Summit to Gully Downhill Mountain Bike Trail

Preliminary Geotechnical Risk Assessment

Falls Creek Resort Management (Alpine Resorts Victoria)

12 March 2024

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1. Introduction

1.1 General

This report presents the preliminary geotechnical risk assessment for the construction of the Summit to Gully Downhill Mountain Bike (MTB) Trails, Falls Creek, which GHD Pty Ltd (GHD) are undertaking for Falls Creek Resort Management (Alpine Resorts Victoria).

It is a requirement that a Preliminary Geotechnical Risk Assessment is prepared when a planning permit is required under Schedule 1 to the Erosion Management Overlay (EMO) for a development within the Alpine Resorts Area. This report has been prepared for this purpose.

The report reviews and qualitatively assesses the geotechnical risks identified at the proposed project site in accordance with Clause 3.1 of the EMO and Australian Geomechanics, 'Practice Note Guidelines for Landslide Risk Management', Vol 42 No. 1, March 2007.

Where the residual qualitative risk to property or persons is identified as greater than low, a Quantitative or Semi Quantitative Risk Assessment is required.

1.2 Scope

The scope of the preliminary geotechnical risk assessment included the following:

- Review of existing documents relevant to the project area alongside the proposed development plans.
- A site visit to collect photographs, assess the existing site conditions and evaluate potential geological and geotechnical hazards.
- Preparation of a preliminary qualitative risk assessment of identified geotechnical hazards assessed at the site in relation to risk to property.
- Preparation of advice and recommendations on risk mitigation strategies and prioritisation of risk remediation works, if required.

1.3 Scope and Limitations

This report: has been prepared by GHD for Falls Creek Resort Management (Alpine Resorts Victoria) and may only be used and relied on by Falls Creek Resort Management (Alpine Resorts Victoria) for the purpose agreed between GHD and Falls Creek Resort Management (Alpine Resorts Victoria) as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Falls Creek Resort Management (Alpine Resorts Victoria) arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 1.2 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Falls Creek Resort Management (Alpine Resorts Victoria), preliminary vector files provided by Falls Creek Resort Management and others who provided information to GHD (including other Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

Accessibility of documents

If this report is required to be accessible in any other format, this can be provided by GHD upon request and at an additional cost if necessary.

1.4 Available information

A review of readily available information including published geological mapping, previous GHD reports, and historical geotechnical risk assessments associated with the site and neighbouring sites, was undertaken as part of our assessment. This information includes:

- 'Summit-Gully MTB Option 2' Spatial data provided by Alpine Resorts Victoria, dated 2023.
- Bligh Gilding Consulting (2023) Falls Creek Alpine Resort: Summit Gravity Mountain Bike Trail Cultural Heritage management Plan (ref: 19838), draft report.
- Australian Stratigraphic units Database (asud.ga.gov.au/search-stratigraphic-units).
- Falls Creek Resort Management Geotechnical Risk Management Database, various site risk assessments and mapping information (held by GHD).
- Geological Survey of Victoria, 2014, Seamless Geology 1:50,000 geology dataset viewed through Earth Resources' GeoVic portal (earthresources.vic.gov.au/geology-exploration/maps-reports-data/geovic).
- Geological Survey of Victoria, online digital maps of 1:50,000 and 1:100,000 scales accessed through Earth Resources' GeoVic portal (earthresources.vic.gov.au/geology-exploration/maps-reports-data/geovic).
- GHD (2012) Falls Creek Risk Mitigation Program, Refinement of Geological and Hydrogeological Models, November 12.
- GHD (2015) Stage 4 Falls Creek Mountain Bike Trails – Preliminary Geotechnical Risk Assessment
- GHD (2021) Stage 5 Falls Creek Mountain Bike Trails – Preliminary Geotechnical Risk Assessment, ref: 312993418
- Golder (2020) Victorian Alpine Resorts Geotechnical Risk Assessment Program 2018-2020, Falls Creek, ref: 18111998-007-R-Rev0
- GEO-ENG (2000) Falls Creek resort wide landslide risk mapping
- SMEC (1999) Assessment of Slope Instability – Moloney's Gebi's Ski Hire (FC 221)

1.5 Proposed development

The proposed developments evaluated as part of this geotechnical risk assessment include the construction of a new unidirectional downhill mountain bike trails, the Summit to Gully trails which will cover a linear distance of approximately 1810 m. The proposed trail will connect into the existing mountain bike trail network to the north-west of the Falls Creek Village and improve the overall trail connectivity and mountain biking experience within the greater Falls Creek Resort.

Whilst a site-specific construction plan has not been provided, assessment of similar geotechnical risk assessments in the Falls Creek area and anecdotal information provided by Alpine Resorts Victoria suggests proposed development works are likely to entail the following:

- Construction of trails will generally require the permanent removal and/or lopping of vegetation along a 1.0 m trail corridor.
- The track will have an approximate width of 600 mm and construction will involve the removal of top layer of vegetation and topsoil.
- Typically the trail grade (shown on Figure 1, Figure 2 and Figure 3 below) varies from approximately 10% to 30% with a maximum trail grade be up to approximately 80% in small, localised sections.
- Construction of several berm structures, which are proposed at sharper corners along the proposed trail.
- Construction of several jumps towards the southern margin of the trail. It is understood these will be constructed locally sourced material and removed during the ski season.

– It is understood the trails will be constructed from a combination of:
  - Standard benching (machine), a 1.7t excavator will be utilised in lower parts of the trails .
  - Standard benching (hand), which will be utilised in sensitive, rocky and/or very steeply sloping areas of the trails. It is understood hand building techniques are preferred in the upper sections of the trail above the aqueduct where there tends to be more rock exposed at the surface making accessibility difficult for a machine.
  - It is currently unknown if rock armouring will be required as part of the trail construction.

