Slope Stability Assessment

No. 99, Bena Road, Korumburra, Victoria, 3950

Submitted To

Hillview Rise c/o Brosnan Engineering Solutions

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Table of Contents

Table of Figures and Tables

List of Appendices

Appendix A

Site Plan and Borehole Logs

Appendix B

Cross Sections

Appendix C

Site Photography

Appendix D

Laboratory Test Reports

References:

AS 1726-2017, Geotechnical site investigations, Standards Australia, Sydney, Retrieved from SAI Global

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1 Introduction

Hillview Rise c/o Brosnan Engineering Solutions have engaged Intrax Consulting Engineers Pty Ltd (Intrax) to conduct slope stability assessment for the proposed residential subdivision project located at No. 99, Bena Road, Korumburra.

The scope of work and terms and conditions of our engagement are set out in the fee proposal QU1402537. Approval to proceed was given Matt Brosnan of Brosnan Engineering Solutions by signed quote via email correspondence 03/08/2022.

1.1 Project Description

Hillview Rise c/o Brosnan Engineering Solutions has provided Intrax with layout drawings for review and to provide project background. The following drawings have been used for the assessment:

- Land Slope Plan (18078 PPS Rev E) by Brosnan Engineering Solutions
- Plan of Feature and Levels Survey (W1741 Rev A, dated 21/01/2019) by Raso Consulting Surveyors
- Surrounding Conditions Plan (18078 Rev A) by Brosnan Engineering Solutions
- Proposed Plan of Subdivision (18078 Rev C) by Brosnan Engineering Solutions
- Staging Plan (18078 Rev B) by Brosnan Engineering Solutions

The design drawings for the lot propose the current allotment to be subdivided into 135 residential lots, with associated access roads constructed within 7 stages.

Proposed foundation types or layouts buildings have not been provided to Intrax for preparation of this report.

2 Investigations

2.1 Objectives and Scope

The objective of this investigation is to assess the slope of the site and comment on the suitability of the land for development, in response to *Clause 43.04 Development Plan Overlay (DPO6) point 4.0 Earthworks and Land Form* of the South Gippsland Planning Scheme.

The scope of the work was:

- Preparation of health, safety and environmental documents
- Travel to site
- Machine drilling of 10 borehole to a maximum depth of 3.0 metres below ground level (mbgl) or prior refusal
- Laboratory testing on selected samples
- Analysis and review of field geotechnical test information and the preparation of this report.

The objectives of this report are to:

- Present the findings of the geotechnical site investigation
- Regional geological context
- Topographical, vegetation, and land use description of the site,
- Observations of site walk over
- Slope stability assessment of the site in relation to the proposed development
- Recommendations for any further required assessments

Additionally, a contamination assessment was undertaken by a subcontracted Environmental Scientist (DRC Environmental), in response to *Clause 43.04 Development Plan Overlay (DPO6) point 4.Land Contamination* of the South Gippsland Planning Scheme.

2.2 Desktop assessment

A review of geological maps from the Geological Survey of Victoria, aerial photography and search of Intrax's internal project records were used to assess the anticipated site conditions prior to site and aid in identification of the geological origin.

2.3 Field Investigations

The fieldwork was conducted on 28/09/2022. Fieldwork was conducted in accordance with the proposed scope of work.

Completed boreholes (BH01 to BH10) were drilled by a Vermeer Skid-Steer, EziProbe Hydraulic Drill Rig. Due to ground conditions, boreholes were extended to a maximum depth of 2.2 mbgl where refusal to the solid auger was found. Each borehole was progressed using 100 mm solid flight auger drilling methods through soil. Dynamic Cone Penetrometer (DCP) tests were completed adjacent to each borehole location.

Selected soil samples were retrieved from the substrata for laboratory testing. All test locations were backfilled using the generated spoil.

All materials were described in accordance with the visual and tactile method presented within AS1726-2017: geotechnical Site Investigation. Test positions were recorded using hand-held GPS units, which provide a horizontal accuracy of +/- 5 m. Relative vertical levels from hand-held GPS units are unreliable and are therefore not reported.

The test locations are shown on the site plan provided in Appendix A. Logs from the boreholes and an explanatory sheet outlining the terms and symbols used on the logs is presented in Appendix A.

2.4 Laboratory Testing

Disturbed soil samples collected during borehole drilling were transported to the Intrax Scoresby laboratory for testing. Laboratory testing included Emerson Crumb tests.

3 Site Conditions

3.1 Site Description

The site is located at No. 99, Bena Road, Korumburra, Victoria (-38.436828, 145.806822).

The site is located at the western end of Bena Road, leading from the Korumburra town centre. The site is a mostly rectangular parcel of land, with moderate fall from the centre of the lot to all surrounding boundaries. The site falls approximately 3° to 9° (8 to 15%) to the south and southwest, and 5° to 9° (9 to 15%) to the north, northeast and northwest. Slopes are mostly rounded, with generally consistent gradients. Steeper regions of the block are denoted up to 20% gradient. The northern face of the hill slopes towards Bena Road, whilst the southern face of the hill slopes to the natural creek in the southeast corner of the property.

The site is bound by Bena Road along the northern boundary, existing residential subdivision developments to the east, and vacant paddocks to the south and west.

At the time of investigation, the site was mostly free of structures. A concrete water tank was noted on the southern flank of the property, assumed to be related to the previous agricultural use of the property. Isolated mature trees were observed throughout the property, generally the site appears virgin, with most elevations covered with grasses.

Site conditions on the date of inspection are visible in the attached photography in Appendix B with the site features indicated in the site plan, refer Appendix A.

3.2 Regional Geology

The surface geology underlying the site has been mapped from the Geological Survey Victoria. The digital seamless geological map for the area indicates that the surface geology is Wonthaggi Formation (Ksw), typically comprising of lithic volcaniclastic sandstone, arkose, siltstone, minor conglomerate and coal An extract of the local geological map is provided below.

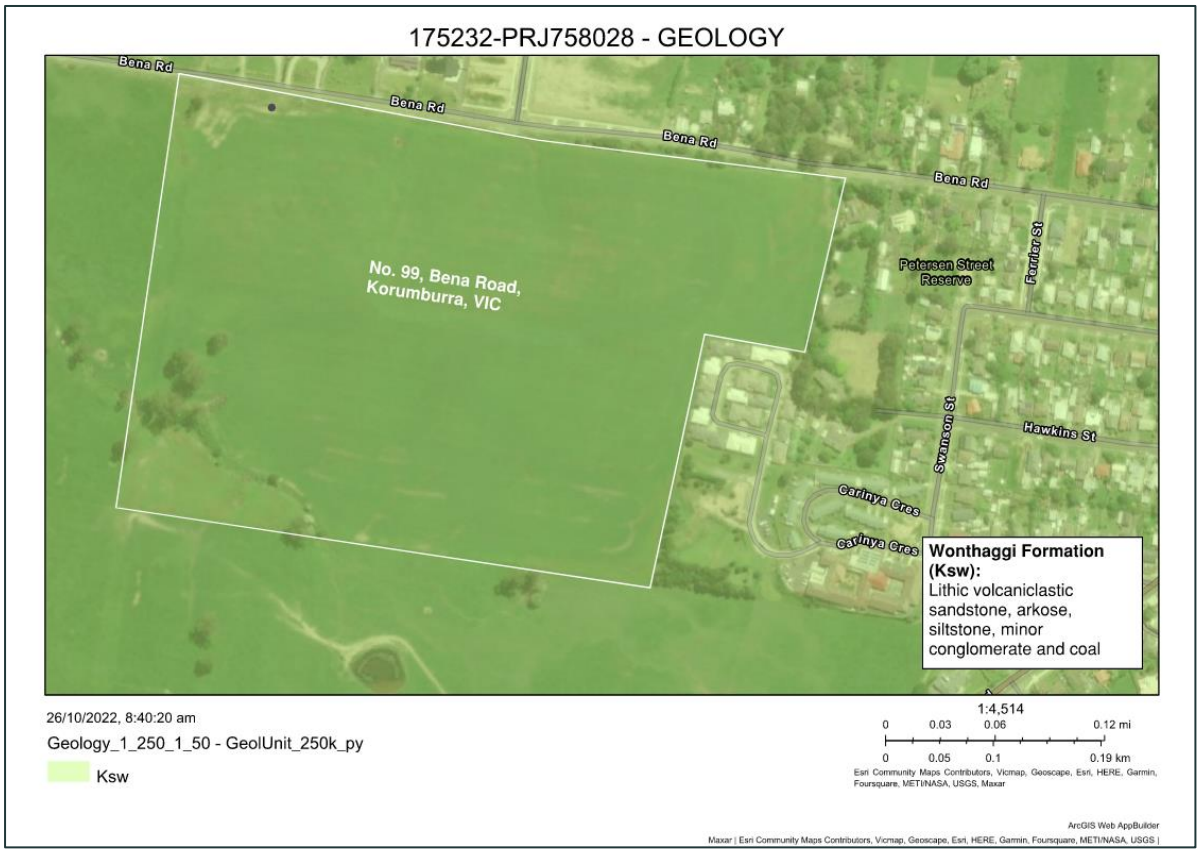

*Figure 1: Extract of local geology, Geological Survey of Victoria (Source: **Intrax.maps.arcgis.com**)*

3.3 Subsurface Conditions

The ground profile and geotechnical units encountered within the investigation boreholes consisted of the following generalised materials encountered. Detailed records of the ground profiles encountered are provided in the borehole logs provided in Appendix A.

