passing Limits	
0.425 mm	**100**		
0.3 mm	**100**		
0.15 mm	**100**		
0.075 mm	**24**		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**2**		
Soil Description	Silty clayey SAND		
Nature of Water	Distilled Water		
Temperature of Water (°C)	21		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	28		
Plastic Limit (%)	25		
Plasticity Index (%)	**3**		



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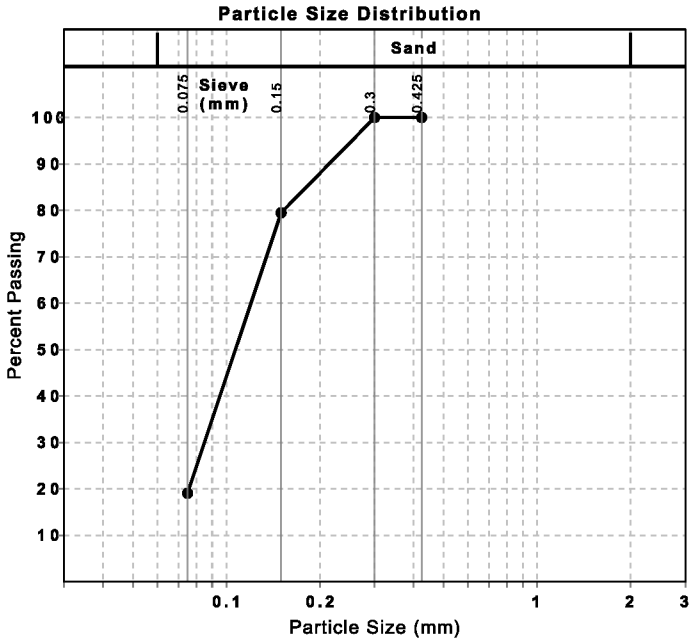
Approved Signatory: [redacted]
Laboratory Manager

NATA Accredited Laboratory Number: 3145

Report Number: **V220433-2**
Issue Number: 1
Date Issued: 15/11/2022
Client: Developer Consortium
Suite 2, Level 8, 412 St Kilda Rd,, Melbourne VIC 3004
Project Number: V220433
Project Name: Jettys Road Foreshore
Project Location: 102 - 107 McDermott Road, Curlewis, VIC 3222
Work Request: 165
Sample Number: 22-165l
Date Sampled: 10/10/2022
Dates Tested: 02/11/2022 - 08/11/2022
Sampling Method: Sampled by Engineering Department
The results apply to the sample as received
Sample Location: **BH06, Depth: 18.0(m) - 18.4(m)**
Material: Silty SAND

Particle Size Distribution (AS1289 3.6.1)			
Sieve	Passed %	Passing Limits	
0.425 mm	**100**		
0.3 mm	**100**		
0.15 mm	**79**		
0.075 mm	**19**		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	Not Obtainable		
Plastic Limit (%)	Not Obtainable		
Plasticity Index (%)	**Non Plastic**		



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Suite 2, Level 8, 412 St Kilda Rd,, Melbourne VIC 3004
Project Number: V220433
Project Name: Jettys Road Foreshore
Project Location: 102 - 107 McDermott Road, Curlewis, VIC 3222
Work Request: 165
Date Sampled: 10/10/2022
Dates Tested: 02/11/2022 - 02/11/2022
Sampling Method: Sampled by Engineering Department
The results apply to the sample as received

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Approved Signatory: [redacted]
Laboratory Manager
NATA Accredited Laboratory Number: 3145

Moisture Content AS 1289 2.1.1

Sample Number	Sample Location	Moisture Content (%)	Material
22-165A	BH01 , Depth: 9.0(m) - 9.3(m)	15.6 %	Sandy CLAY
22-165B	BH01, Depth: 21.0(m)	45.4 %	Sandy silty CLAY
22-165C	BH02, Depth: 6.0(m) - 6.4(m)	14.3 %	Clayey silty SAND
22-165D	BH02 , Depth: 20.0(m)	26.8 %	SAND
22-165E	BH04 , Depth: 24.0(m) - 24.35(m)	30.3 %	Clayey SAND
22-165F	BH04, Depth: 25.5(m)	31.7 %	Silty clayey SAND
22-165G	BH05 , Depth: 3.0(m)	12.2 %	Clayey SAND
22-165H	BH05, Depth: 30.5(m)	28.7 %	Silty clayey SAND
22-165I	BH06, Depth: 18.0(m) - 18.4(m)	28.1 %	Silty SAND
22-165J	BH06, Depth: 27.0(m) _ 27.45(m)	27.1 %	Silty sandy CLAY

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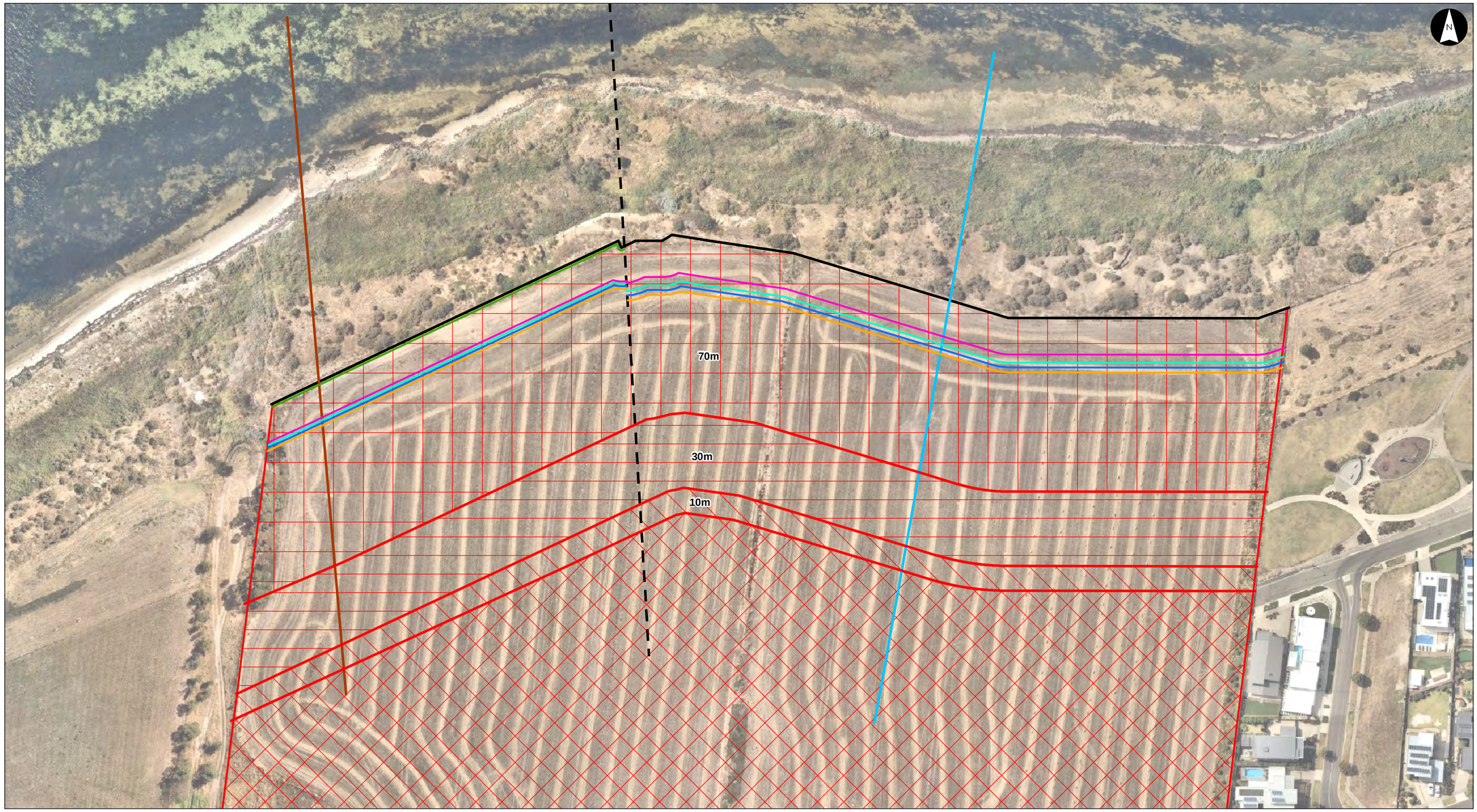
Approved Signatory [redacted]
Laboratory Manager
NATA Accredited Laboratory Number: 3145