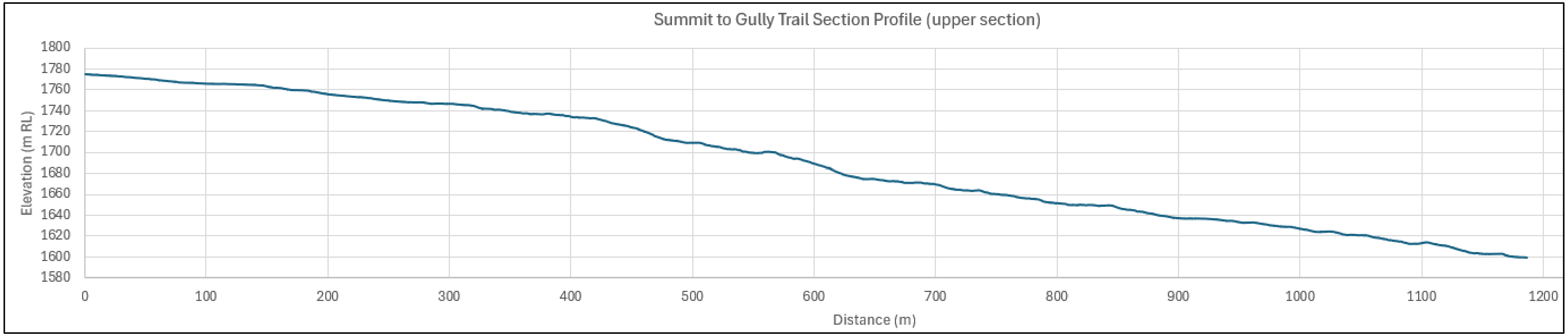

Figure 1 Summit to Gully MTB trail elevation profile - upper section

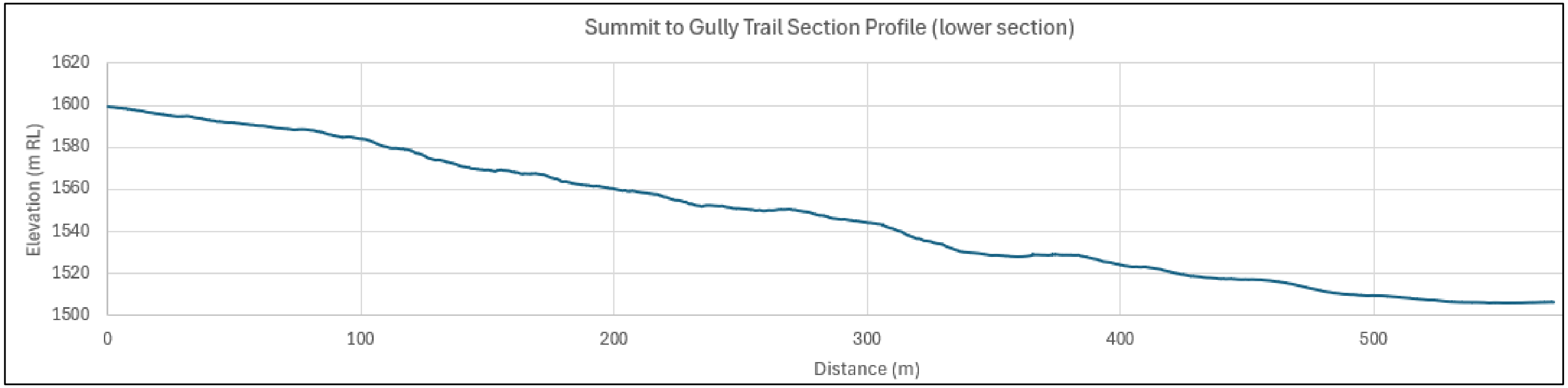

Figure 2 Summit to Gully MTB trail elevation profile - lower section

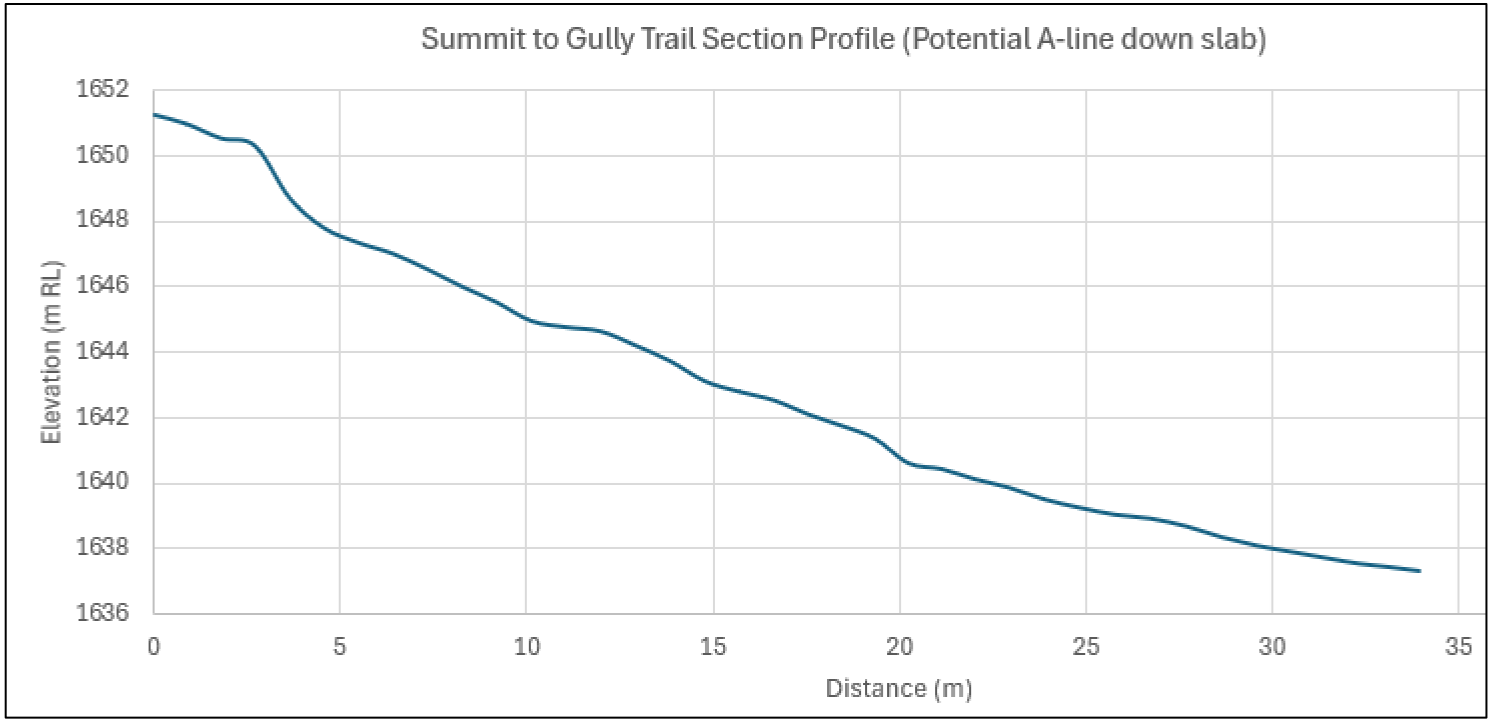

Figure 3 ***Summit to Gully MTB trail elevation profile – potential A-line down slab section***