Material	Description, material, relative consistency. Extent of occurrence
TOPSOIL (T1)	Clay (CI) and Sandy Clay; medium plasticity, grey-brown, sand is coarse grained and trace root fibres. Moist, dry of the plastic limit, firm to stiff consistency. Encountered in all boreholes from surface level to 0.2 to 0.4 mbgl. DCP blow counts per 100 mm penetration ranged from 2 to 4.
RESIDUAL (RS1)	Clay (CI) and Silty Clay (CI) medium plasticity, grey-brown, with coarse grained sand and trace fine grained subangular orange gravel. Moist, dry of the plastic limit, wet of the plastic limit in BH01. Mostly firm consistency, pockets of very stiff consistency and isolated soft pockets. Encountered in all boreholes below topsoil. DCP blow counts per 100 mm penetration ranged from 1 to 20, averaging 5.
RESIDUAL (RS2)	Clayey Sand (SC); fine to medium grained, pale grey-brown, moist, medium dense consistency. Encountered in BH06 only between 1.1 to 1.3 mbgl. DCP blow counts per 100 mm penetration ranged from 3 to 5.

EXTREMELY WEATHERED MATERIAL(EW1)	XW Sandstone, recovered as Sandy Clay and Clayey Sand; Sand is fine to medium grained, brown mottled grey-black, trace medium grained angular sandstone gravel, dry, dense to very dense. Clay is low plasticity, yellow brown, moist, dry of the plastic limit, very stiff to hard consistency. Encountered in all boreholes, clay in BH01 to BH 06 and BH09 to BH10, sand in BH07 and BH08. Encountered below residual soil to termination refusal depth.

Table 1 Below presents the generalised subsurface profile, with a summary of the materials encountered and their properties:

Table 1: Generalised subsurface profile

Depth (mbg)		Layer thickness (m)	Unit	Occurrence	Consistency / Density	Ground water
From	To					
0	0.2		TOPSOIL (T1)	All boreholes	FIRM	
0.2	0.8		RESIDUAL (RS1)	All boreholes	FIRM TO STIFF	Perched groundwater at 0.6 mbgl in BH01
0.8	>2.2		EXTREMELY WEATHERED MATERIAL(EW1)	All boreholes	VERY STIFF TO HARD / DENSE TO VERY DENSE	

Given the nature of ground it can be anticipated that variation in the below ground profile shall exist throughout the site the profile above is a generalised ground model of the site.

Ground conditions encountered within the completed boreholes are interpreted to be generally consistent with the mapped surface geology and published information.

3.3.1 Ground Water

Groundwater was intersected at a depth of 0.6 mbgl during borehole drilling of BH01 only, this water is assumed to be perched, and intersected at the low-lying borehole location. Groundwater was not intersected through borehole drilling in BH02 through BH10. It is noted that no groundwater monitoring well was installed during the site investigation program, therefore slow seepage through low permeability materials would not have been evident during the short period of time the borehole remained open during drilling activities.

Review of visualising ground water Victoria (http://www.vvg.org.au), an online resource for groundwater information, estimates the water table to be in the range of 20 to 50 metres below ground level.

Substrata conditions encountered are such that infiltration and occurrence of perched water at the interface between different material layers may occur, consideration to perched water infiltration shall be considered for construction or design.

3.4 In-situ Test Results

3.4.1 Penetration Testing (SPT / DCP)

Penetration testing was conducted within the soil profile to assess the soil strength. Dynamic Cone Penetrometer (DCP) tests were conducted from surface adjacent to each borehole. Details of the DCP test results are provided on the borehole logs in Appendix A.

3.5 Laboratory Test Results

Laboratory test results are summarised below, full test reports are provided in Appendix C.

3.5.1 Emerson Class

Four samples were obtained to determine the Emerson Class number. Test results are summarised in the Table 2.

The results indicate that the clay soils onsite classify as Emerson Class 2 soils, indicating they have dispersive tendencies. Where vegetation is removed, leaving topsoils exposed, construction operations should install adequate surface drainage and monitor any surface scouring.

Table 2. Emerson Class test results

Sample Location	Sample Depth (m)	Unit	Nature of Water	Temperature of Water (°C)	Emerson Class
BH04	0.5	Clay	Distilled	20	2
BH05	1.0	Clay			2
BH06	2.0	Sand			1
BH10	0.6	Clay			2

4 Ground Model

A geotechnical ground model has been developed based on the available information compiled within this geotechnical investigation. The ground model is a generalised and simplified representation of the site conditions. The accuracy of presented ground model is limited to the extent and detail of ground data available. The presented ground model is considered suitable for design of the proposed structure, where recommendations in this report are followed, however a more extensive site investigation and testing program will improve the accuracy of the ground model.

Table 3: Geotechnical material parameters

Unit	Depth (mbgl)		Y	Su	c′	φ′	ν	E′	K_a	K_p	K_0
	From	To	kN/m³	kPa	kPa	Degree		MPa			
TOPSOIL (T1)	0	0.2	18	35	-	26	0.3	6	0.39	2.56	0.56
RESIDUAL (RS1)	0.2	0.8	18	75	2	26	0.3	13	0.39	2.56	0.56
EXTREMELY WEATHERED MATERIAL(EW1)	0.8	>2.2	21	150	10	32	0.3	26	0.31	3.25	0.66

Notes: g: bulk unit weight, Su: undrained shear strength, c′: drained cohesion; ϕ': drained friction angle, E′: drained elastic modulus, v: drained Poisson's ratio, mbgl: metres below ground level, K_a, K_p, K_0: Active, At rest and Passive lateral earth pressure coefficients respectively,

Mohr-Coulomb design parameters and modulus values presented in the weathered rock units are provided for the rock mass. Rock mass properties are determined via assessment through *RocScience* software *RocLab 1.0*

Material properties are based on the findings of the intrusive investigations, typical material properties, previous experience, and available published information. Where site specific test data is available it is used to determine material properties, in the absence of test results, typical material properties, previous experience and available published information are adopted.

5 Discussion and Recommendations

The design drawings for the lot propose the current allotment to be subdivided into 135 residential lots, with associated access roads constructed within 7 stages. It is expected that excavations for the development will likely require retaining walls where benching is not readily available.

The proposed development and its construction are assessed for potential slope instability hazards that may occur and impact owners of property (ie. landowners and Council).

A series of sections through the proposed development has been documented in Appendix B. The section locations are denoted in the site plan in Appendix A. Sections have been generated to assess:

a) Road construction

b) Driveway construction

c) Dwelling construction

This assessment has been undertaken by reviewing the proposed subdivision development drawings in conjunction with a site walk over and analysis of site features.

5.1 Landslide Risk Analysis/Assessment

5.1.1 Risk Management Terminology

Risk is defined as a measure of the probability and severity of an adverse effect to health, property or the environment. (Australian Geomechanics Society Landslide Taskforce. 2007).

Risk = the chance of an event times the consequences.

5.1.2 Hazard Identification

The identified hazards associated with the site are presented based on the cross sections attached in Appendix B and are summarised as follows:

a) Shallow Translations Slide:

Where steep excavation is made, during prolong rainy period there is a potential for the upper soils may become saturate and unstable. As such, movement of the surface soil down the slope towards roadways and neighbouring properties.

b) Debris Flow / Earth Flow

Where surface soils become saturated and unstable, large volumes of earth may flow down the hill towards Bena Road at the north and the adjoining properties to the south. Often, flows are graduated from shallow translational slides.

c) Slow Earthflow (Creep)

Creep surface movement occurs where slow steady downward movement of soil or rock migrates down a slope. Movement is generally caused by internal shear stresses building up in the soil block to a point that is sufficient to stop major deformation, however insufficient for stopping stability failures.

5.1.3 Likelihood Assessment

a) Shallow Translations Slide:

It is expected that steep excavation cuts will be supported with an engineering designed retaining wall structure with a suitable drainage network. As such, the likelihood of this hazard occurring is assessed as **'unlikely.'**

b) Debris Flow / Earth Flow

Good drainage practices are expected to be employed throughout the development. Additionally, slopes are expected to be well vegetated, vertical cuts are required to be retained with an engineering designed retaining wall. Therefore, the likelihood of this event is assessed as **'unlikely.'**

c) Slow Earthflow (Creep)

No signs of creep movement or hummocky ground was noted on the site or on adjoining properties at the time of investigation. Landform features are observed as uniform, rounded, and stable. Excavations for the proposed subdivision are not expected to increase the likelihood of creep movement. As such, the likelihood of creep occurring is assessed as **'rare.'**

5.1.4 Consequence Values

Using the table *Qualitative Measures of Consequences to Property* of Appendix C AGS (2007) and taking into account the proposed development the consequences are assessed as follows

a) Shallow Translations Slide:

Where a translational slide occurs, property damage is expected to range from localised undermining of structures, failure of retaining walls, undermining and damage of driveways and roadways. An indicative approximate cost of damage to properties is expected to be in the range of 20%, described as **'medium'** damage.

b) Debris Flow / Earth Flow

Debris flows are expected to impact roads by locally undermining shoulders and partial lane failures. Retaining walls may be damages via local failures, and dwellings may be impacted by impact of a flow of earth building up on external walls. An indicative approximate cost of damage to properties is expected to be in the range of 20%, described as **'medium'** damage.

c) Slow Earthflow (Creep)

Slow earthflows occurring over a period of time will create localised piles of earth that may migrate onto roadways and properties. An indicative approximate cost of damage to properties is expected to be in the range of 0.5%, described as **'insignificant'** damage.