Report Number: V220433-1
Issue Number: 1
Date Issued: 21/10/2022
Client: Developer Consortium
Suite 2, Level 8, 412 St Kilda Rd,, Melbourne VIC 3004
Project Number: V220433
Project Name: Jettys Road Foreshore
Project Location: 102 - 107 McDermott Road, Curlewis, VIC 3222
Work Request: 151
Date Sampled: 26/09/2022
Dates Tested: 03/10/2022 - 04/10/2022
Sampling Method: Sampled by Engineering Department
The results apply to the sample as received

Moisture Content AS 1289 2.1.1

Sample Number	Sample Location	Moisture Content (%)	Material
22-151A	BH03, Depth: 3.0(m)	16.5 %	Sandy silty CLAY with trace gravel
22-151B	BH03, Depth: 7.0(m)	19.8 %	Sandy CLAY
22-151C	BH03, Depth: 10.5(m)	41.2 %	Clayey SAND
22-151D	BH03, Depth: 15.0(m)	43.2 %	Sandy CLAY
22-151E	BH03, Depth: 18.0(m)	47.3 %	Sandy CLAY with trace gravel
22-151F	BH03, Depth: 22.5(m) - 22.9	51.0 %	Silty CLAY with sand and gravel
22-151G	BH03, Depth: 24.0(m) - 24.5(m)	31.7 %	Silty SAND

Appendix D – MAPS ON ANNUAL PROBABILITY OF FAILURE



Foreshore Area
Development Extents - 2023

72-100 McDermott Rd, Curlewis, VIC

Project Code: V220433 (GS-009)
Drawn By: AL
Figure No: 1 | Rev: 1
Date: 2023-04-12

Stantec

Legend

- Exclusion Zone
- Property Construction Zone
- Public Space
- Road Reserve
- Fenceline
- Section 1
- Section 2
- Dividing Line
- Boundaries

Line Reference

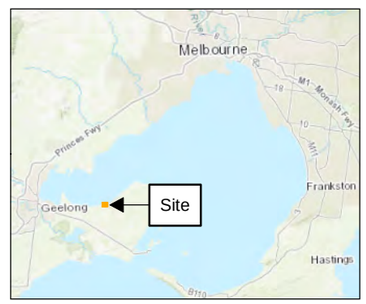
- 0.33 – 0.1
- 0.1 – 0.01
- 0.01 – 0.001
- 0.001 – 0.0001
- 0.0001 – 0.00001

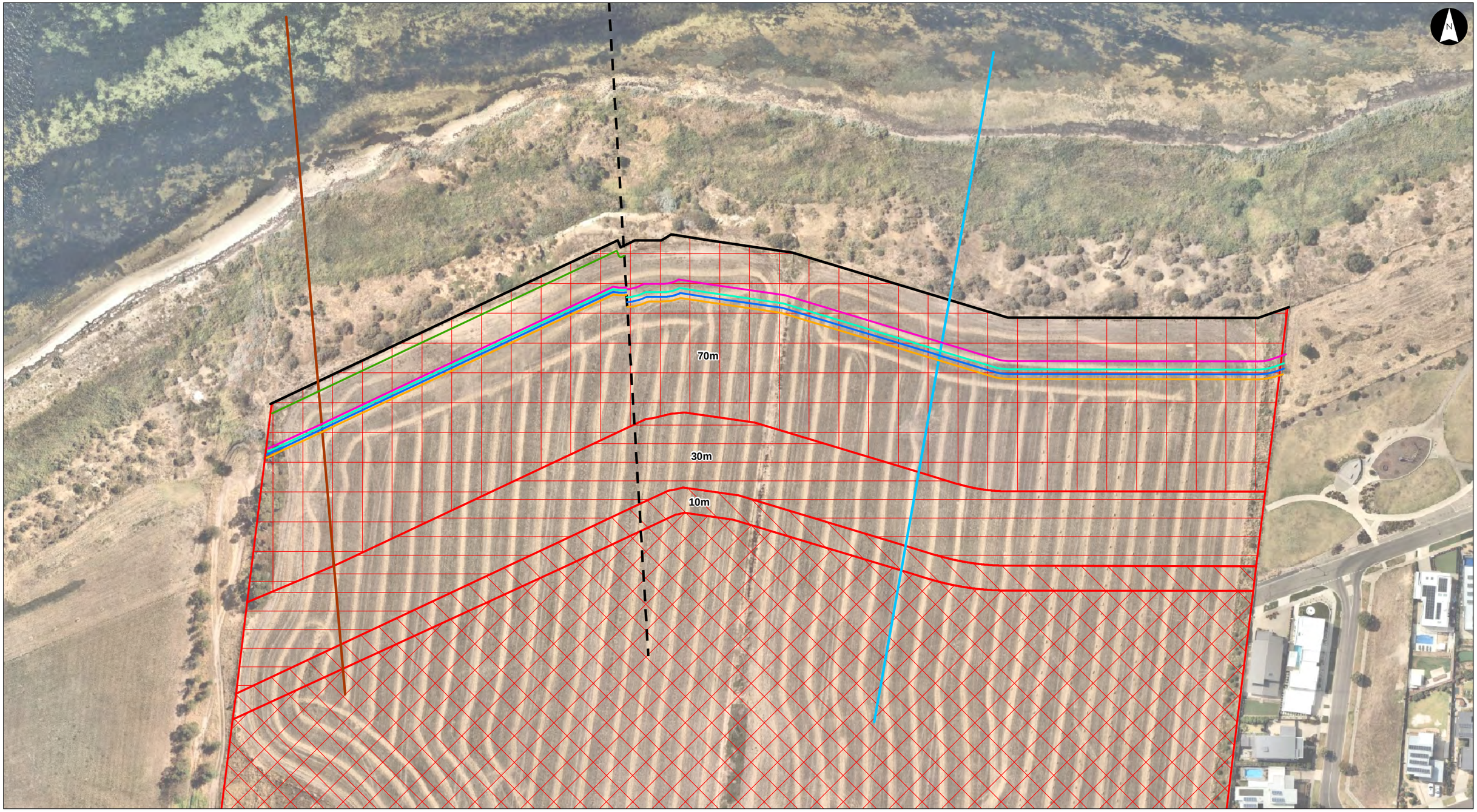
Notes:
1. Coordinate System: GDA2020 MGA Zone 55

References:
1. Aerial Imagery Supplied by Nearmap (February, 2023)

0 30 60 Metres

Scale at A3 1:1,500





Foreshore Area
Development Extents - 2030

72-100 McDermott Rd, Curlewis, VIC

Project Code: V220433 (GS-010)
Drawn By: AL
Figure No: 2 | Rev: 1
Date: 2023-04-12

Stantec

Legend

- Exclusion Zone
- Property Construction Zone
- Public Space
- Road Reserve
- Fenceline
- Section 1
- Section 2
- Dividing Line
- Boundaries