1.6 Regional geology

Illustrated on Figure 4 below, the 2007-2014 Seamless Geology 1:50,000 map (produced by the Geological Survey of Victoria) indicates the project area is predominantly underlain by the East Kiewa Granodiorite and Omeo Metamorphic Complex migmatites along both proposed alignments. The Summit to Gully MTB Trail may traverse the Cobungra Granite in a localised domain towards the lower portion of the alignment. Geological mapping and the Australian Stratigraphic Units Database (Geoscience Australia) describe these units as:

- Early Silurian Cobungra Granite (G549): Granite, granodiorite: dark grey, fine to coarse-grained, massive to strongly foliated; abundant K-feldspar phenocrysts and variable muscovite-biotite-cordierite-sillimanite content; abundant metasedimentary enclaves
- Early Devonian East Kiewa Granodiorite (G151): Biotite granodiorite: grey, medium grained, equigranular; some muscovite-bearing phases; I-type
- Early Silurian Omeo Metamorphic Complex migmatite (Som): Quartzo-feldspathic migmatite: banded; with biotite, andalusite, cordierite, sillimanite; light bands are quartz-K -feldspar-plagioclase partial melts, dark bands are restite with biotite, sillimanite, andalusite, cordierite and rare garnet

A more recent geological interpretation by GHD (2012) (GHD report 31/28685/06/6398) suggests the wider Falls Creek area is predominantly comprised of high-grade regionally metamorphosed rock (gneiss to migmatite) which is locally anatexised to isolated granodiorite bodies. Anatexis refers to the process of partial melting or recrystallisation due to high pressure/temperature and may explain the juxtaposition of the medium-grained gneiss to migmatite rocks, which display common foliations, and the medium to coarse grained, unfoliated granodiorites. The mapping completed by GHD only covers the Falls Creek Village area, Figure 5 shows the likely geological conditions underlying part of the proposed trail, based on this mapping.

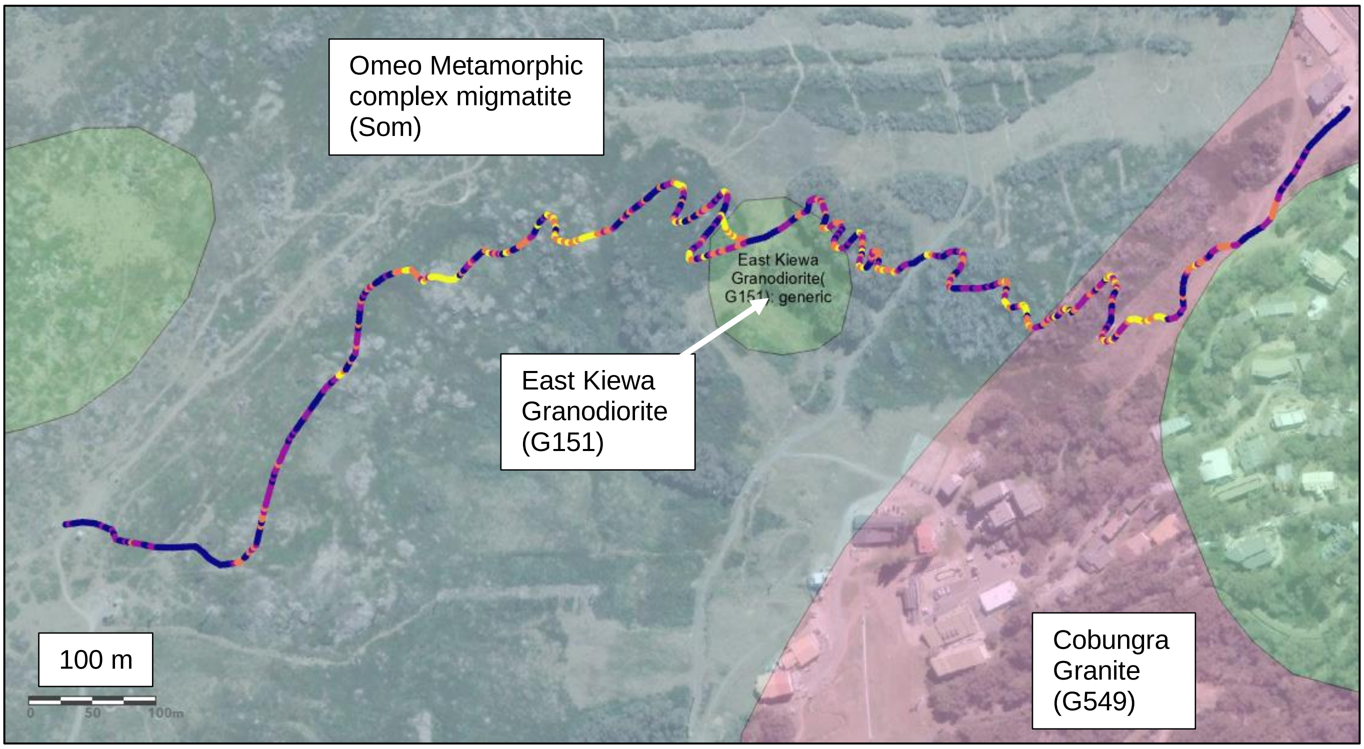

Figure 4 Geology underlying the proposed trail alignment (1:50,000 mapping)