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	Notional Boundary					
10^{-1}	$5x10^{-2}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}		100 years		The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-3}$	1000 years	200 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-4}$	10,000 years	2000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-5}$	100,000 years	20,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}	$5x10^{-6}$	1,000,000 years	200,000 years	The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	Notional Boundary			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

91 Australian Geomechanics Vol 42 No 1 March 2007

Figure 2. Landslide Risk Assessment

5.1.5 Risk Assessment for Property

The following table is a brief risk assessment to highlight the potential risk of landslides to the proposed development/allotment associated with the current hazards identified during the site inspection and fieldwork.

Table 4. Landslide Risk Assessment

Landslide Event	Likelihood	Consequence	Risk
Shallow Translational Slide	Unlikely	Medium	**Low**
Debris Flow / Earth Flow	Unlikely	Medium	**Low**
Slow Earthflow (Creep)	Rare	Insignificant	**Very Low**

The above terminology is taken from the AGS Practice note guidelines for Landslide Risk Management (2007) – Appendix C (as reproduced below)

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	1: CATASTROPHIC 200%	2: MAJOR 60%	3: MEDIUM 20%	4: MINOR 5%	5: INSIGNIFICANT 0.5%
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or L (5)
B - LIKELY	10^{-2}	VH	VH	H	M	L
C - POSSIBLE	10^{-3}	VH	H	M	M	VL
D - UNLIKELY	10^{-4}	H	M	L	L	VL
E - RARE	10^{-5}	M	L	L	VL	VL
F - BARELY CREDIBLE	10^{-6}	L	VL	VL	VL	VL

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.
(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

Figure 3. Extract Appendix C – AGS (2007)

5.1.6 Recommendations – Risk Management Property

Based on risk assessment this site poses a **low risk** for all hazards. Therefore, no further risk management process is required for proposed development. However, as precautionary measures following construction practices must be adopted with the proposed development.

- All surface and run off water must be collected and discharge into the legal point of discharge. No water ponding or collecting within the site is not recommended. This can be achieved by installing appropriate drainage up slope of the site and around the perimeter of the site. The drainage system design is to be reviewed by Intrax
- Revegetation of any disturbed areas must be undertaken as soon as possible.
- Any cuts within the site must be retained by engineer designed retention system. Installation of drainage behind the retaining walls must be installed.

Please note: If proposed development alters the land use in drawings provided by Brosnan Engineering Solutions, this office must be contacted for a review of the design.

South Gippsland Shire Council do not have a policy nominating the accepted and tolerable risk criteria. In this instance, the criteria is adopted per the AGS Guidelines 2007.

Note, good hillside practices should be adopted at all times when building on sites that may become unstable. The AGS - GEOGUIDES outlines good hillside practices and can be found attached to this document.

5.1.7 Risk Assessment for Life Post Construction

The risk to life is considered not credible at this site under the current assessment. The likelihood that any event at this site would be rapid and pose a threat to occupants of the proposed development is not credible.

Further, it is the intention of the above analysis to eliminate where possible the hazards identified with the development and mitigate any risks through engineering design.

5.2 Subdivision Considerations

Subdivision plans have been provided to this office that nominate the location of roads and lot boundaries only. Cut and fill plans have not been provided to this office as part of this review.

5.2.1 Environmental, Access and Amenity

Roadways and Property Driveways

Roadways are nominated to be aligned both parallel and perpendicular to existing slopes. It is expected that in the majority of road cases, cut and fill exercises will be employed to balance earthworks for civil construction. The roadway between lots 72-81 and 82-93 is likely to require an engineering designed retaining wall system along the fill side of the road due to the steep gradient. Alternatively, bulk earthworks may reduce the current gradient, stockpiling material for reuse across the development.

Where roads are constructed perpendicular with the current gradient, excavations for road bases should be constructed on-grade as much as possible. All cuts are to adopt parameters stipulated in Table 6, below. Any filling should be keyed into the slope to ensure a satisfactory base and mitigate instability or creep actions and **not exceed a depth of 1.0m**. Where batters are required to be steeper than 1V:2H, an engineering designed retaining wall system should be incorporated. Options such as crib or gabion walls may be adopted. Where permanent batters are proposed, they are to be revegetated immediately following construction completion.

Earthworks must follow the guidelines recommended in section 6.

5.2.2 Building Controls

As identified in the landslide risk assessment, property development is assessed as Low Risk in accordance with AGS Guidelines 2007. Residential lot construction is expected to be typical of footings prescribed in AS2870-2011, namely, benched sites with slabs on ground, or stump footings on existing or modified slopes.

Based on the hazard analysis, where there is modifications to the slope, likelihood and consequence of failure is not expected to increase beyond a residual Low Risk classification. Cut and fills are to be designed appropriately to ensure that stability conditions are not adversely affected.

5.2.3 Site Classification – AS 2870

It is noted that following classification is strictly only applicable to Class 1 and 10a structures in accordance with the Building Code of Australia, generally referring to residential dwelling or other lightweight structures. Notwithstanding the above limitations, the classification is a useful measure of site reactivity and can be considered in the design on numerous lightweight structures likely to be influenced by surface movements resulting from soil suction (moisture) changes.

After considering the area geology, the soil profile encountered in the borehole, and the climatic zone of the area, this site has been classified as CLASS P with respect to Australian Standard 2870-2011 “Residential Slabs and Footings”. The site is categorised as CLASS P due to the prevailing abnormal moisture conditions resulting from trees or removed trees and the likelihood of introduced fill on the site. The abnormal moisture conditions must be alleviated or allowed for in design of the footing system. It is anticipated that in the absence of the abnormal moisture conditions and fill material the seasonal surface movement would be in the order of 20 mm to 40 mm. Following completion of the subdivision it would be a requirement of this report that individual classification be carried out acknowledging the findings of this report.

5.2.4 Retaining Walls

The following parameters established from Rankine's theory would be valid in the design of a retention system.

Table 5. Geotechnical soil and retention design parameters

Unit	Material Strength	Ka	Kp	Ko
Topsoil (T1)	FIRM	0.39	2.56	0.56
Residual Soil (RS1)	FIRM TO STIFF	0.39	2.56	0.56
Extremely Weathered Material (EW1)	VERY STIFF TO HARD / DENSE TO VERY DENSE	0.31	3.25	0.47

K_a, K_p and K_o are the active, passive and at-rest earth pressure coefficients.

The above values assume:

- a vertical wall with horizontal ground surface.
- water table is below the bottom of the excavation using adequate drainage
- any adjacent surcharge loads are superimposed.

5.2.5 Short and Long Term Batters

Table 6. Acceptable Batter Angles

Unit	Short Term Batter Angles	Long Term Batter Angles
Topsoil	1V:2H	1V:3H
Residual Soil (Clay / Clayey Sand)	1V:1H	1V:2H
Extremely Weathered Sandstone	1V:0.5H	1V:1H

6 Earthworks Specification

6.1 Methodology

It is understood from a review of the provided design documentation and discussions with the client that the earthworks intent is to reuse site won soils where possible. Site won material is to be placed under Level 1 supervision in accordance with AS3798-2007, with the purpose of classifying the soils as structural engineered fill, providing adequate bearing capacity for foundations.

6.2 Suitability of Onsite Soils for Earthworks

Laboratory testing of the site won material is beyond the scope of this investigation. Intrax's experience with materials in this geology are used for assessing the suitability for earthworks. The residual soils and extremely weathered material onsite are considered suitable for reuse onsite as engineered fill. Results of borehole drilling and insitu testing indicate that the materials onsite present approximate CBR values of at least 3%. Further laboratory testing is advised to confirm the engineering properties where bulk excavation is required and site won material is nominated for reuse.

6.3 Unsuitable Materials

The following materials are considered unsuitable:

a) Organic soils, such as topsoils, severely root effected subsoils and peat
b) Contaminated soils
c) Silts or materials that have deleterious engineering properties of silt
d) Fill that contains wood, metal, plastic, boulders, concrete, or deleterious material.

And/or any other materials as described in AS3798 Section 4.2. They should be removed to spoil and not be incorporated into the fill.

The investigation conducted encountered minor topsoils and silt layers which are unsuitable for use and are to be stripped.

6.4 Suitable Materials

Site won material including the existing uncontrolled fill, which is inferred to be previously derived from the site itself, and natural residual soils and weathered sandstone are suitable for use.

Imported material shall maintain similar or better material characteristics to the existing site derived material. To ensure site reactivity remains in line with other sections of this report any imported fill must have a Shrink-Swell Index of no greater than 2% and a CBR swell potential less than 1.0%. All imported fill shall achieve a minimum CBR of 4%. Generalised material descriptions suitable for this use include; low to moderately plastic clay, soft rock or quarried sand/gravel products.

In this instance, clay derived from the site is considered suitable for use as fill following moisture conditioning.