Line Reference

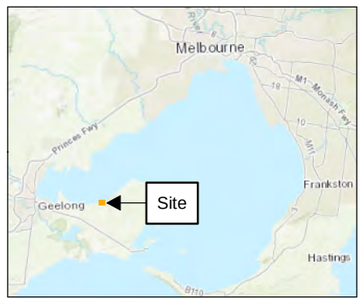
- 0.33 – 0.1
- 0.1 – 0.01
- 0.01 – 0.001
- 0.001 – 0.0001
- 0.0001 – 0.00001

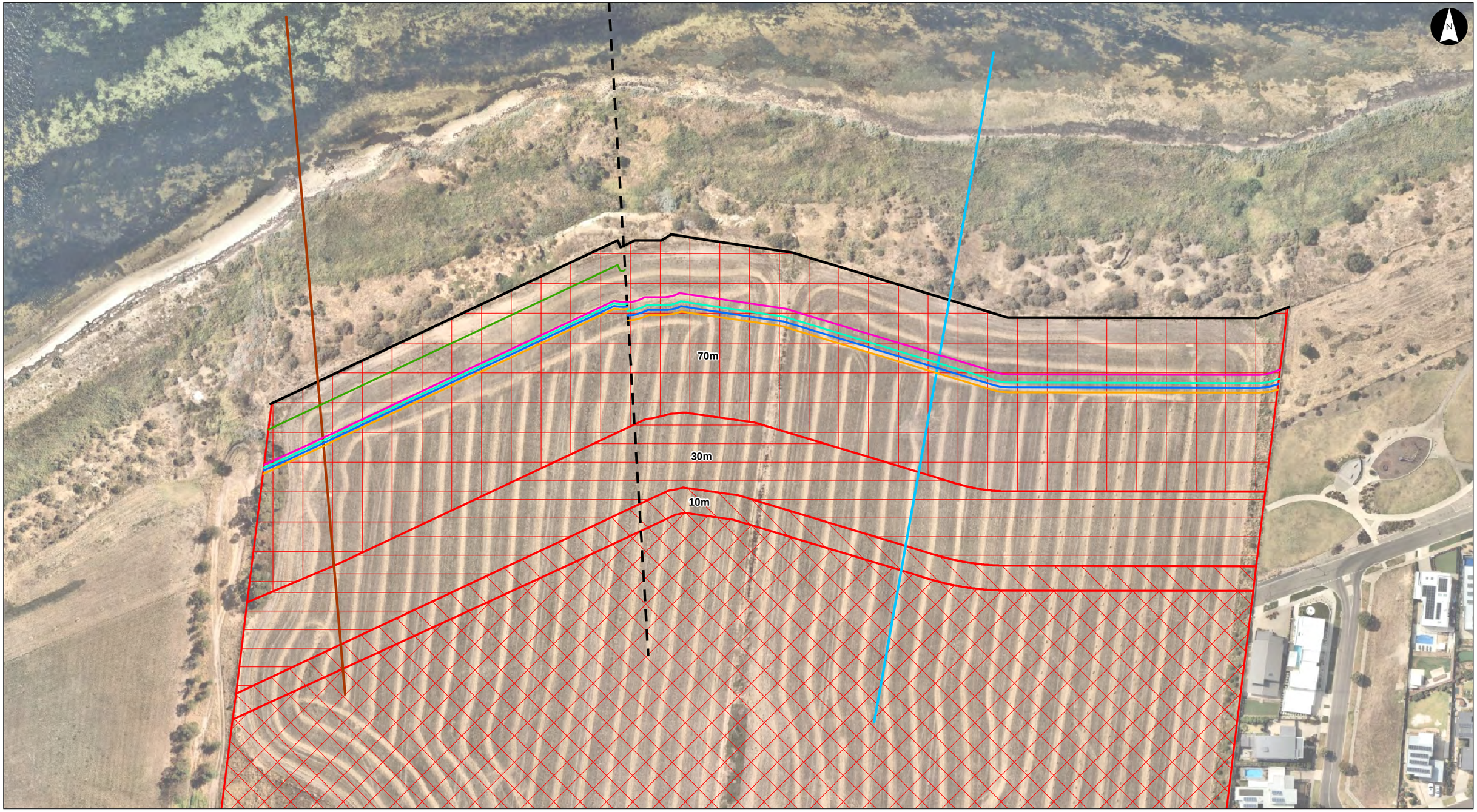
Notes:
1. Coordinate System: GDA2020 MGA Zone 55

References:
1. Aerial Imagery Supplied by Nearmap (February, 2023)

0 30 60 Metres

Scale at A3 1:1,500





Foreshore Area
Development Extents - 2070

72-100 McDermott Rd, Curlewis, VIC

Project Code: V220433 (GS-011)
Drawn By: AL
Figure No: 3 | Rev: 1
Date: 2023-04-12

Stantec

Legend

- Exclusion Zone
- Property Construction Zone
- Public Space
- Road Reserve
- Fenceline
- Section 1
- Section 2
- Dividing Line
- Boundaries

Line Reference

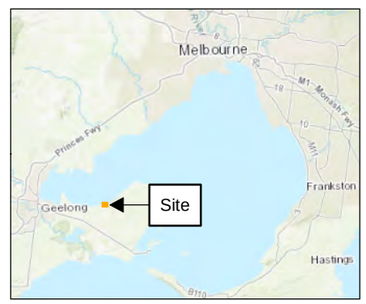
- 0.33 – 0.1
- 0.1 – 0.01
- 0.01 – 0.001
- 0.001 – 0.0001
- 0.0001 – 0.00001

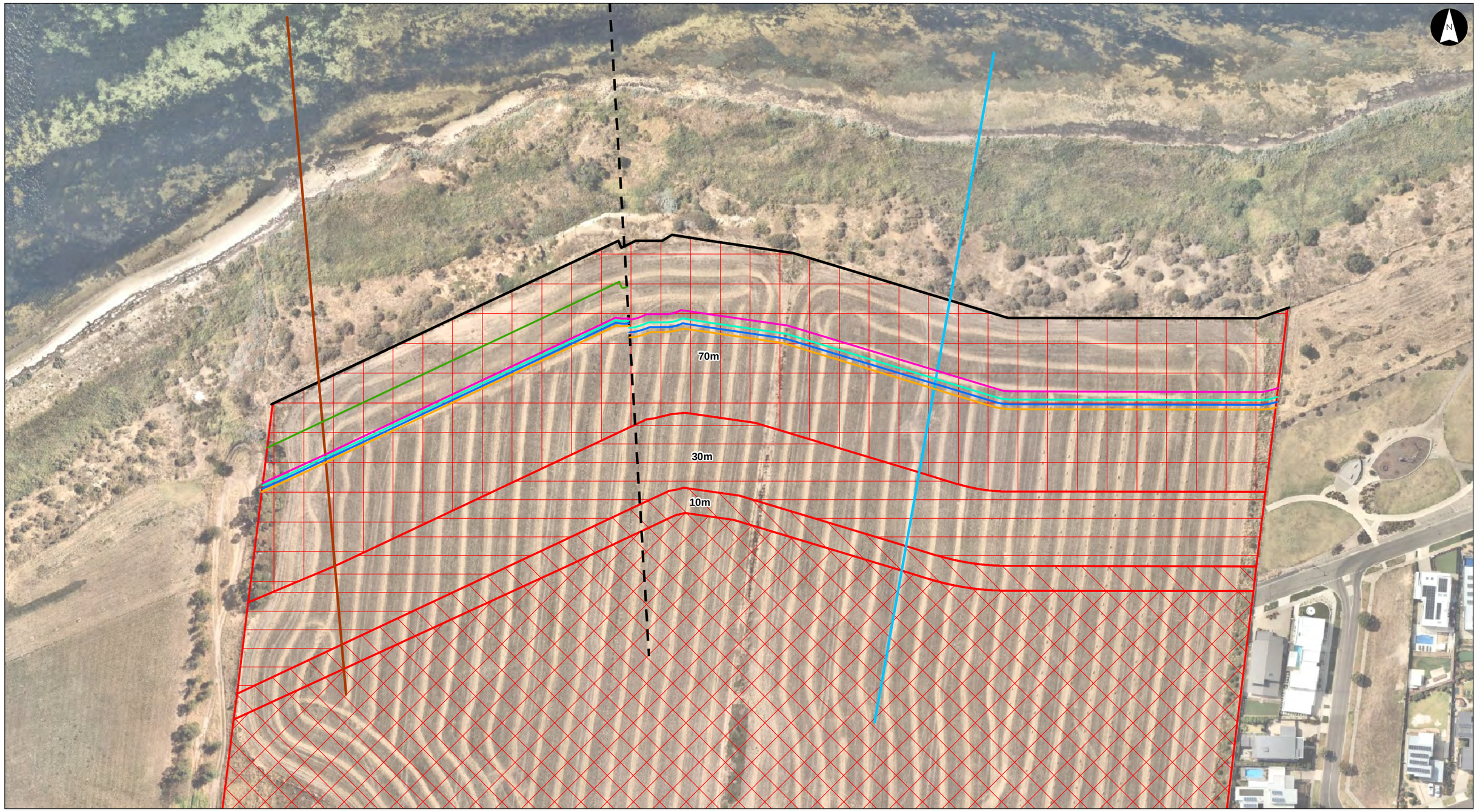
Notes:
1. Coordinate System: GDA2020 MGA Zone 55