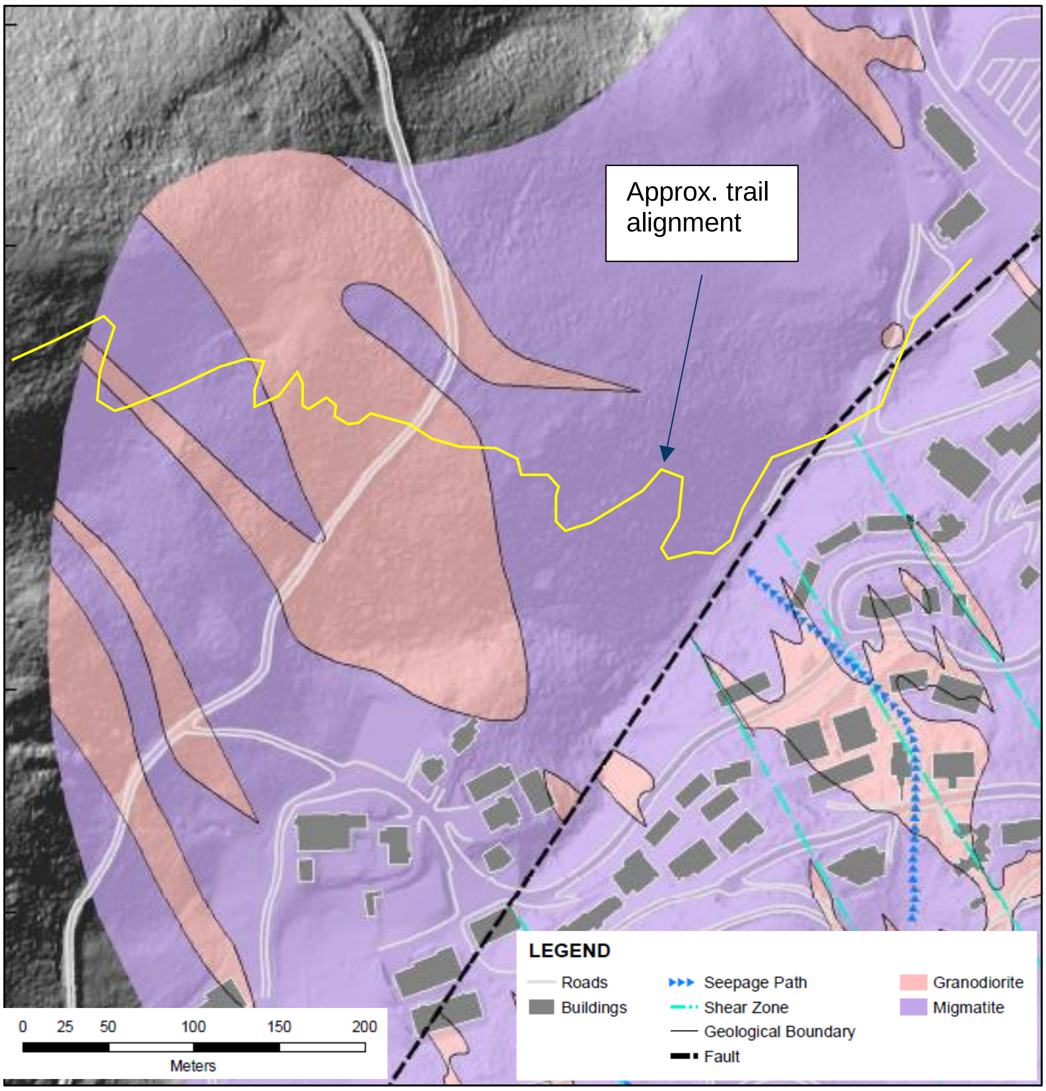

Figure 5 *Geology underlying the proposed trail alignment (GHD (2012) village wide mapping)*

2. Existing information

2.1 Previous geotechnical risk assessments

A limited number of previous geotechnical risk assessments have been completed within the vicinity of the proposed mountain bike trails, the majority of which are related to the development of previous mountain bike trails. The key findings from the geotechnical risk assessment reports are summarised in Table 1 below.

GHD (2021) completed a geotechnical risk assessment in relation to the development of the Stage 5 Falls Creek Mountain Bike Trails and reported the highest level of risk in the existing site conditions as 'Moderate'. These risk ratings related to rockfall from the dislodgement of boulders from soil matrix, small to large scale debris flows, shallow failure of slopes and larger, global failure of slopes.

Table 1 Summary of historical geotechnical risk assessments in the vicinity of the proposed trails

Site	Previous geotechnical risk assessment reference	Assessment findings/results
Stage 5 MTB Trails	GHD (2021) Stage 5 Falls Creek Mountain Bike Trails – Preliminary Geotechnical Risk Assessment	Shallow failure of slope (within XW soil or colluvium **(Moderate)** Rockfall from slopes (boulders dislodge from soil matrix) **(Moderate)** Rockfalls from rock outcrops **(Low)** Small to large scale debris flow (following high rainfall events) **(Moderate)** Larger/global failure of slope **(Moderate)**
Gebi's Ski Hire (near end of Summit to Gully MTB trail)	SMEC (1999) Assessment of Slope Instability – Moloney's Gebi's Ski Hire (FC 221)	Natural shallow landslide **(Low)**

2.2 Landslide mapping

Resort wide landslide mapping has been undertaken historically by GEO-ENG (2000) and more recently by Golders (2020) which identified rockfall hazards as risk on the slopes above the village bowl area. Landslide risk mapping completed by GEO-ENG identified isolated areas of the rocky outcrop on the upper portions of the slopes as low, moderate and high risk. Mitigation measures in the form of rock bolting were used to secure boulders within the identified high risk areas following the GEO-ENG risk assessment.

The Golders (2020) landslide susceptibility mapping employed a more universal approach by identifying the entire rock outcrop on the slopes above the village bowl as potential source areas and mapping the potential rockfall runout extent as the base of the gully (Figure 6).

The Golders assessment reports that no rockfalls were observed or are known to have occurred in the recent past but there is evidence of boulder detachment and travel in geological time. It concluded that most near surface boulders appear embedded and that the key trigger for failure would be detachment through earthworks or other anthropogenic processes. A 1 in 100 to 1 in 1000 year frequency was adopted for the likelihood of a rockfall hazard.

It is noted that the upper section of the proposed trail is generally located above the outcrops mapped by GEO-ENG and Golders as potential rockfalls hazards. A small section of the trails passes below and in close proximity to these outcrops.