6.5 Drainage

It is necessary to ensure that, until the fill is at a level where it will self-drain, adequate drainage be maintained to prevent water being retained on the surface of the proposed FILL pad in the event of significant rainfall.

6.6 Site Clearing

All trees (including root systems), stumps, building and other debris as well as other organic materials are unsuitable for incorporation into the filling should be removed and disposed of appropriately. Organic material must not be mixed into the material being placed onsite, and tree roots/bulbs should not be left in place prior to placing fill over the area or in cut areas of the site. Removed tree bulbs shall be backfilled within material compacted in accordance with this specification.

6.7 Stripping

All materials listed in section 6.3 must be removed prior to the placement of any FILL at this site. Upon completion of site stripping an inspection will be required to ensure the exposed surface is suitable for acceptance of the filling. Localised areas may require further stripping.

6.8 Slope Preparation (Cut Fill sites)

Where fill abuts sloping ground, it is desirable that the fill be benched into the slope. The cut benches should be shaped to provide free drainage. Benches 200 mm in height can be cut and fill can be keyed into and compacted following these steps are no higher than 200 mm. Fill shall be over placed or undercut on batters and the final batter surface achieved by trimming back the surface.

6.9 Foundation Preparation

Following clearing and stripping any soft/wet material shall be removed to expose a firm base to be rolled and approved by Intrax's geotechnical compaction supervisor prior to placement of any fill. A formal proof roll shall be undertaken to ensure that soft spots are not prevalent, refer section 6.10.4. Where proof rolls identify soft areas, these areas will be locally excavated and reworked with imported or site won materials as directed by the technician supervising the base inspection.

Prior to placing any new fill, the existing approved surface should be ripped to 150 mm below existing surface level and moisture conditioned to between +/-2% of the optimum moisture content. Once this is achieved, fill can be placed directly over the compacted surface.

6.10 Backfilling and Compaction

6.10.1 Compactive Effort

The contractor is to adopt appropriate machinery to both spread and place fill. As a minimum it would be expected that spreading of the fill be undertaken with graders/dozers to ensure the requirements of section 6.10.2 can be met. As a guide 5 tonne or greater sheep's foot rollers / compactors would be applicable at this site.

6.10.2 Placement of Fill

All fill should be placed in horizontal layers of maximum 200 mm loose thickness and at a uniform moisture condition between +/-2% of optimum moisture content as determined by either AS1289 5.1.1 or 5.7.1, prior to compaction.

6.10.3 Compaction of Fill

Fill shall be compacted to achieve a density ratio of not less than 95% Standard Compaction in all areas, as determined by either AS1289 5.1.1 or 5.7.1

6.10.4 Proof Roll Testing

Areas where structural fills are placed and materials within 150mm of permanent subgrade cutting levels should be compacted so as to withstand test rolling without visible deformation or springing. Suitable plant for testing rolling procedures may consist of:

a) Static smooth steel wheeled rollers with a mass of not less than 12t and a load intensity under either the front or rear wheels of not less than 6 t/m width of wheel.
b) Pneumatic tyred plant with a mass of not less than 20t and a ground contact pressure under either the front or rear wheels of not less than 450 kPa per tyre. The area over which this ground contact pressure is applied should be not less than 0.035 m^2 per tyre.
c) Highway truck with rear axle or axles loaded to not less than 8t each, with tyres inflated to 550 kPa.

6.11 Supervision, Inspection and Testing of Fill

Level 1 supervision and inspection is considered suitable (refer AS3798-2007) for the intention of this specification. This is further defined below.

Frequency of field density testing shall be in accordance with AS3798-2007 Table 8.1 Type 1 large scale operations using test method AS1289 5.8.1 (determination of field density using a nuclear gauge). The testing frequency is defined as follows;

a) 1 test per layer or
b) 1 test per 500m3 (reasonably distributed throughout the full depth and area)

6.12 Acceptance of Filling

Upon completion of the works, Intrax can provide a report can be provided which certifies the filling procedures and compaction control works which thus details that the fill can be deemed Controlled FILL as defined by AS2870-2011 Section 6.4.2. Intrax requires sufficient notification of the pending earthworks in order to observe the completed filling works and make an assessment of these works.

Note, the building supervisor and earthworks contractor is required to review this document prior to commencing works.

7 Limitations of Report

1. The recommendations in this report are based on the following:
    a. Information about the site & its history, proposed site treatment and building type conveyed to us by the client and or their agent
    b. Professional judgements and opinions using the most recent information in soil testing practice that is available to us.
    c. The location of our test sites and the information gained from this and other investigations.

    Should the client or their agent neglect to supply us with correct or relevant information, including information about previous buildings, trees or past activities on the site, or should changes be made to the building type, size and or/position, this report may be made obsolete, irrelevant or unsuitable. In such cases, Intrax will not accept any liability for the consequences and Intrax reserves the right to make an additional charge if more testing or a change to the report is necessary.
2. The recommendations made in this report may need to be reviewed should any site works disturb any soil 200mm below the proposed founding depth.
3. The descriptions of the soils encountered in the boreholes follow those outlined in AS1726-2017; Geotechnical Site Investigations. Colour descriptions can vary with soil moisture content and individual interpretation.
4. If the site conditions at the time of construction differ from those described in this report, then Intrax must be contacted so a site inspection can be carried out prior to any footing being poured. The owner/builder will be responsible for any fees associated with this additional work.
5. This report assumes that the soil profile observed in the boreholes are representative of the entire site. If the soil profile and site conditions appear to differ substantially from those reported herein, then Intrax should be contacted immediately and this report may need to be reviewed and amended where appropriate. The owner/builder will be responsible for any fees associated with this additional work.
6. The user of this report must consider the following limitations. Soil and drilling depths are given to a tolerance of +/- 200mm.

    It must be understood and a condition of acceptance of this report is that whilst every effort is made to identify fill material across the site, difficulties exist in determining fill material, in particular, for example, well compacted site or area derived fill, when utilising a small diameter auger. Consequently, Intrax emphasises that we will not be responsible for any financial losses, consequential or otherwise, that may occur as a result of not accurately determining the fill profile across the site.
7. Finally, no responsibility will be taken for this report if it is altered in any way or is not reproduced in full.

Appendix A

Site Plan and Borehole Logs

Intrax GROUP

Civil
Forensic
Hydraulic
Structural
Surveying
Residential
Geotechnical
Building Services

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EMAIL: info@intrax.com.au
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Client: Hillview Rise c/o Brosnan Engineering Solutions

Project: No. 99, Bena Road, Korumburra, VIC, 3950

Drawing: Site Plan

Logged:	TR	Scale (A4):	Not to scale
Driller:	AJ	Date:	28/09/2022
Checked:	JM	Sheets:	1
Project No.	175232 PRJ758028	Drawing No.	1 of 1
		Ver.	1

BOREHOLE: BH 01

Sheet 1 OF 1

Project:	Landslide Risk Assessment		Date Started: 28/9/2022
Location:	No. 99, Bena Road, Korrumburra, VIC, 3950	Coordinates: 396211.0 mE 4299136.3 mN MGA94 Zone 55	Date Completed: 28/9/2022
Position:		Contractor: Intrax	Logged: TR
Job No.:	175232-PRJ758208	Drill Rig: Eziprobe	Checked: JM
Client:	Brosnan Engineering Services	Inclination: -90°	Date: 18/10/2022

Drilling					Sampling / Testing			Field Material Description					
Method	Penetration Resistance	Water	Depth (m)	Depth RL	Sample or Test	DCP	Recovered	Graphic Log	Group Symbol	Material Description	Moisture Condition	Consistency / Density	Origin and Aditional Observations
		Not Observed	0.0			5			Cl	CLAY; medium plasticity, grey-brown, with coarse grained sand, trace root fibres		St	TOPSOIL
			0.2	0.20		4			Cl	CLAY; medium plasticity, grey-brown, with coarse grained sand, trace fine grained subangular orange gravel	w < PL		RESIDUAL SOIL
			0.4			2							
			0.6	0.60		2				increase in moisture content, possible perched water		F	
			0.8			2							
			1.0	1.00		4					w > PL		
			1.2			8				XW SANDSTONE; recovered as Sandy CLAY; low plasticity, yellow-brown		H	EXTREMELY WEATHERED MATERIAL
				1.30		15							
			1.4			20				Hole Terminated at 1.30 m Refusal			
			1.6										
			1.8										
			2.0										
			2.2										
			2.4										

Refer to explanatory notes for definitions and abbreviations

INTRAX 2.00 LIB.GLB Log INTRAX STD BOREHOLE 175232-PRJ758208-GEO-BH LOGS.GPJ <<DrawingFile>> 18/10/2022 12:45 10.02.00.04 Datgel Lab and In Situ Tool - DGD | Lib: Intrax 1.00 2020-04-14 Prj: intrax 1.00 2020-04-14

BOREHOLE: BH 02

Sheet 1 OF 1

Project:	Landslide Risk Assessment		Date Started: 28/9/2022
Location:	No. 99, Bena Road, Korrumburra, VIC, 3950	Coordinates: 395617.9 mE 4254853.2 mN MGA94 Zone 55	Date Completed: 28/9/2022
Position:		Contractor: Intrax	Logged: TR
Job No.:	175232-PRJ758208	Drill Rig: Eziprobe	Checked: JM
Client:	Brosnan Engineering Services	Inclination: -90°	Date: 18/10/2022