References:
1. Aerial Imagery Supplied by Nearmap (February, 2023)

0 30 60 Metres

Scale at A3 1:1,500





Foreshore Area
Development Extents - 2100

72-100 McDermott Rd, Curlewis, VIC

Project Code: V220433 (GS-012)
Drawn By: AL
Figure No: 4 | Rev: 1
Date: 2023-04-12

Stantec

Legend

- Exclusion Zone
- Property Construction Zone
- Public Space
- Road Reserve
- Fenceline
- Section 1
- Section 2
- Dividing Line
- Boundaries

Line Reference

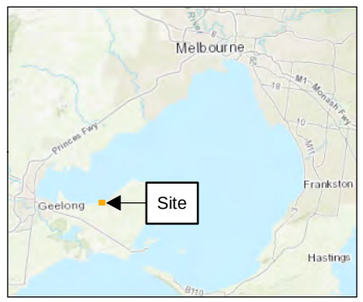
- 0.33 – 0.1
- 0.1 – 0.01
- 0.01 – 0.001
- 0.001 – 0.0001
- 0.0001 – 0.00001

Notes:
1. Coordinate System: GDA2020 MGA Zone 55

References:
1. Aerial Imagery Supplied by Nearmap (February, 2023)

0 30 60 Metres

Scale at A3 1:1,500



Appendix E – LANDSLIDE RISK ASSESSMENT CALCULATION

Landslide Risk Assessment

Stantec Australia Pty Ltd

V220433 Jetty Road, Curlewis

Section 1

Quantitative Risk Assessment (Risk to Life)

Mobile Element at Risk

$R_{(LOL)} = P_{(H)}.P_{(S:H)}.P_{(T:S)}.V_{(D:T)}$

Person at Risk	Person walking in exclusion zone	Person walking in exclusion zone	Person walking in exclusion zone	Person walking in exclusion zone	Person walking in exclusion zone
Hazard	Green - small	Pink - Medium	Cyan - Medium to Large	Blue - Very Large	Yellow - Very Large
Condition	Proposed	Proposed	Proposed	Proposed	Proposed
Suggested Tolerable Limit[1]	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05
Annual Probability - $P_{(H)}$	1.0E-01	1.0E-02	1.0E-03	1.0E-04	1.0E-05
Length of Area at Risk (m)	180.00	180.00	180.00	180.00	180.00
Width of Area (m)	70.00	70.00	70.00	70.00	70.00
Width of Landslide (along area) (m)	86	86	86	86	86
Width of Area Affected (m)	1.10	13.50	14.50	15.50	16.50
$P_{(S:H)}$, Probability of Spatial Impact	7.5E-03	9.2E-02	9.9E-02	1.1E-01	1.1E-01
Speed of Walker - s (km.hr)	3.00	3.00	3.00	3.00	3.00
Time in affected area - t (hr)	6.00E-02	6.00E-02	6.00E-02	6.00E-02	6.00E-02
$P_{(T:S)}$, Annual Temporal Spatial Probability	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06
Vulnerability $V_{(D:T)}$	0.01000	0.01000	0.01000	0.01000	0.01000
$R_{(LOL)}$	5.1E-11	6.3E-11	6.8E-12	7.2E-13	7.7E-14
	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
Average Speed of User - s (km/hr)	1.0	1.0	1.0	1.0	1.0
Av$R_{(LOL)}$	1.5E-10	1.9E-10	2.0E-11	2.2E-12	2.3E-13
Number of People/Groups per Day	1	1	1	1	1
Number of People/Groups per Year	365	365	365	365	365
F - Annual Probability of Loss of Life	5.6E-08	6.9E-08	7.4E-09	7.9E-10	8.4E-11
Number of People Per Group	1	1	1	1	1
F - N	5.6E-08	6.9E-08	7.4E-09	7.9E-10	8.4E-11
	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable

People Walking in Exlusion Zone - Combined: **1.3E-07**

Acceptable

Landslide Risk Assessment

Stantec Australia Pty Ltd

V220433 Jetty Road, Curlewis

Section 1

Quantitative Risk Assessment (Risk to Life)

Mobile Element at Risk

$R_{(LOL)} = P_{(H)}.P_{(S:H)}.P_{(T:S)}.V_{(D:T)}$

Person at Risk	Person walking in reserve	Person walking in reserve	Person walking in reserve	Person walking in reserve	Person walking in reserve
Hazard	Green - small	Pink - Medium	Cyan - Medium to Large	Blue - Very Large	Yellow - Very Large
Condition	Proposed	Proposed	Proposed	Proposed	Proposed
Suggested Tolerable Limit[1]	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05
Annual Probability - $P_{(H)}$	1.0E-01	1.0E-02	1.0E-03	1.0E-04	1.0E-05
Length of Area at Risk (m)	180.00	180.00	180.00	180.00	180.00
Width of Area (m)	30.00	30.00	30.00	30.00	30.00
Width of Landslide (along area) (m)	86	86	86	86	86
Width of Area Affected (m)	0.00	0.00	0.00	0.00	0.00
$P_{(S:H)}$, Probability of Spatial Impact	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Speed of Walker - s (km.hr)	3.00	3.00	3.00	3.00	3.00
Time in affected area - t (hr)	6.0E-02	6.0E-02	6.0E-02	6.0E-02	6.0E-02
$P_{(T:S)}$, Annual Temporal Spatial Probability	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06
Vulnerability $V_{(D:T)}$	0.01000	0.01000	0.01000	0.01000	0.01000
$R_{(LOL)}$	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
Average Speed of User - s (km/hr)	1.0	1.0	1.0	1.0	1.0
$AvR_{(LOL)}$	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Number of People/Groups per Day	10	10	10	10	10
Number of People/Groups per Year	3650	3650	3650	3650	3650
F - Annual Probability of Loss of Life	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Number of People Per Group	3	3	3	3	3
F - N	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable

People Walking in Reserve - Combined: **0.0E+00**

Acceptable

Landslide Risk Assessment

Stantec Australia Pty Ltd

V220433 Jetty Road, Curlewis

Section 1

Quantitative Risk Assessment (Risk to Life)