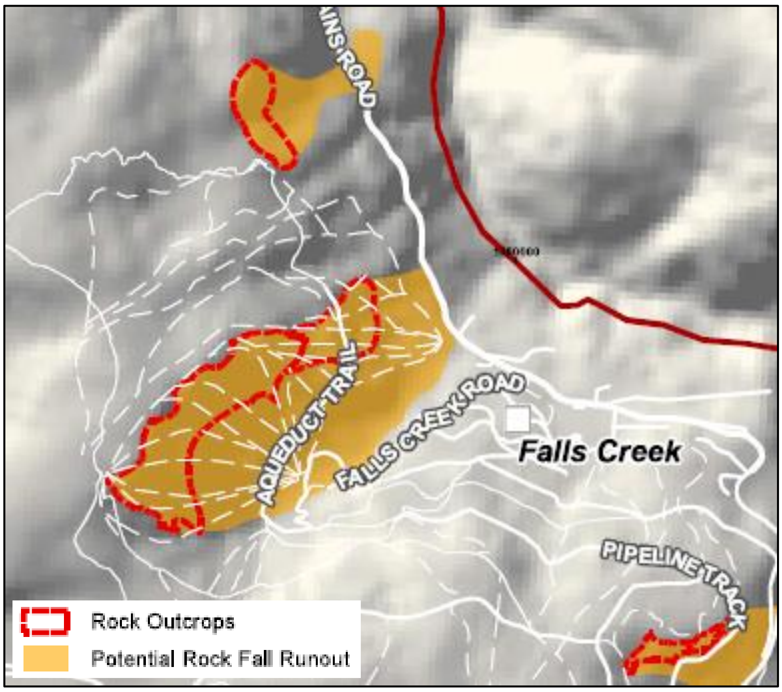

Figure 6 *Extract from the Golders (2020) rockfall suceptibility mapping for the area of the proposed trail*

2.3 Groundwater and rainfall monitoring

The bedrock (migmatite to granodiorite) in the Falls Creek area forms a fractured rock aquifer system, where groundwater is stored and transmitted through fractures, joints and discontinuities in the basement rock mass. Saturation of overlying sediments may result in the formation of an additional perched aquifer system in some areas, and this is generally considered likely to be hydraulically connected to the fractured rock aquifer below.

Long-term groundwater monitoring suggests groundwater levels fluctuate significantly as a result of seasonal rainfall variations and environmental conditions across the Falls Creek area with groundwater levels generally peaking following snow melt in the springtime and lowest levels recorded in autumn (GHD, 2012). Groundwater is thought to discharge into creeks and into localised alpine swamps and bogs which are relatively frequent across the resort area and may be encountered within the lower portions of the trail.

As indicated in Figure 2.1, monthly rainfall at Falls Creek exhibits strong seasonal variation and experiences intermittent periods of very heavy rainfall.

Figure 7 *Cumulative monthly rainfall levels at Falls Creek from 2004 to present*

3. Site assessment

3.1 General

The following methodology has been undertaken to assess the existing conditions at the site and inform the preliminary geotechnical risk assessment:

– A review of aerial imagery and Lidar hillshade imagery encompassing the entire trail alignment (exhibited on Figure 8, Figure 9 and Figure 10 in Section 3.2 below).
– A site visit undertaken on 12 May 2023 by a Senior Engineering Geologist and Graduate Geologist to observe the current site conditions along the proposed trail. Site photographs obtained during the visit are presented in Section 3.2.
– A desktop review of pre-existing geotechnical investigation reports and geotechnical risk assessments completed in the vicinity of the proposed trails (Section 2).
– A review of the geological conditions anticipated at the site.

3.2 Slope conditions

The Summit to Gully Downhill MTB Trail is located to the north-west of the Falls Creek Village, on the slopes above the Village Bown and largely traverses the east-southeast dipping slopes of the northern flank of a broad gully shaped feature comprising forested, grassy and rocky mountain terrain. The mapping in Figure 8, Figure 9 and Figure 10 below illustrate the existing slope conditions along the proposed trail network.

The trail commences at the Summit Trailhead (approximately 1770 m RL), where it converges with the existing Frying Pan Spur, Summit Road and Big Fella MTB trails. This area is relatively flat and unvegetated (Figure 11). The trail descends into its upper section crossing relatively rocky terrain with numerous exposed outcrops (Figure 12, Figure 13, Figure 14, Figure 15). The terrain is steepest within this section with localised trail grades up to 80%. Towards the centre of the alignment (approximately 1630 m RL), conditions vary between open alpine grasslands (Figure 16) and heavily vegetated/forested areas (Figure 17). The trail crosses the existing Aqueduct Trail through this section which has a maximum gradient of approximately 40%. In the lower reaches of the trail (from approximately 1540 m RL) closer to Falls Creek Village, the slope gradient shallows (Figure 18 and Figure 19) with open grassland conditions, before terminating at the Gully carpark (approximately 1500 m RL). T

It is noted that except for minor ski infrastructure (snow fencing), some existing trails, the aqueduct trails and unsealed tracks and carparking, the trail does not interact with or pass any significant existing infrastructure.

The following observations were noted during the visual site assessment along the proposed trails:

– The majority of the proposed trail will follow the natural topography utilising the existing slope grade minimising the requirement for cut/fill operations.
– The depth to rock is likely to be variable across the proposed trails, ranging from outcropping rock throughout the higher topographic sections of the site to thicker overlying soils within the lower sections of the trails.
– Permanent removal of vegetation will be necessary along the entirety of the proposed trails. This will be completed through both hand and machine-based techniques. Excess removal of vegetation on steeper slopes may result in increased slope instability.
– Where the trail will cross the aqueduct towards the centre of the proposed alignment pipelines have already been installed at this location (due to the proximal ski slopes), therefore further crossing infrastructure is not considered necessary.
– Outcropping rock is evident across the trail network (mainly upper section) on variable slopes. These outcrops generally occur both upslope and downslope of the proposed trails and where present as loose blocks or boulders held within a soil matrix, may be conducive to detachment.
– Lower sections of the Summit to Gully MTB Trail are within the vicinity of drainage areas and small sections of boggy or water-logged ground was observed.