Drilling					Sampling / Testing			Field Material Description					
Method	Penetration Resistance	Water	Depth (m)	Depth RL	Sample or Test	DCP	Recovered	Graphic Log	Group Symbol	Material Description	Moisture Condition	Consistency / Density	Origin and Aditional Observations
		Not Observed	0.0			4			Cl	Sandy CLAY; medium plasticity, grey-brown, sand is coarse grained, trace root fibres		St	TOPSOIL
			0.2			3							
				0.30		2							
						2			Cl	CLAY; medium plasticity, grey-brown, with coarse grained sand, trace fine grained subangular orange gravel			RESIDUAL SOIL
			0.4			2							
						2							
			0.6			2					w < PL	F	
						2							
			0.8			2							
				0.90		6							
						10				XW SANDSTONE; recovered as Sandy CLAY; low plasticity, yellow-brown			EXTREMELY WEATHERED MATERIAL
			1.0			13							
						15						St to VSt	
			1.2										
				1.40									
			1.4							Hole Terminated at 1.40 m Refusal			
			1.6										
			1.8										
			2.0										
			2.2										
			2.4										

Refer to explanatory notes for definitions and abbreviations

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BOREHOLE: BH 03

Sheet 1 OF 1

Project:	Landslide Risk Assessment		Date Started: 28/9/2022
Location:	No. 99, Bena Road, Korrumburra, VIC, 3950	Coordinates: 395614.7 mE 4254958.2 mN MGA94 Zone 55	Date Completed: 28/9/2022
Position:		Contractor: Intrax	Logged: TR
Job No.:	175232-PRJ758208	Drill Rig: Eziprobe	Checked: JM
Client:	Brosnan Engineering Services	Inclination: -90°	Date: 18/10/2022

Drilling					Sampling / Testing			Field Material Description					
Method	Penetration Resistance	Water	Depth (m)	Depth RL	Sample or Test	DCP	Recovered	Graphic Log	Group Symbol	Material Description	Moisture Condition	Consistency / Density	Origin and Aditional Observations
			0.0			2			Cl	Sandy CLAY; medium plasticity, grey-brown, sand is coarse grained, trace root fibres			TOPSOIL
			0.2	0.20		3							
						2			Cl	CLAY; medium plasticity, grey-brown, with coarse grained sand, trace fine grained subangular orange gravel		F	RESIDUAL SOIL
						2							
			0.4	0.40		4				XW SANDSTONE; recovered as Sandy CLAY; low plasticity, yellow-brown			EXTREMELY WEATHERED MATERIAL
						6							
		Not Observed	0.6			8					w < PL	St to VSt	
			0.8			10							
						10							
			1.0			13							
						17							
						20						H	
			1.2	1.30									
										Hole Terminated at 1.30 m Refusal			
			1.4										
			1.6										
			1.8										
			2.0										
			2.2										
			2.4										

Refer to explanatory notes for definitions and abbreviations

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BOREHOLE: BH 04

Sheet 1 OF 1

Project:	Landslide Risk Assessment			Date Started:	28/9/2022
Location:	No. 99, Bena Road, Korrumburra, VIC, 3950	Coordinates:	395603.6 mE 4255018.0 mN MGA94 Zone 55	Date Completed:	28/9/2022
Position:		Contractor:	Intrax	Logged:	TR
Job No.:	175232-PRJ758208	Drill Rig:	Eziprobe	Checked:	JM
Client:	Brosnan Engineering Services	Inclination:	-90°	Date:	18/10/2022

Drilling					Sampling / Testing			Field Material Description					
Method	Penetration Resistance	Water	Depth (m)	Depth RL	Sample or Test	DCP	Recovered	Graphic Log	Group Symbol	Material Description	Moisture Condition	Consistency / Density	Origin and Aditional Observations
			0.0			2			Cl	Sandy CLAY; medium plasticity, grey-brown, sand is coarse grained, trace root fibres			TOPSOIL
				0.20		2							
			0.2			2			Cl	CLAY; medium plasticity, grey-brown, with coarse grained sand, trace fine grained subangular orange gravel			RESIDUAL SOIL
			0.4			2						F	
					D 0.50 m	2							
			0.6			6							
		Not Observed				6					w < PL	St to VSt	
			0.8			12							
				1.00		14							
			1.0			20				XW SANDSTONE; recovered as Sandy CLAY; low plasticity, yellow-brown			EXTREMELY WEATHERED MATERIAL
			1.2									VSt to H	
			1.4										
			1.6										
				1.70									
			1.8							Hole Terminated at 1.70 m Refusal			
			2.0										
			2.2										
			2.4										

Refer to explanatory notes for definitions and abbreviations

INTRAX 2.00 LIB.GLB Log INTRAX STD BOREHOLE 175232-PRJ758208-GEO-BH LOGS.GPJ <<DrawingFile>> 18/10/2022 12:45 10.02.00.04 Datgel Lab and In Situ Tool - DGD | Lib: Intrax 1.00 2020-04-14 Prj: intrax 1.00 2020-04-14

BOREHOLE: BH 05

Sheet 1 OF 1

Project:	Landslide Risk Assessment			Date Started:	28/9/2022
Location:	No. 99, Bena Road, Korrumburra, VIC, 3950	Coordinates:	395718.1 mE 4255072.6 mN MGA94 Zone 55	Date Completed:	28/9/2022
Position:		Contractor:	Intrax	Logged:	TR
Job No.:	175232-PRJ758208	Drill Rig:	Eziprobe	Checked:	JM
Client:	Brosnan Engineering Services	Inclination:	-90°	Date:	18/10/2022

Drilling					Sampling / Testing			Field Material Description					
Method	Penetration Resistance	Water	Depth (m)	Depth RL	Sample or Test	DCP	Recovered	Graphic Log	Group Symbol	Material Description	Moisture Condition	Consistency / Density	Origin and Aditional Observations
		Not Observed	0.0			2			Cl	Sandy CLAY; medium plasticity, grey-brown, sand is coarse grained, trace root fibres			TOPSOIL
			0.2	0.20		2			Cl	CLAY; medium plasticity, grey-brown, with coarse grained sand, trace fine grained subangular orange gravel		F	RESIDUAL SOIL
			0.4			2							
						3							
			0.6			2					w < PL		
						3							
			0.8			5						VSt	
						10							
			1.0		D 1.00 m	11							
						13							
			1.2			20						VSt to H	
				1.30						XW SANDSTONE; recovered as Sandy CLAY; low plasticity, yellow-brown			EXTREMELY WEATHERED MATERIAL
			1.4	1.40						Hole Terminated at 1.40 m Refusal			
			1.6										
			1.8										
			2.0										
			2.2										
			2.4										

Refer to explanatory notes for definitions and abbreviations

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BOREHOLE: BH 06

Sheet 1 OF 1

Project:	Landslide Risk Assessment		Date Started: 28/9/2022
Location:	No. 99, Bena Road, Korrumburra, VIC, 3950	Coordinates: 395819.5 mE 4254953.3 mN MGA94 Zone 55	Date Completed: 28/9/2022
Position:		Contractor: Intrax	Logged: TR
Job No.:	175232-PRJ758208	Drill Rig: Eziprobe	Checked: JM
Client:	Brosnan Engineering Services	Inclination: -90°	Date: 18/10/2022

Drilling					Sampling / Testing			Field Material Description					
Method	Penetration Resistance	Water	Depth (m)	Depth RL	Sample or Test	DCP	Recovered	Graphic Log	Group Symbol	Material Description	Moisture Condition	Consistency / Density	Origin and Aditional Observations
			0.0			1			CI	Sandy CLAY; medium plasticity, grey-brown, sand is coarse grained, trace root fibres		S to F	TOPSOIL
				0.20		2							
			0.2			3			CI	CLAY; medium plasticity, grey-brown, with coarse grained sand, trace fine grained subangular orange gravel	w < PL		RESIDUAL SOIL
			0.4			3							
						2							
			0.6			3						F	
						2							
			0.8			2							
						2							
			1.0			3					w > PL		
		Not Observed		1.10		3			SC	Clayey SAND; fine to medium grained, pale grey brown	M	MD	
			1.2			5							
				1.30		20			CI	CLAY; medium plasticity, grey mottled pale brown, trace fine to medium grained angular gravel			
			1.4										
			1.6										
				1.70						XW SANDSTONE; recovered as Sandy CLAY; low plasticity, yellow-brown	w < PL	VSt to H	EXTREMELY WEATHERED MATERIAL
			1.8										
			2.0		D 2.00 m								
				2.20									
			2.2							Hole Terminated at 2.20 m Refusal			
			2.4										

Refer to explanatory notes for definitions and abbreviations

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BOREHOLE: BH 07

Sheet 1 OF 1

Project:	Landslide Risk Assessment		Date Started: 28/9/2022
Location:	No. 99, Bena Road, Korrumburra, VIC, 3950	Coordinates: 396009.3 mE 4255083.2 mN MGA94 Zone 55	Date Completed: 28/9/2022
Position:		Contractor: Intrax	Logged: TR
Job No.:	175232-PRJ758208	Drill Rig: Eziprobe	Checked: JM
Client:	Brosnan Engineering Services	Inclination: -90°	Date: 18/10/2022