Mobile Element at Risk

$R_{(LOL)} = P_{(H)}.P_{(S:H)}.P_{(T:S)}.V_{(D:T)}$

Person at Risk	Person walking along the road	Person walking along the road	Person walking along the road	Person walking along the road	Person walking along the road
Hazard	Green - small	Pink - Medium	Cyan - Medium to Large	Blue - Very Large	Yellow - Very Large
Condition	Proposed	Proposed	Proposed	Proposed	Proposed
Suggested Tolerable Limit[1]	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05
Annual Probability - $P_{(H)}$	1.0E-01	1.0E-02	1.0E-03	1.0E-04	1.0E-05
Length of Area at Risk (m)	180.00	180.00	180.00	180.00	180.00
Width of Area (m)	10.00	10.00	10.00	10.00	10.00
Width of Landslide (along area) (m)	86	86	86	86	86
Width of Area Affected (m)	0.00	0.00	0.00	0.00	0.00
$P_{(S:H)}$, Probability of Spatial Impact	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Speed of Walker - s (km.hr)	3.00	3.00	3.00	3.00	3.00
Time in affected area - t (hr)	6.0E-02	6.0E-02	6.0E-02	6.0E-02	6.0E-02
$P_{(T:S)}$, Annual Temporal Spatial Probability	6.8E-06	6.8E-06	6.8E-06	6.8E-06	6.8E-06
Vulnerability $V_{(D:T)}$	0.01000	0.01000	0.01000	0.01000	0.01000
$R_{(LOL)}$	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
Average Speed of User - s (km/hr)	3.0	3.0	3.0	3.0	3.0
$AvR_{(LOL)}$	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Number of People/Groups per Day	15	15	15	15	15
Number of People/Groups per Year	5475	5475	5475	5475	5475
F - Annual Probability of Loss of Life	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Number of People Per Group	3	3	3	3	3
F - N	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable

People Walking in Road Reserve - Combined: **0.0E+00**

Acceptable

Landslide Risk Assessment

Stantec Australia Pty Ltd

V220433 Jetty Road, Curlewis

Section 1

Quantitative Risk Assessment (Risk to Life)

Mobile Element at Risk

$R_{(LOL)} = P_{(H)}.P_{(S:H)}.P_{(T:S)}.V_{(D:T)}$

Person at Risk	Person at home	Person at home	Person at home	Person at home	Person at home
Hazard	Green - small	Pink - Medium	Cyan - Medium to Large	Blue - Very Large	Yellow - Very Large
Condition	Proposed	Proposed	Proposed	Proposed	Proposed
Suggested Tolerable Limit[1]	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05
Annual Probability - $P_{(H)}$	1.0E-01	1.0E-02	1.0E-03	1.0E-04	1.0E-05
Length of Area at Risk (m)	180.00	180.00	180.00	180.00	180.00
Width of Area (m)	25.00	25.00	25.00	25.00	25.00
Width of Landslide (along area) (m)	86	86	86	86	86
Width of Area Affected (m)	0.00	0.00	0.00	0.00	0.00
$P_{(S:H)}$, Probability of Spatial Impact	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Speed of Walker - s (km.hr)	0.01	0.01	0.01	0.01	0.01
Time in affected area - t (hr)	2.5E+01	2.5E+01	2.5E+01	2.5E+01	2.5E+01
$P_{(T:S)}$, Annual Temporal Spatial Probability	2.9E-03	2.9E-03	2.9E-03	2.9E-03	2.9E-03
Vulnerability $V_{(D:T)}$	0.01000	0.01000	0.01000	0.01000	0.01000
$R_{(LOL)}$	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
Average Speed of User - s (km/hr)	3.0	3.0	3.0	3.0	3.0
$AvR_{(LOL)}$	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Number of People/Groups per Day	25	25	25	25	25
Number of People/Groups per Year	9125	9125	9125	9125	9125
F - Annual Probability of Loss of Life	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Number of People Per Group	4	4	4	4	4
F - N	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable

People in Houses - Combined: **0.0E+00**

Acceptable

Landslide Risk Assessment

Stantec Australia Pty Ltd

V220433 Jetty Road, Curlewis

Section 2

Quantitative Risk Assessment (Risk to Life)

Mobile Element at Risk

$R_{(LOL)} = P_{(H)}.P_{(S:H)}.P_{(T:S)}.V_{(D:T)}$

Person at Risk	Person walking in exclusion zone	Person walking in exclusion zone	Person walking in exclusion zone	Person walking in exclusion zone	Person walking in exclusion zone
Hazard	Green - small	Pink - Medium	Cyan - Medium to Large	Blue - Very Large	Yellow - Very Large
Condition	Proposed	Proposed	Proposed	Proposed	Proposed
Suggested Tolerable Limit[1]	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05
Annual Probability - $P_{(H)}$	1.0E-01	1.0E-02	1.0E-03	1.0E-04	1.0E-05
Length of Area at Risk (m)	240.00	240.00	240.00	240.00	240.00
Width of Area (m)	70.00	70.00	70.00	70.00	70.00
Width of Landslide (along area) (m)	119	119	119	119	119
Width of Area Affected (m)	0.00	14.70	18.00	19.90	21.90
$P_{(S:H)}$, Probability of Spatial Impact	0.00E+00	1.04E-01	1.28E-01	1.41E-01	1.55E-01
Speed of Walker - s (km.hr)	3.00	3.00	3.00	3.00	3.00
Time in affected area - t (hr)	8.0E-02	8.0E-02	8.0E-02	8.0E-02	8.0E-02
$P_{(T:S)}$, Annual Temporal Spatial Probability	9.1E-06	9.1E-06	9.1E-06	9.1E-06	9.1E-06
Vulnerability $V_{(D:T)}$	0.01000	0.01000	0.01000	0.01000	0.01000
$R_{(LOL)}$	0.0E+00	9.5E-11	1.2E-11	1.3E-12	1.4E-13
	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
Average Speed of User - s (km/hr)	1.0	1.0	1.0	1.0	1.0
$AvR_{(LOL)}$	0.0E+00	2.9E-10	3.5E-11	3.9E-12	4.3E-13
Number of People/Groups per Day	1	1	1	1	1
Number of People/Groups per Year	365	365	365	365	365
F - Annual Probability of Loss of Life	0.0E+00	1.0E-07	1.3E-08	1.4E-09	1.6E-10
Number of People Per Group	1	1	1	1	1
F - N	0.0E+00	1.0E-07	1.3E-08	1.4E-09	1.6E-10
	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable

People Walking in Exlusion Zone - Combined: **1.2E-07**

Acceptable

Landslide Risk Assessment

Stantec Australia Pty Ltd

V220433 Jetty Road, Curlewis

Section 2

Quantitative Risk Assessment (Risk to Life)

Mobile Element at Risk

$R_{(LOL)} = P_{(H)}.P_{(S:H)}.P_{(T:S)}.V_{(D:T)}$

Person at Risk	Person walking in reserve	Person walking in reserve	Person walking in reserve	Person walking in reserve	Person walking in reserve
Hazard	Green - small	Pink - Medium	Cyan - Medium to Large	Blue - Very Large	Yellow - Very Large
Condition	Proposed	Proposed	Proposed	Proposed	Proposed
Suggested Tolerable Limit[1]	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05
Annual Probability - $P_{(H)}$	1.0E-01	1.0E-02	1.0E-03	1.0E-04	1.0E-05
Length of Area at Risk (m)	240.00	240.00	240.00	240.00	240.00
Width of Area (m)	30.00	30.00	30.00	30.00	30.00
Width of Landslide (along area) (m)	119	119	119	119	119
Width of Area Affected (m)	0.00	0.00	0.00	0.00	0.00
$P_{(S:H)}$, Probability of Spatial Impact	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Speed of Walker - s (km.hr)	3.00	3.00	3.00	3.00	3.00
Time in affected area - t (hr)	8.0E-02	8.0E-02	8.0E-02	8.0E-02	8.0E-02
$P_{(T:S)}$, Annual Temporal Spatial Probability	9.1E-06	9.1E-06	9.1E-06	9.1E-06	9.1E-06
Vulnerability $V_{(D:T)}$	0.01000	0.01000	0.01000	0.01000	0.01000
$R_{(LOL)}$	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
Average Speed of User - s (km/hr)	1.0	1.0	1.0	1.0	1.0
$AvR_{(LOL)}$	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Number of People/Groups per Day	10	10	10	10	10
Number of People/Groups per Year	3650	3650	3650	3650	3650
F - Annual Probability of Loss of Life	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Number of People Per Group	3	3	3	3	3
F - N	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable

People Walking in Reserve - Combined: **0.0E+00**

Acceptable

Landslide Risk Assessment

Stantec Australia Pty Ltd

V220433 Jetty Road, Curlewis

Section 2

Quantitative Risk Assessment (Risk to Life)

Mobile Element at Risk

$R_{(LOL)} = P_{(H)}.P_{(S:H)}.P_{(T:S)}.V_{(D:T)}$

Person at Risk	Person walking along the road	Person walking along the road	Person walking along the road	Person walking along the road	Person walking along the road
Hazard	Green - small	Pink - Medium	Cyan - Medium to Large	Blue - Very Large	Yellow - Very Large
Condition	Proposed	Proposed	Proposed	Proposed	Proposed
Suggested Tolerable Limit[1]	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05
Annual Probability - $P_{(H)}$	1.0E-01	1.0E-02	1.0E-03	1.0E-04	1.0E-05
Length of Area at Risk (m)	240.00	240.00	240.00	240.00	240.00
Width of Area (m)	10.00	10.00	10.00	10.00	10.00
Width of Landslide (along area) (m)	119	119	119	119	119
Width of Area Affected (m)	0.00	0.00	0.00	0.00	0.00
$P_{(S:H)}$, Probability of Spatial Impact	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Speed of Walker - s (km.hr)	3.00	3.00	3.00	3.00	3.00
Time in affected area - t (hr)	8.0E-02	8.0E-02	8.0E-02	8.0E-02	8.0E-02
$P_{(T:S)}$, Annual Temporal Spatial Probability	9.1E-06	9.1E-06	9.1E-06	9.1E-06	9.1E-06
Vulnerability $V_{(D:T)}$	0.01000	0.01000	0.01000	0.01000	0.01000
$R_{(LOL)}$	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
Average Speed of User - s (km/hr)	3.0	3.0	3.0	3.0	3.0
$AvR_{(LOL)}$	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Number of People/Groups per Day	15	15	15	15	15
Number of People/Groups per Year	5475	5475	5475	5475	5475
F - Annual Probability of Loss of Life	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Number of People Per Group	3	3	3	3	3
F - N	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable

People Walking in Road Reserve - Combined: **0.0E+00**

Acceptable

Landslide Risk Assessment

Stantec Australia Pty Ltd

V220433 Jetty Road, Curlewis

Section 2

Quantitative Risk Assessment (Risk to Life)

Mobile Element at Risk

$R_{(LOL)} = P_{(H)}.P_{(S:H)}.P_{(T:S)}.V_{(D:T)}$

Person at Risk	Person at home	Person at home	Person at home	Person at home	Person at home
Hazard	Green - small	Pink - Medium	Cyan - Medium to Large	Blue - Very Large	Yellow - Very Large
Condition	Proposed	Proposed	Proposed	Proposed	Proposed
Suggested Tolerable Limit[1]	1.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05
Annual Probability - $P_{(H)}$	1.0E-01	1.0E-02	1.0E-03	1.0E-04	1.0E-05
Length of Area at Risk (m)	240.00	240.00	240.00	240.00	240.00
Width of Area (m)	25.00	25.00	25.00	25.00	25.00
Width of Landslide (along area) (m)	119	119	119	119	119
Width of Area Affected (m)	0.00	0.00	0.00	0.00	0.00
$P_{(S:H)}$, Probability of Spatial Impact	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Speed of Walker - s (km.hr)	0.01	0.01	0.01	0.01	0.01
Time in affected area - t (hr)	2.4E+01	2.4E+01	2.4E+01	2.4E+01	2.4E+01
$P_{(T:S)}$, Annual Temporal Spatial Probability	2.8E-03	2.8E-03	2.8E-03	2.8E-03	2.8E-03
Vulnerability $V_{(D:T)}$	0.01000	0.01000	0.01000	0.01000	0.01000
$R_{(LOL)}$	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
Average Speed of User - s (km/hr)	3.0	3.0	3.0	3.0	3.0
$AvR_{(LOL)}$	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Number of People/Groups per Day	25	25	25	25	25
Number of People/Groups per Year	9125	9125	9125	9125	9125
F - Annual Probability of Loss of Life	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Number of People Per Group	4	4	4	4	4
F - N	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable

People in Houses - Combined: **0.0E+00**

Acceptable

Landslide Risk Assessment

Stantec Australia Pty Ltd

V220433 Jetty Rd Stage 2

Section 1 - Reserve

Qualitative Risk Assessment (Risk to Property)

(AGS, Vol 42, No 1, 2007, Appendix C Practice Note)

	0.33-0.1	0.1-0.01	0.01-0.001	0.001-0.0001	0.0001-0.00001	
Property at Risk	Green	Pink	Cyan	Blue	Yellow	
Hazard	Small	Medium	Medium to Large	Very Large	Very Large	
Likelihood - Upper Bound	Certain	Almost Certain	Likely	Possible	Unlikely	
Likelihood - Lower Bound	Almost Certain	Likely	Possible	Unlikely	Rare	
Consequence to Property - Upper Bound	Not Credible	Not Credible	Not Credible	Not Credible	Not Credible	
Consequence to Property - Lower Bound	Not Credible	Not Credible	Not Credible	Not Credible	Not Credible	
Level of Risk - Upper Bound	LOW	LOW	VERY LOW	VERY LOW	VERY LOW	
Level of Risk - Lower Bound	LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW	

Notes:

1. Annual Probability. Certain = 1:1, Almost Certain = 1:10, Likely = 1:100, Possible = 1:1,000, Unlikely = 1:10,000, Rare = 1:100,000, Barely Credible = 1:1,000,000

2. Consequence. Catastrophic = Structure completely destroyed, Major = Structure extensively damaged, Medium = Moderate damage, Minor = Limited damage, Insignificant = Little to insignificant damage

	Probability		Catastrophic	Major	Medium	Minor	Insignificant	Not Credible
	Indicative Value of Cost of Property		200%	60%	20%	5%	0.50%	0.00%
Certain	1:1	1.00E+00	VERY HIGH	VERY HIGH	VERY HIGH	VERY HIGH	HIGH	LOW
Almost Certain	1:10	1.00E-01	VERY HIGH	VERY HIGH	VERY HIGH	HIGH	MODERATE	LOW
Likely	1:100	1.00E-02	VERY HIGH	VERY HIGH	HIGH	MODERATE	LOW	VERY LOW
Possible	1:1000	1.00E-03	VERY HIGH	HIGH	MODERATE	MODERATE	VERY LOW	VERY LOW
Unlikely	1:10000	1.00E-04	HIGH	MODERATE	LOW	LOW	VERY LOW	VERY LOW
Rare	1:100000	1.00E-05	MODERATE	LOW	LOW	VERY LOW	VERY LOW	VERY LOW
Barely Credible	1:1000000	1.00E-06	LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW

* 'Not Credible' category not included in AGS

Landslide Risk Assessment

Stantec Australia Pty Ltd

V220433 Jetty Rd Stage 2

Section 1 - Road (assuming 30m width reserve)

Qualitative Risk Assessment (Risk to Property)