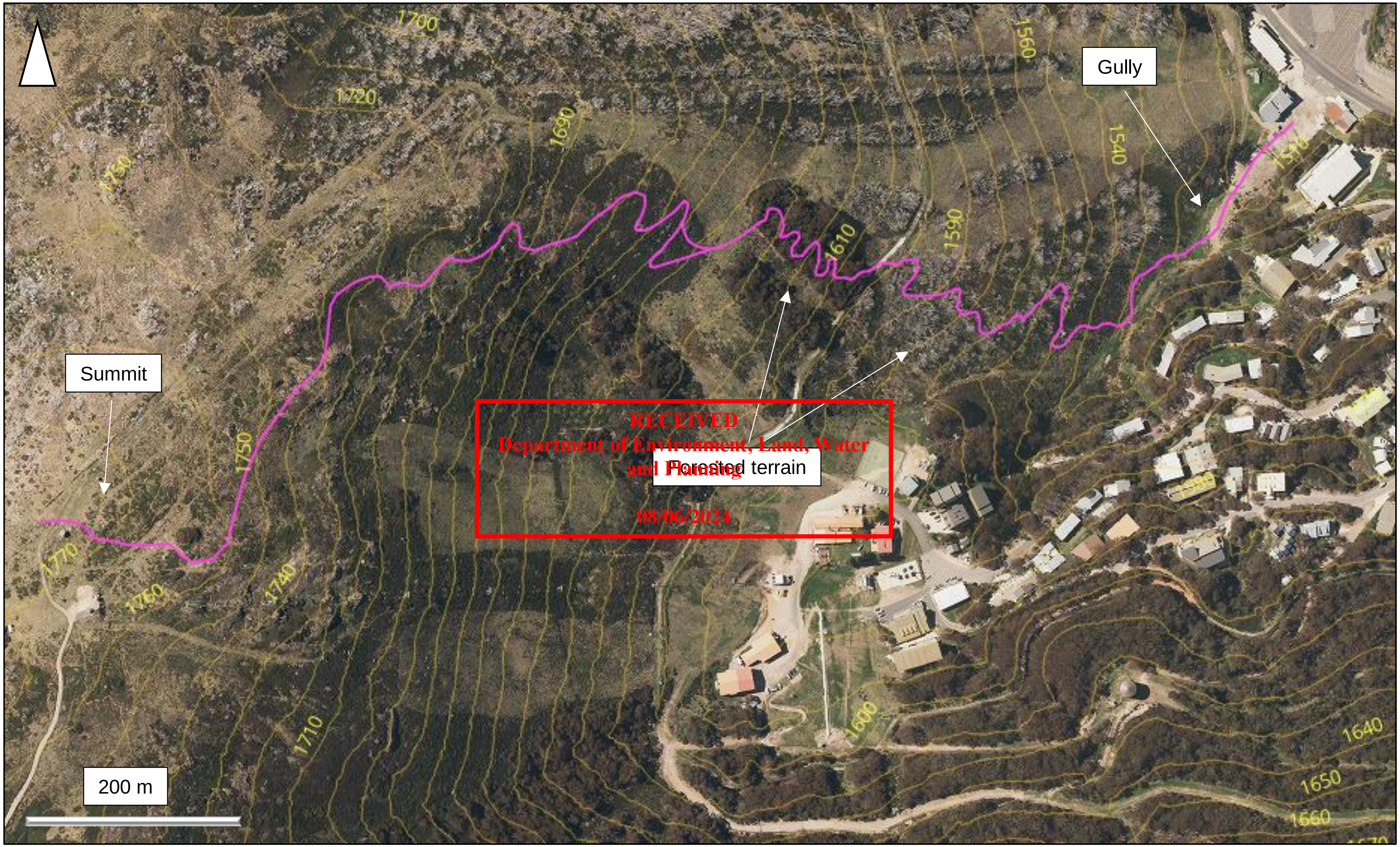

Figure 8 *Proposed trail alignment with aerial imagery*

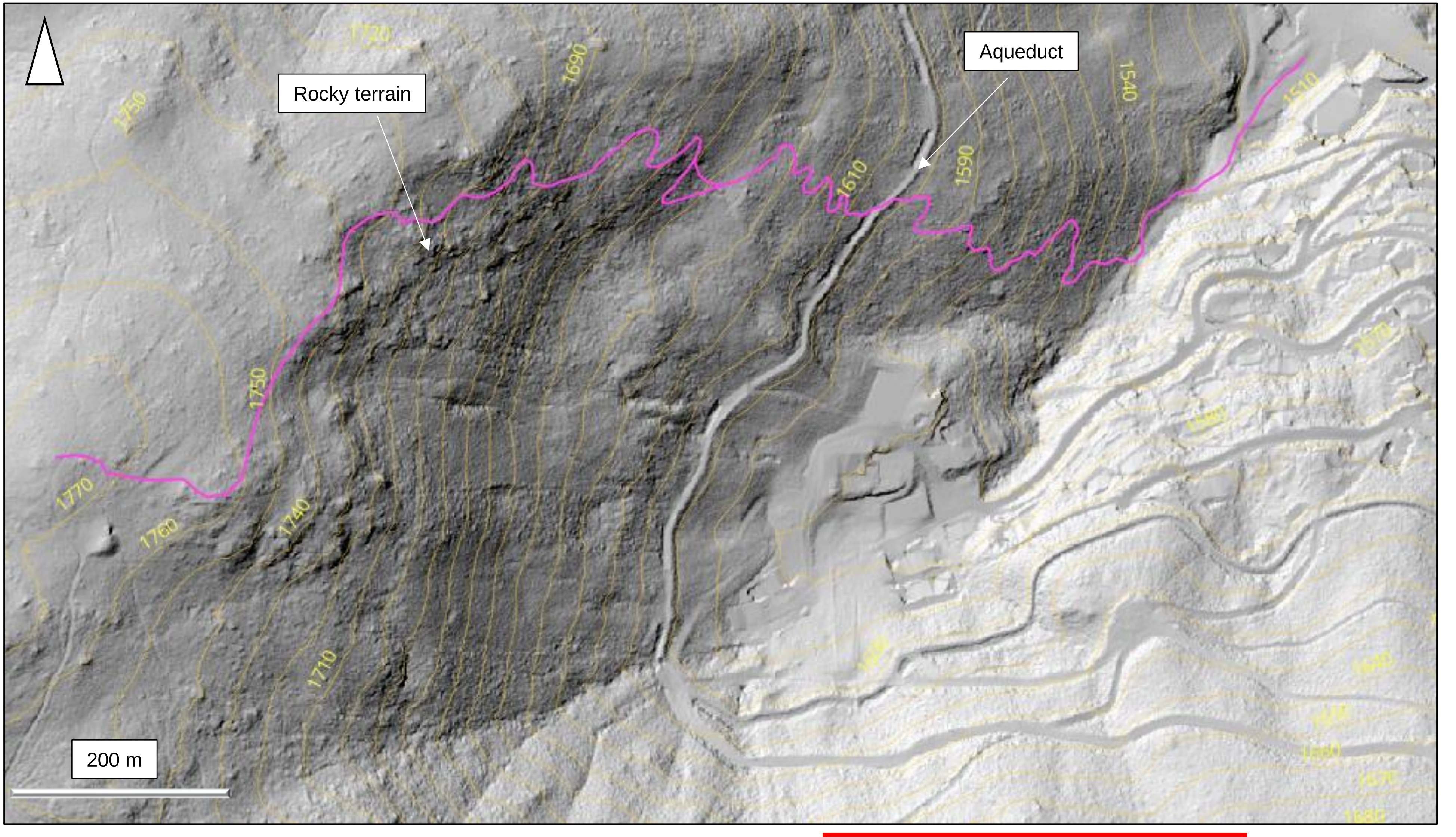

Figure 9 *Proposed trail alignment with Lidar hillshade imagery*

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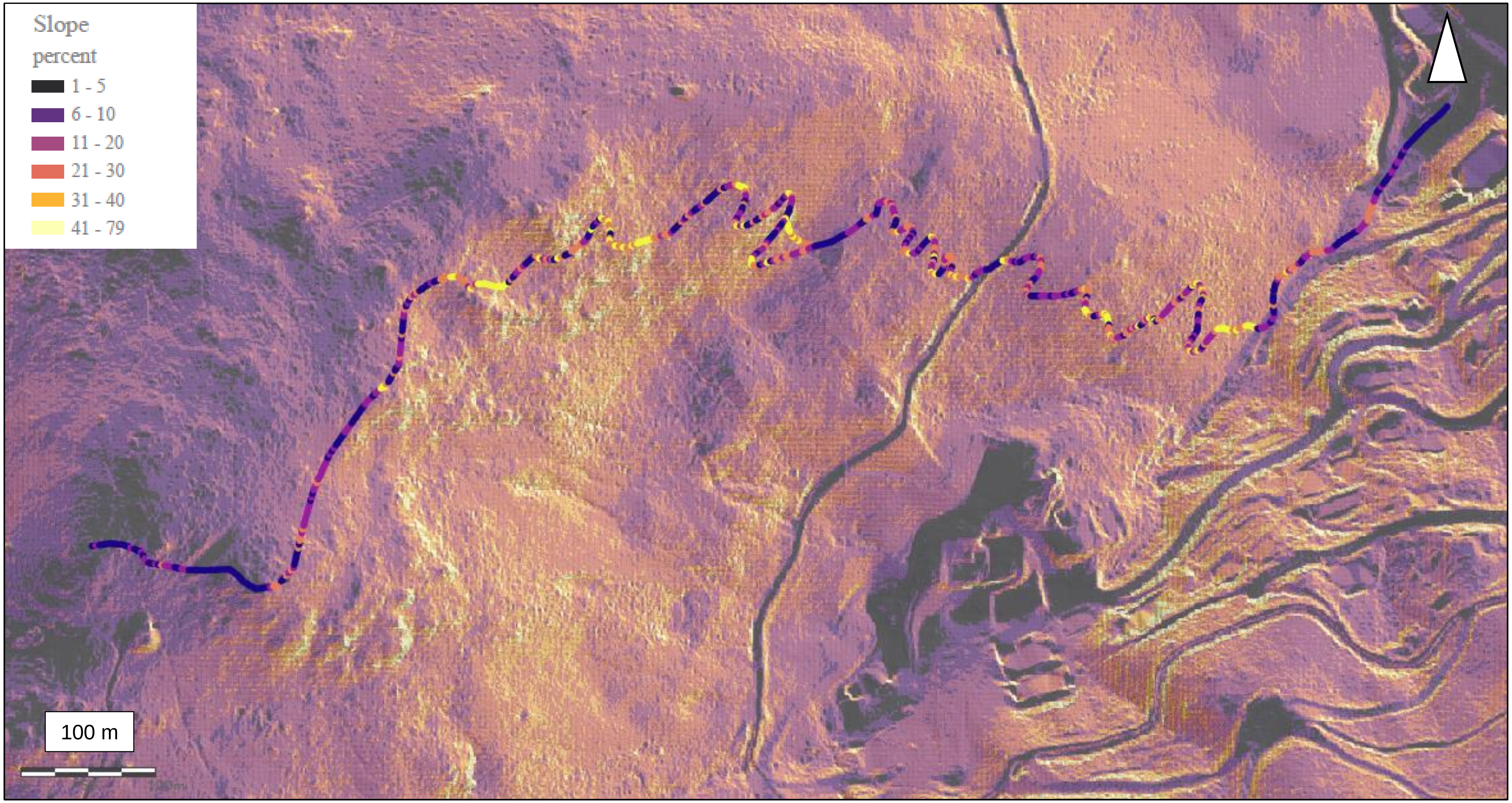

Figure 10 *Proposed trail alignment with estimated slope gradients*

Figure 11 The start of the Summit to Gully MTB Trail

Figure 12 Rocky outcrops (migmatite) proximal to the start of the Summit to Gully MTB Trail

Figure 13 Typical rocky terrain along the start of the Summit to Gully MTB Trail

Figure 14 Large rocky (migmatite) outcrop upslope of the proposed Summit to Gully MTB Trail