Drilling					Sampling / Testing			Field Material Description					
Method	Penetration Resistance	Water	Depth (m)	Depth RL	Sample or Test	DCP	Recovered	Graphic Log	Group Symbol	Material Description	Moisture Condition	Consistency / Density	Origin and Aditional Observations
		Not Observed	0.0			1			CL	Silty CLAY; low plasticity, grey-brown, trace coarse grained sand, trace root fibres	w < PL	S to F	TOPSOIL
			0.2			2							
						2							
			0.4	0.40		2			CL	Silty CLAY; low plasticity, grey-brown, trace coarse grained sand	w > PL		RESIDUAL SOIL
						2							
			0.6			2							
						2					w < PL	F to St	
			0.8			3							
						4							
			1.0			4							
				1.10		20				XW SANDSTONE; recovered as clayey SAND; fine to medium grained, yellow-brown	D	D to VD	EXTREMELY WEATHERED MATERIAL
			1.2										
			1.4										
			1.6										
			1.8	1.80						Hole Terminated at 1.80 m Refusal			
			2.0										
			2.2										
			2.4										

Refer to explanatory notes for definitions and abbreviations

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BOREHOLE: BH 08

Sheet 1 OF 1

Project:	Landslide Risk Assessment		Date Started: 28/9/2022
Location:	No. 99, Bena Road, Korrumburra, VIC, 3950	Coordinates: 395983.4 mE 4254898.1 mN MGA94 Zone 55	Date Completed: 28/9/2022
Position:		Contractor: Intrax	Logged: TR
Job No.:	175232-PRJ758208	Drill Rig: Eziprobe	Checked: JM
Client:	Brosnan Engineering Services	Inclination: -90°	Date: 18/10/2022

Drilling					Sampling / Testing			Field Material Description					
Method	Penetration Resistance	Water	Depth (m)	Depth RL	Sample or Test	DCP	Recovered	Graphic Log	Group Symbol	Material Description	Moisture Condition	Consistency / Density	Origin and Aditional Observations
		Not Observed	0.0			1			CL	Silty CLAY; low plasticity, grey-brown, trace coarse grained sand, trace root fibres		S to F	TOPSOIL
				0.20		2							
			0.2			1			CL	Silty CLAY; low plasticity, grey-brown, trace coarse grained sand	w < PL		RESIDUAL SOIL
			0.4			2							
						2							
			0.6			2						S to F	
						2							
			0.8			2							
				0.90		8							
			1.0			8				XW SANDSTONE; recovered as clayey SAND; fine to medium grained, yellow-brown	D	D to VD	EXTREMELY WEATHERED MATERIAL
						14							
			1.2			20							
				1.30						Hole Terminated at 1.30 m Refusal			
			1.4										
			1.6										
			1.8										
			2.0										
			2.2										
			2.4										

Refer to explanatory notes for definitions and abbreviations

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BOREHOLE: BH 09

Sheet 1 OF 1

Project:	Landslide Risk Assessment			Date Started:	28/9/2022
Location:	No. 99, Bena Road, Korrumburra, VIC, 3950	Coordinates:	396117.3 mE 4254868.8 mN MGA94 Zone 55	Date Completed:	28/9/2022
Position:		Contractor:	Intrax	Logged:	TR
Job No.:	175232-PRJ758208	Drill Rig:	Eziprobe	Checked:	JM
Client:	Brosnan Engineering Services	Inclination:	-90°	Date:	18/10/2022

Drilling					Sampling / Testing			Field Material Description					
Method	Penetration Resistance	Water	Depth (m)	Depth RL	Sample or Test	DCP	Recovered	Graphic Log	Group Symbol	Material Description	Moisture Condition	Consistency / Density	Origin and Aditional Observations
			0.0			2			Cl	Sandy CLAY; medium plasticity, grey-brown, sand is coarse grained, trace root fibres			TOPSOIL
			0.2			3							
						3							
						3							
			0.4	0.40		3			Cl	CLAY; medium plasticity, grey-brown, with coarse grained sand, trace fine grained subangular orange gravel	w < PL	F	RESIDUAL SOIL
			0.6			3							
						3							
		Not Observed	0.8			3							
				0.90		3				XW SANDSTONE; recovered as clayey SAND; fine to medium grained, brown mottled grey-black, trace medium grained angular gravel			EXTREMELY WEATHERED MATERIAL
			1.0			9							
						20						D to VD	
			1.2										
			1.4								D		
			1.6	1.70									
			1.8							Hole Terminated at 1.70 m Refusal			
			2.0										
			2.2										
			2.4										

Refer to explanatory notes for definitions and abbreviations

INTRAX 2.00 LIB.GLB Log INTRAX STD BOREHOLE 175232-PRJ758208-GEO-BH LOGS.GPJ <<DrawingFile>> 18/10/2022 12:45 10.02.00.04 Datgel Lab and In Situ Tool - DGD | Lib: Intrax 1.00 2020-04-14 Prj: intrax 1.00 2020-04-14

BOREHOLE: BH 10

Sheet 1 OF 1

Project:	Landslide Risk Assessment		Date Started: 28/9/2022
Location:	No. 99, Bena Road, Korrumburra, VIC, 3950	Coordinates: 395920.3 mE 4254775.2 mN MGA94 Zone 55	Date Completed: 28/9/2022
Position:		Contractor: Intrax	Logged: TR
Job No.:	175232-PRJ758208	Drill Rig: Eziprobe	Checked: JM
Client:	Brosnan Engineering Services	Inclination: -90°	Date: 18/10/2022

Drilling					Sampling / Testing			Field Material Description					
Method	Penetration Resistance	Water	Depth (m)	Depth RL	Sample or Test	DCP	Recovered	Graphic Log	Group Symbol	Material Description	Moisture Condition	Consistency / Density	Origin and Aditional Observations
		Not Observed	0.0		D 0.60 m	2			CL	Silty CLAY; low plasticity, grey-brown, trace coarse grained sand, trace root fibres	w < PL	F	TOPSOIL
			0.2	0.20		2			CL	Silty CLAY; low plasticity, grey-brown, trace coarse grained sand			RESIDUAL SOIL
			0.4			2							
			0.6			2							
						1						S	
				0.70		1				XW SANDSTONE; recovered as Sandy CLAY; low plasticity, yellow-brown	w > PL		EXTREMELY WEATHERED MATERIAL
			0.8			2							
						7							
			1.0			8					w < PL	VSt to H	
				1.10		20				Hole Terminated at 1.10 m Refusal			
			1.2										
			1.4										
			1.6										
			1.8										
			2.0										
			2.2										
			2.4										

Refer to explanatory notes for definitions and abbreviations

INTRAX 2.00 LIB.GLB Log INTRAX STD BOREHOLE 175232-PRJ758208-GEO-BH LOGS.GPJ <<DrawingFile>> 18/10/2022 12:45 10.02.00.04 Datgel Lab and In Situ Tool - DGD | Lib: Intrax 1.00 2020-04-14 Prj: intrax 1.00 2020-04-14

EXPLANATORY NOTES AND ABBREVIATIONS

The following presents a depiction and explanation of terms adopted by Intrax Land in geotechnical borehole logs, test pits and other soil and rock descriptions. Soil and rock descriptions are in accordance with Australian Standard 1726-2017, Geotechnical Site Investigations.

Investigation methods, sampling, testing & groundwater

Drilling Method	
AD/V	Auger drilling with V bit
AD/T	Auger drilling with TC-Bit
DPT	Direct push tube
HA	Hand auger
WB	Wash boring
HOA	Hollow auger
AH	Air Hammer
SPT	Standard Penetration Test
NQ	Diamond Core – 47mm
NMLC	Diamond Core – 52mm
HQ	Diamond Core – 63mm
PQ	Diamond Core – 81mm
SO	Sonic drilling
NDD	Non-destructive digging
EX	Excavator bucket
BH	Backhoe bucket
EE	Existing Excavation

Groundwater & Support	
▼	Standing water level at date shown
►	Water inflow
◄	Water loss
GROUNDWATER NOT OBSERVED	Observation of groundwater, whether present or not, was not possible due to drilling water, seepage or cave in
GROUNDWATER NOT ENCOUNTERED	Borehole was dry soon after excavation, however, no well was installed to monitor seepage from low permeability materials
C	Casing
M	Mud

Field Sampling & Testing	
W	Water Sample
D	Disturbed Sample
B	Bulk Disturbed Sample
U50 / U63	Undisturbed Tube Sample (50/63mm diameter tube)
E	Environmental Sample
PP	Pocket Penetrometer Test (kPa)
FV	Field Shear Vane (kPa)
CPT	Static cone penetration test
CPTu	Static cone penetration test with pore pressure measurement
DCP	**Dynamic Cone Penetrometer (blows / 100mm)**
R	DCP refusal condition 20 blows with less than 100mm penetration
SPT	**Standard penetration Test**
5, 8, 22	SPT blow counts (150mm increments)
N = 30	SPT N count (blows for final 300mm)
30/100mm	Refused test with partial penetration
R	SPT refusal conditions. 30 blows with less than 100mm penetration or 5 blows with hammer bounce or no measurable movement
RW	Rod Weight only causing penetration (SPT N < I)
HW	Hammer and rod weight only causing full penetration (N < I)
HB	Hammer Bouncing