(AGS, Vol 42, No 1, 2007, Appendix C Practice Note)

	0.33-0.1	0.1-0.01	0.01-0.001	0.001-0.0001	0.0001-0.00001	
Property at Risk	Green	Pink	Cyan	Blue	Yellow	
Hazard	Small	Medium	Medium to Large	Very Large	Very Large	
Likelihood - Upper Bound	Certain	Almost Certain	Likely	Possible	Unlikely	
Likelihood - Lower Bound	Almost Certain	Likely	Possible	Unlikely	Rare	
Consequence to Property - Upper Bound	Not Credible	Not Credible	Not Credible	Not Credible	Not Credible	
Consequence to Property - Lower Bound	Not Credible	Not Credible	Not Credible	Not Credible	Not Credible	
Level of Risk - Upper Bound	LOW	LOW	VERY LOW	VERY LOW	VERY LOW	
Level of Risk - Lower Bound	LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW	

Notes:

1. Annual Probability. Certain = 1:1, Almost Certain = 1:10, Likely = 1:100, Possible = 1:1,000, Unlikely = 1:10,000, Rare = 1:100,000, Barely Credible = 1:1,000,000

2. Consequence. Catastrophic = Structure completely destroyed, Major = Structure extensively damaged, Medium = Moderate damage, Minor = Limited damage, Insignificant = Little to insignificant damage

	Probability		Catastrophic	Major	Medium	Minor	Insignificant	Not Credible
	Indicative Value of Cost of Property		200%	60%	20%	5%	0.50%	0.00%
Certain	1:1	1.00E+00	VERY HIGH	VERY HIGH	VERY HIGH	VERY HIGH	HIGH	LOW
Almost Certain	1:10	1.00E-01	VERY HIGH	VERY HIGH	VERY HIGH	HIGH	MODERATE	LOW
Likely	1:100	1.00E-02	VERY HIGH	VERY HIGH	HIGH	MODERATE	LOW	VERY LOW
Possible	1:1000	1.00E-03	VERY HIGH	HIGH	MODERATE	MODERATE	VERY LOW	VERY LOW
Unlikely	1:10000	1.00E-04	HIGH	MODERATE	LOW	LOW	VERY LOW	VERY LOW
Rare	1:100000	1.00E-05	MODERATE	LOW	LOW	VERY LOW	VERY LOW	VERY LOW
Barely Credible	1:1000000	1.00E-06	LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW

* 'Not Credible' category not included in AGS

Landslide Risk Assessment

Stantec Australia Pty Ltd

V220433 Jetty Rd Stage 2

Section 1 - Properties

Qualitative Risk Assessment (Risk to Property)

(AGS, Vol 42, No 1, 2007, Appendix C Practice Note)

	0.33-0.1	0.1-0.01	0.01-0.001	0.001-0.0001	0.0001-0.00001	
Property at Risk	Green	Pink	Cyan	Blue	Yellow	
Hazard	Small	Medium	Medium to Large	Very Large	Very Large	
Likelihood - Upper Bound	Certain	Almost Certain	Likely	Possible	Unlikely	
Likelihood - Lower Bound	Almost Certain	Likely	Possible	Unlikely	Rare	
Consequence to Property - Upper Bound	Not Credible	Not Credible	Not Credible	Not Credible	Not Credible	
Consequence to Property - Lower Bound	Not Credible	Not Credible	Not Credible	Not Credible	Not Credible	
Level of Risk - Upper Bound	LOW	LOW	VERY LOW	VERY LOW	VERY LOW	
Level of Risk - Lower Bound	LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW	

Notes:

1. Annual Probability. Certain = 1:1, Almost Certain = 1:10, Likely = 1:100, Possible = 1:1,000, Unlikely = 1:10,000, Rare = 1:100,000, Barely Credible = 1:1,000,000

2. Consequence. Catastrophic = Structure completely destroyed, Major = Structure extensively damaged, Medium = Moderate damage, Minor = Limited damage, Insignificant = Little to insignificant damage

	Probability		Catastrophic	Major	Medium	Minor	Insignificant	Not Credible
	Indicative Value of Cost of Property		200%	60%	20%	5%	0.50%	0.00%
Certain	1:1	1.00E+00	VERY HIGH	VERY HIGH	VERY HIGH	VERY HIGH	HIGH	LOW
Almost Certain	1:10	1.00E-01	VERY HIGH	VERY HIGH	VERY HIGH	HIGH	MODERATE	LOW
Likely	1:100	1.00E-02	VERY HIGH	VERY HIGH	HIGH	MODERATE	LOW	VERY LOW
Possible	1:1000	1.00E-03	VERY HIGH	HIGH	MODERATE	MODERATE	VERY LOW	VERY LOW
Unlikely	1:10000	1.00E-04	HIGH	MODERATE	LOW	LOW	VERY LOW	VERY LOW
Rare	1:100000	1.00E-05	MODERATE	LOW	LOW	VERY LOW	VERY LOW	VERY LOW
Barely Credible	1:1000000	1.00E-06	LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW

* 'Not Credible' category not included in AGS

Landslide Risk Assessment

Stantec Australia Pty Ltd

V220433 Jetty Rd Stage 2

Section 2 - Exclusion Zone

Qualitative Risk Assessment (Risk to Property)

(AGS, Vol 42, No 1, 2007, Appendix C Practice Note)

	0.33-0.1	0.1-0.01	0.01-0.001	0.001-0.0001	0.0001-0.00001	
Property at Risk	Green	Pink	Cyan	Blue	Yellow	
Hazard	Small	Medium	Medium to Large	Very Large	Very Large	
Likelihood - Upper Bound	Certain	Almost Certain	Likely	Possible	Unlikely	
Likelihood - Lower Bound	Almost Certain	Likely	Possible	Unlikely	Rare	
Consequence to Property - Upper Bound	Not Credible	Not Credible	Not Credible	Not Credible	Not Credible	
Consequence to Property - Lower Bound	Not Credible	Not Credible	Not Credible	Not Credible	Not Credible	
Level of Risk - Upper Bound	LOW	LOW	VERY LOW	VERY LOW	VERY LOW	
Level of Risk - Lower Bound	LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW	

Notes:

1. Annual Probability. Certain = 1:1, Almost Certain = 1:10, Likely = 1:100, Possible = 1:1,000, Unlikely = 1:10,000, Rare = 1:100,000, Barely Credible = 1:1,000,000

2. Consequence. Catastrophic = Structure completely destroyed, Major = Structure extensively damaged, Medium = Moderate damage, Minor = Limited damage, Insignificant = Little to insignificant damage

	Probability		Catastrophic	Major	Medium	Minor	Insignificant	Not Credible
	Indicative Value of Cost of Property		200%	60%	20%	5%	0.50%	0.00%
Certain	1:1	1.00E+00	VERY HIGH	VERY HIGH	VERY HIGH	VERY HIGH	HIGH	LOW
Almost Certain	1:10	1.00E-01	VERY HIGH	VERY HIGH	VERY HIGH	HIGH	MODERATE	LOW
Likely	1:100	1.00E-02	VERY HIGH	VERY HIGH	HIGH	MODERATE	LOW	VERY LOW
Possible	1:1000	1.00E-03	VERY HIGH	HIGH	MODERATE	MODERATE	VERY LOW	VERY LOW
Unlikely	1:10000	1.00E-04	HIGH	MODERATE	LOW	LOW	VERY LOW	VERY LOW
Rare	1:100000	1.00E-05	MODERATE	LOW	LOW	VERY LOW	VERY LOW	VERY LOW
Barely Credible	1:1000000	1.00E-06	LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW

* 'Not Credible' category not included in AGS

Landslide Risk Assessment

Stantec Australia Pty Ltd

V220433 Jetty Rd Stage 2

Section 2 - Road

Qualitative Risk Assessment (Risk to Property)