Core Recovery Measurements		Definition
TCR	Total Core Recovery (%)	$\frac{Lenth\ of\ core\ recovered}{Length\ of\ core\ run} \times 100$
SCR	Solid Core Recovery* (%)	$\frac{\sum Lenth\ of\ cylindrical\ core\ recovered}{Length\ of\ core\ run} \times 100$
RQD	Rock Quality Designation* (%)	$\frac{\sum Length\ of\ sound\ core\ pieces > 100\ mm\ length}{Length\ of\ core\ run} \times 100$

*Only natural breaks considered, mechanical breaks shall be ignored, and core shall be marked with chalk

Penetration / Excavation Resistance

Symbol	Term	Description
L	Low resistance	Rapid penetration with little effort from equipment used
M	Medium resistance	Penetration progresses at normally accepted rate with moderate effort from equipment
H	High resistance	Penetration rate is slow and requires significant effort from equipment
R	Practical Refusal	Further progress is not practical without damage or unacceptable wear to the equipment

SOIL DESCIPTION

Soil classification symbols

Classification Symbol	Typical Soil Name
GW	Well graded gravels, sand-gravel mixtures – little or no fines
GP	Poorly graded gravels, sand-gravel mixtures – little or no fines, uniform gravels
GM	Silty gravels, gravel-sand-silt mixtures
GC	Clayey gravels, gravel-sand-clay mixtures
ML	Inorganic silts of low plasticity
MH	Inorganic silts of high plasticity
OL	Organic silts of low plasticity
OH	Organic clay of medium to high plasticity

Classification Symbol	Typical Soil Name
SW	Well graded sands, gravel-sand mixtures – little or no fines
SP	Poorly graded sands, gravel-sand mixtures – little or no fines, uniform sands
SM	Silty sands, sand-silt mixtures
SC	Clayey sands, sand-clay mixtures
CL	Inorganic clay of low plasticity
CI	Inorganic clay of medium plasticity
CH	Inorganic clay of high plasticity
Pt	Peat – highly organic material

Dual classification (SP-SM, GP-GC) may be adopted for coarse grained soils with fines contents between 5% and 12%

Particle size distributions and material components

Particle Size Divisions			
Group	**Name**	**Division**	**Size (mm)**
Coarse	BOULDERS		> 200
	COBBLES		63 to 200
	GRAVEL	coarse	19 to 63
		medium	6.7 to 19
		fine	2.36 to 6.7
	SAND	coarse	0.6 to 2.36
		medium	0.21 to 0.6
		fine	0.075 to 0.21
Fine	SILT		0.002 to 0.075
	CLAY		< 0.002

Minor and Secondary Components			
Fine Grained Minor Component		**Coarse Grained Minor Component**	
≤5%	Trace clay/silt	≤15%	Trace sand/gravel
>5%, ≤12%	With clay/silt	>15%, ≤30%	With sand/gravel
>12%	Prefix 'Silty' or 'Clayey'	>30%	Prefix 'Sandy' or 'Gravelly'

Plasticity

Descriptive Term	Range of liquid limit or silt	Range of liquid limit for clay
Low	≤50	≤35
Medium	Not Applicable	>35 and ≤50
High	>50	>50

Moisture Condition

Fine grain soils		Coarse grain soils	
w < PL	Moist, dry of plastic limit	D	Dry, non-cohesive and free running
w ≈ PL	Moist, near plastic limit	M	Moist, soil feels cool tends to stick together
w > PL	Moist, wet of plastic limit	W	Wet, soil feel cool, free water forms when handling
w ≈ LL	Wet, near liquid limit		
w > LL	Wet, wet of liquid limit		

Consistency of cohesive soils

Abbreviation	Term	Undrained Shear Strength (kPa)	Indicative SPT N*	Indicative DCP per 100mm*	Pocket Penetrometer	Visual Assessment
VS	Very Soft	≤ 12	0 to 2	0 to 1	25	Exudes between the fingers when squeezed in hand
S	Soft	>12 to ≤25	2 to 4	1 to 2	25 to 50	Can be moulded by light finger pressure
F	Firm	>25 to ≤50	4 to 8	2 to 3	50 to 100	Can be moulded by strong finger pressure
St	Stiff	>50 to ≤100	8 to 15	3 to 5	100 to 200	Cannot be moulded by fingers
VSt	Very Stiff	>100 to ≤200	15 to 30	5 to 10	200 to 400	Can be indented by thumb nail
H	Hard	> 200	> 30	> 10	> 400	Can be indented with difficulty with thumb nail
Fr	Friable	-	-	-	-	Can be easily crumbled or broken into small pieces by hand

*Indicative correlations, accuracy will vary with soil type, testing equipment and groundwater conditions. Site specific correlations developed with more accurate testing methods would take precedence over the above relationships.

Relative density of non-cohesive soils

Abbreviation	Term	Density Index (%)	Indicative SPT (N) blows per 300mm	Approximate DCP per 100mm	Approximate PSP per 100mm
VL	Very Loose	0 to ≤15	0 to 4	0 to 1	0 to 2
L	Loose	>15 to ≤35	4 to 10	1 to 3	2 to 6
MD	Medium Dense	>35 to ≤65	10 to 30	3 to 8	6 to 8
D	Dense	>65 to ≤85	30 to 50	8 to 15	8 to 15
VD	Very Dense	> 85	> 50	> 15	> 15

Relative density is typically only provided where testing is conducted, where testing is not conducted the relative density shall be noted as inferred by use of an asterisk (*) symbol

ROCK DESCIPTION

Rock weathering

Abbreviation		Term		Definition
RS		Residual Soil		Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported.
XW		Extremely Weathered		Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible.
HW	DW	Highly Weathered	Distinctly Weathered	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognizable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching or may be decreased due to deposition of weathering products in pores.
MW		Moderately Weathered		The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable but shows little or no change of strength from fresh rock.
SW		Slightly Weathered		Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.
FR		Fresh		Rock shows no sign of decomposition of individual minerals or colour changes.

Residual soil and extremely weathered materials are to be described using soil descriptions

Rock strength

Symbol	Term	UCS* (MPa)	Is50* (MPa)	Field Assessment
VL	Very Low Strength	0.6 to 2	0.03 to 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 30 mm thick can be broken by finger pressure.
L	Low Strength	2 to 6	0.1 to 0.3	Easily scored with a knife; indentations 1 mm to 3 mm show in the specimen with firm blows of the pick point; has dull sound under hammer. A piece of core 150 mm long by 50 mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
M	Medium Strength	6 to 20	0.3 to 1	Readily scored with a knife; a piece of core 150 mm long by 50 mm diameter can be broken by hand with difficulty.
H	High Strength	20 to 60	1 to 3	A piece of core 150 mm long by 50 mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
VH	Very High Strength	60 to 200	3 to 10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
EH	Extremely High Strength	> 200	> 10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

Material with strength less than 'Very Low' shall be described using soil characteristics.

*Point load test values are provided a guide, however UCS strengths take precedence, and no correlation between the two measurements should be interpreted from the above

Defect type

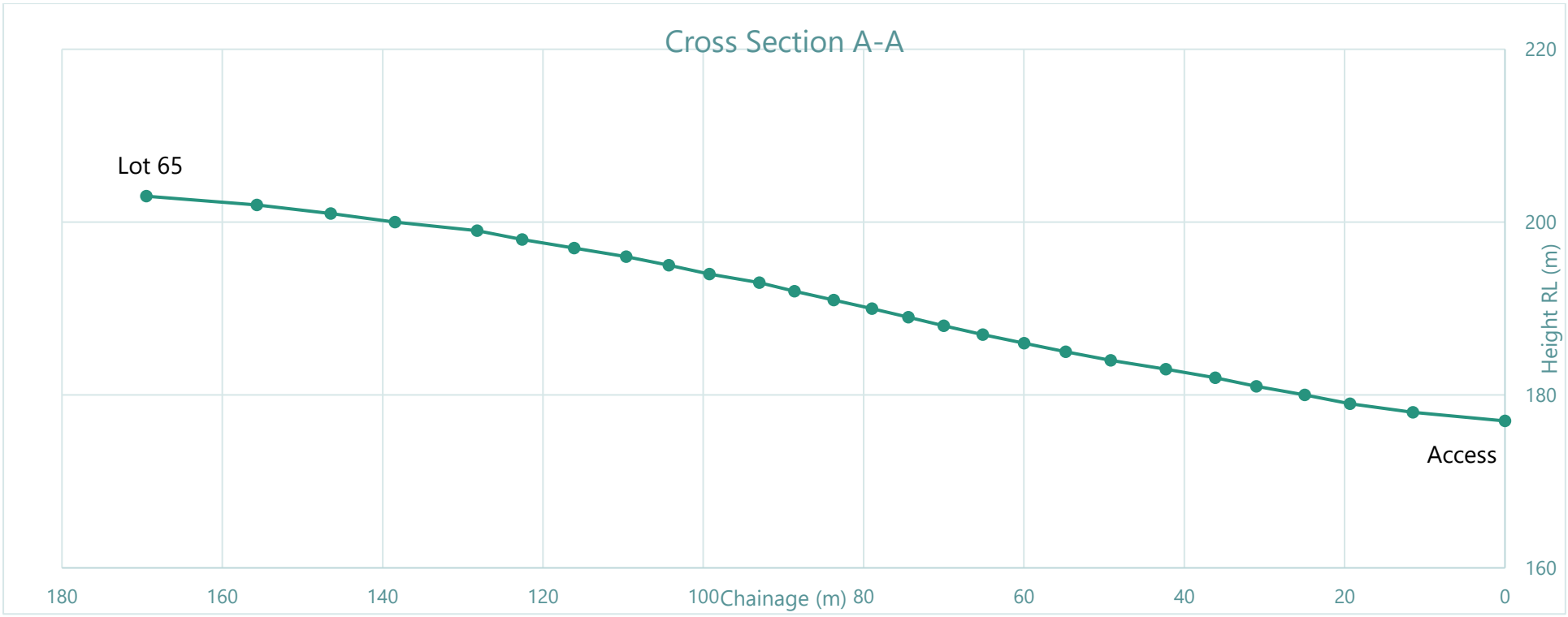
Abbr.	Type	Definition	Diagram
P	Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub-parallel to layering (e.g. bedding) or a planar anisotropy in the rock material (e.g. cleavage). May be open or closed.	
JT	Joint	A surface or crack with no apparent shear displacement and across which the rock has little or no tensile strength, but which is not parallel or sub-parallel to layering or to planar anisotropy in the rock material. May be open or closed.	
SF	Sheared Surface (fault)	A near planar, curved or undulating surface which is usually smooth, polished or slickensided and which shows evidence of shear displacement.	
SZ	Sheared Zone (fault)	Zone of rock material with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge-shaped blocks.	
SS	Sheared Seam (fault)	Seam of soil material with roughly parallel almost planar boundaries, composed of soil materials with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge-shaped blocks.	
CS	Crushed Seam (fault)	Seam of soil material with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock material which may be more weathered than the host rock. The seam has soil properties.	
IS	Infilled Seam	Seam of soil material usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1 mm thick may be described as a veneer or coating on a joint surface.	
XS	Extremely Weathered Seam	Seam of soil material, often with gradational boundaries. Formed by weathering of the rock material in place.	
FZ	Fractured Zone	Heavily fractured section of containing large number of defects	

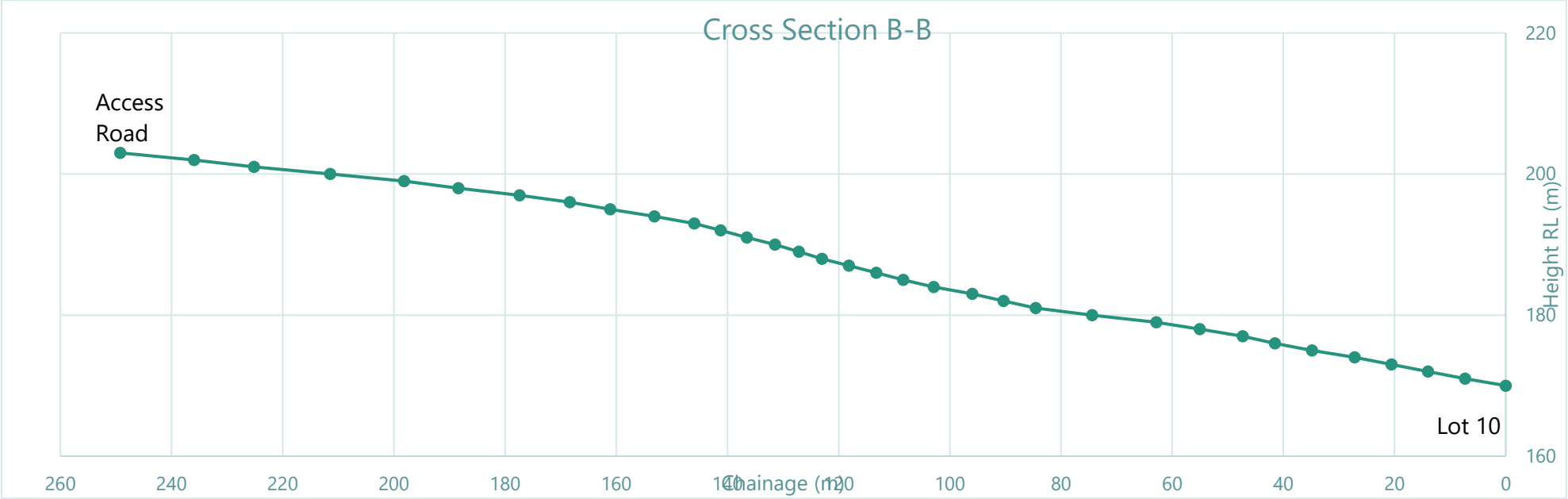
Defect type

Surface Roughness		Surface Shape		Coating / Infill	
VR	Very Rough	ST	Stepped	CN	Clean
RO	Rough	CU	Curved	SN	Stained
SM	Smooth	UN	Undulating	VN	Veneer
PO	Polished	IR	Irregular	CT	Coating
SL	Slickensided	PL	Planar	Infill described separately	

Appendix B

Cross Sections


Cross Section A-A
Lot 65
Access
220
200
180
160
Height RL (m)
180
160
140
120
100
Chainage (m)
80
60
40
20
0


Cross Section B-B
Access
Road
Lot 10
220
200
180
160
Height RL (m)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
Chainage (m)

Appendix C

Site Photography

Intrax
LAND

Appendix D

Laboratory Test Reports

Material Test Report

Report Number: **PRJ758028-1**
Issue Number: 1
Date Issued: 10/10/2022
Client: Hillview Rise C/- Brosnan Engineering Solutions

Project Number: PRJ758028
Project Name: Hillview Rise
Project Location: S#175232 No. 99, Bena Road, Korumburra, Vic, 3950
Work Request: 720
Sample Number: SC22-720A
Date Sampled: 26/09/2022
Dates Tested: 05/10/2022 - 07/10/2022
Sampling Method: Sampled by Client - Tested as Received
The results apply to the sample as received
Site Selection: Selected by Client
Sample Location: **BH4 , Depth: 0.5m**

Intrax Consulting Engineers Pty Ltd
Scoresby Laboratory
11 - 17 Jellico Drive Scoresby VIC 3179
Phone: 0477 6611 753
Email: darryl.pather@intrax.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Darryl Pather
Laboratory Manager
NATA Accredited Laboratory Number: 19862

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**2**		
Soil Description	Silty CLAY, brown, medium plasticity, with gravel, trace sand		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	20		

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Results relate only to the items tested/sampled.

Material Test Report

Report Number: **PRJ758028-1**
Issue Number: 1
Date Issued: 10/10/2022
Client: Hillview Rise C/- Brosnan Engineering Solutions

Project Number: PRJ758028
Project Name: Hillview Rise
Project Location: S#175232 No. 99, Bena Road, Korumburra, Vic, 3950
Work Request: 720
Sample Number: SC22-720B
Date Sampled: 26/09/2022
Dates Tested: 05/10/2022 - 07/10/2022
Sampling Method: Sampled by Client - Tested as Received
The results apply to the sample as received
Site Selection: Selected by Client
Sample Location: **BH5 , Depth: 1.0m**

Intrax Consulting Engineers Pty Ltd
Scoresby Laboratory
11 - 17 Jellico Drive Scoresby VIC 3179
Phone: 0477 6611 753
Email: darryl.pather@intrax.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Darryl Pather
Laboratory Manager
NATA Accredited Laboratory Number: 19862

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**2**		
Soil Description	Silty CLAY, grey brown, medium to high plasticity, trace sand		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	20		

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Material Test Report

Intrax Consulting Engineers Pty Ltd
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Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Darryl Pather
Laboratory Manager
NATA Accredited Laboratory Number: 19862

Report Number: **PRJ758028-1**
Issue Number: 1
Date Issued: 10/10/2022
Client: Hillview Rise C/- Brosnan Engineering Solutions

Project Number: PRJ758028
Project Name: Hillview Rise
Project Location: S#175232 No. 99, Bena Road, Korumburra, Vic, 3950
Work Request: 720
Sample Number: SC22-720C
Date Sampled: 26/09/2022
Dates Tested: 05/10/2022 - 07/10/2022
Sampling Method: Sampled by Client - Tested as Received
The results apply to the sample as received
Site Selection: Selected by Client
Sample Location: **BH6 , Depth: 2.0m**

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**1**		
Soil Description	Clayey SAND, brown, low plasticity, with gravel		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	20		

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Material Test Report

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Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Darryl Pather
Laboratory Manager
NATA Accredited Laboratory Number: 19862

Report Number: **PRJ758028-1**
Issue Number: 1
Date Issued: 10/10/2022
Client: Hillview Rise C/- Brosnan Engineering Solutions

Project Number: PRJ758028
Project Name: Hillview Rise
Project Location: S#175232 No. 99, Bena Road, Korumburra, Vic, 3950
Work Request: 720
Sample Number: SC22-720D
Date Sampled: 26/09/2022
Dates Tested: 05/10/2022 - 07/10/2022
Sampling Method: Sampled by Client - Tested as Received
The results apply to the sample as received
Site Selection: Selected by Client
Sample Location: **BH10 , Depth: 0.6m**

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**2**		
Soil Description	Silty CLAY, brown, medium to high plasticity, trace sand & gravel		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	20		

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Results relate only to the items tested/sampled.