(AGS, Vol 42, No 1, 2007, Appendix C Practice Note)

	0.33-0.1	0.1-0.01	0.01-0.001	0.001-0.0001	0.0001-0.00001	
Property at Risk	Green	Pink	Cyan	Blue	Yellow	
Hazard	Small	Medium	Medium to Large	Very Large	Very Large	
Likelihood - Upper Bound	Certain	Almost Certain	Likely	Possible	Unlikely	
Likelihood - Lower Bound	Almost Certain	Likely	Possible	Unlikely	Rare	
Consequence to Property - Upper Bound	Not Credible	Not Credible	Not Credible	Not Credible	Not Credible	
Consequence to Property - Lower Bound	Not Credible	Not Credible	Not Credible	Not Credible	Not Credible	
Level of Risk - Upper Bound	LOW	LOW	VERY LOW	VERY LOW	VERY LOW	
Level of Risk - Lower Bound	LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW	

Notes:

1. Annual Probability. Certain = 1:1, Almost Certain = 1:10, Likely = 1:100, Possible = 1:1,000, Unlikely = 1:10,000, Rare = 1:100,000, Barely Credible = 1:1,000,000

2. Consequence. Catastrophic = Structure completely destroyed, Major = Structure extensively damaged, Medium = Moderate damage, Minor = Limited damage, Insignificant = Little to insignificant damage

	Probability		Catastrophic	Major	Medium	Minor	Insignificant	Not Credible
	Indicative Value of Cost of Property		200%	60%	20%	5%	0.50%	0.00%
Certain	1:1	1.00E+00	VERY HIGH	VERY HIGH	VERY HIGH	VERY HIGH	HIGH	LOW
Almost Certain	1:10	1.00E-01	VERY HIGH	VERY HIGH	VERY HIGH	HIGH	MODERATE	LOW
Likely	1:100	1.00E-02	VERY HIGH	VERY HIGH	HIGH	MODERATE	LOW	VERY LOW
Possible	1:1000	1.00E-03	VERY HIGH	HIGH	MODERATE	MODERATE	VERY LOW	VERY LOW
Unlikely	1:10000	1.00E-04	HIGH	MODERATE	LOW	LOW	VERY LOW	VERY LOW
Rare	1:100000	1.00E-05	MODERATE	LOW	LOW	VERY LOW	VERY LOW	VERY LOW
Barely Credible	1:1000000	1.00E-06	LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW

* 'Not Credible' category not included in AGS

Landslide Risk Assessment

Stantec Australia Pty Ltd

V220433 Jetty Rd Stage 2

Section 1 - Properties

Qualitative Risk Assessment (Risk to Property)

(AGS, Vol 42, No 1, 2007, Appendix C Practice Note)

	0.33-0.1	0.1-0.01	0.01-0.001	0.001-0.0001	0.0001-0.00001	
Property at Risk	Green	Pink	Cyan	Blue	Yellow	
Hazard	Small	Medium	Medium to Large	Very Large	Very Large	
Likelihood - Upper Bound	Certain	Almost Certain	Likely	Possible	Unlikely	
Likelihood - Lower Bound	Almost Certain	Likely	Possible	Unlikely	Rare	
Consequence to Property - Upper Bound	Not Credible	Not Credible	Not Credible	Not Credible	Not Credible	
Consequence to Property - Lower Bound	Not Credible	Not Credible	Not Credible	Not Credible	Not Credible	
Level of Risk - Upper Bound	LOW	LOW	VERY LOW	VERY LOW	VERY LOW	
Level of Risk - Lower Bound	LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW	

Notes:

1. Annual Probability. Certain = 1:1, Almost Certain = 1:10, Likely = 1:100, Possible = 1:1,000, Unlikely = 1:10,000, Rare = 1:100,000, Barely Credible = 1:1,000,000

2. Consequence. Catastrophic = Structure completely destroyed, Major = Structure extensively damaged, Medium = Moderate damage, Minor = Limited damage, Insignificant = Little to insignificant damage

	Probability		Catastrophic	Major	Medium	Minor	Insignificant	Not Credible
	Indicative Value of Cost of Property		200%	60%	20%	5%	0.50%	0.00%
Certain	1:1	1.00E+00	VERY HIGH	VERY HIGH	VERY HIGH	VERY HIGH	HIGH	LOW
Almost Certain	1:10	1.00E-01	VERY HIGH	VERY HIGH	VERY HIGH	HIGH	MODERATE	LOW
Likely	1:100	1.00E-02	VERY HIGH	VERY HIGH	HIGH	MODERATE	LOW	VERY LOW
Possible	1:1000	1.00E-03	VERY HIGH	HIGH	MODERATE	MODERATE	VERY LOW	VERY LOW
Unlikely	1:10000	1.00E-04	HIGH	MODERATE	LOW	LOW	VERY LOW	VERY LOW
Rare	1:100000	1.00E-05	MODERATE	LOW	LOW	VERY LOW	VERY LOW	VERY LOW
Barely Credible	1:1000000	1.00E-06	LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW

* 'Not Credible' category not included in AGS

Appendix F – LIMITATIONS OF REPORT

LIMITATIONS OF GEOTECHNICAL REPORTS

The purpose of this report is to provide a geotechnical assessment of the sites examined. The information provided herein will reduce the exposure to risks, but no geotechnical assessment can eliminate them. Nonetheless, even a rigorous assessment may fail to detect all of the geotechnical conditions on a site. Site variations may have occurred in areas not investigated or sampled.

This geotechnical report should not be used when the nature of the proposed site usage changes, when the size, layout, or location of the development is modified, when the site ownership changes nor should it be applied to a nearby area. No environmental assessment has been undertaken nor is implied.

This site geotechnical assessment identifies actual subsurface conditions where the samples were taken and at the time they were taken. Any soil tests completed, were carried out in Cardno's NATA accredited soil laboratory. Geotechnical engineers then interpreted the laboratory results and field data and rendered an opinion about the overall subsurface conditions, including the soil type, extent of the soil layers, and their likely impact on the proposed development, with a discussion of the implications considered likely. The actual conditions may differ from the inferred conditions, as no person (no matter how qualified) or even the most detailed subsurface investigation can predict with confidence what may be hidden by soil or water or may have altered with time. Often the interface between different geotechnical areas may be more abrupt or gradual than anticipated. The actual conditions in an area may differ from those predicted.

Site assessments are limited by time, and natural processes such as erosion, or mankind altering the ground conditions, including the site levels or filled areas, may affect a site assessment. This geotechnical assessment is prepared in response to a client's specific requirements. No person other than the client should apply the report without first conferring with Cardno.

Costly problems can occur if the report is misinterpreted. To avoid these problems, Cardno should be retained to work with the appropriate design professionals and to review the adequacy of their plans and specifications relative to the geotechnical matters.

This report should only be reproduced in its entirety. Reproduction of borehole or testpit logs alone without the entire report should not be permitted. Redrafting of the borehole or testpit logs for inclusion in drawings or other reports should not be allowed as errors in the drafting can occur. It is recommended that the report be made available in entirety to persons and organisations involved in the project such as contractors. Simply disclaiming responsibility for the accuracy of the subsurface or geotechnical information does not insulate the organisation from liability. The more information a contractor has available to him, the better able he is to avoid costly construction problems and costly adversarial situations.

Finally, geotechnical reports are based extensively on opinion and judgment and are less exact than other sciences. The report may contain a number of explanatory clauses or limitations on the results to inform the client about the restrictions of the report. These clauses are not meant to be exculpatory clauses to foist liability onto another person, but to identify where Cardno's and the client's responsibilities start and finish. Their use is to clarify where individual responsibilities lie and to allow the individual to take appropriate actions.