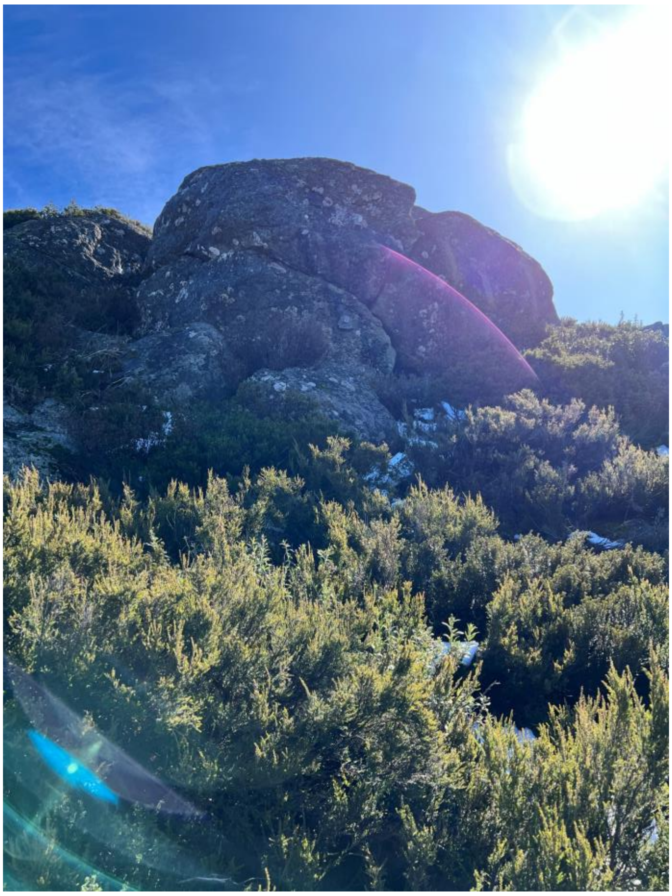

Figure 15 Large rocky outcrop upslope of the proposed Summit to Gully MTB Trail (refer Figure 6)

Figure 16 Open grassland between the rocky slope and vegetated area below (Summit to Gully MTB Trail)

Figure 17 ***Heavily vegetated area towards the south-east of the Summit to Gully MTB Trail. Machine benching construction is proposed for this section of the trail.***

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Figure 18 ***The lower section of the Summit to Gully MTB Trail (looking upslope). A large berm is proposed along the eastern section of this area (here left).***

Figure 19 ***The Summit to Gully MTB Trail will terminate to the east of Gebi's Ski Hire (building to the left). Several jumps are proposed along this section of the trail however these will be removed during the ski season.***

3.3 Geotechnical site hazards

Based on our assessment, several conceivable hazards have been identified along the proposed alignments or associated with slopes within the vicinity. The following hazards have been considered as part of the preliminary geotechnical risk assessment outlined in Section 3:

– Small scale slumping and shallow failures in unconsolidated sediments or highly weathered soils (in natural or modified slopes). This is likely to be associated with heavy rainfall events.
– Rockfalls due to dislodgment from soil matrix on moderate to steep slopes (natural or modified) which may be triggered by excess removal of vegetation and heavy rainfall events which lead to adverse erosion.
– Rockfalls due to dislodgement of blocks from outcropping rock which may be triggered by various mechanisms including root jacking, burrowing animals, freeze-thaw processes, disturbance by the removal of trees or during trail construction.
– Shallow failures that transition into debris flows within gully systems which may result from significantly heavy rainfall events.

4. Qualitative risk assessment

4.1 General

A qualitative assessment has been undertaken for the proposed development. This is an assessment of the "Likelihood" and "Consequence" using descriptors provided in the Australian Geomechanics Society (AGS) Guidelines for Landslide Risk Management (2007).

The estimated likelihood and consequence have been used to derive a risk rating from the risk matrix presented in the AGS (2007) guidelines and reproduced below.

In accordance with Section 3.2 of the EMO if no risks exceed a "Low" risk rating, a Qualitative Risk Assessment is a suitable level of assessment for the proposed works.

Where appropriate risk has been assessed for pre, during and post development conditions in accordance with Section 3.1 of the EMO.

4.2 Likelihood of failure

The likelihoods of occurrence of the identified hazards are presented below. These ratings are qualitative estimates of how likely a failure is without consideration of the *consequences* of this failure. The assessment of the likelihood of failure for each hazard has been determined based on the following factors:

– Observations made of existing site conditions
– Review of existing data
– Engineering geology experience

Appendix B contains details of the qualitative descriptors used for likelihood of failure from AGS (2007).

4.3 Consequence of failure

Consequences of the hazards identified above have been estimated based on observations of existing site conditions. Potential consequences of failure include:

– Impacts on the existing and proposed infrastructure

For the hazards identified, the associated consequences to proposed alignments have been estimated based on the qualitative descriptors presented in AGS (2007) and included in Appendix B.

4.4 Risk rating for property

The following matrix (Table 4) has been used to rate the risk for each of the hazards identified, based on the estimated likelihood and consequence. The risk matrix is reproduced from AGS (2007). Risk ratings for each of the hazards identified are summarised in Table 5, and for, along with recommended control measures to mitigate these risks where applicable.

Table 2 Risk matrix

	Consequences

Likelihood		Catastrophic	Major	Medium	Minor	Insignificant
	Almost Certain	VH	VH	VH	H	M or L
	Likely	VH	VH	H	M	L
	Possible	VH	H	M	M	VL
	Unlikely	H	M	L	L	VL
	Rare	M	L	L	VL	VL
	Barely Credible	L	VL	VL	VL	VL

Table 3 Risk rating

Hazard	Location	Initial Risk Rating			Control Measures	Residual Risk Rating		
		Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
Existing Conditions								
Shallow failure/ slumping of slope (within extremely weathered soil or colluvium)	Existing trails and natural slopes surrounding the site.	**Unlikely** There is no obvious evidence of these type of failures occurring on the slopes surrounding the trail or along the existing trail network. These types of failures have been known to occur along similar trail networks.	**Minor** Failure may cause damage to existing infrastructure (e.g. access tracks, trails and aqueduct trail) and require reinstatement.	Low		N/A	N/A	N/A
Rockfall from moderate to steep slopes (dislodgement from soil matrix)	Existing trails and natural slopes surrounding the site.	**Unlikely** Sporadic boulders were observed on the surface in places. No rockfalls were observed from existing trail cuts, although have been known to occur along similar trail networks.	**Minor** May cause damage to existing tracks/trails and require removal	Low		N/A	N/A	N/A
Rockfall from outcropping rock	Upper section of proposed trail	**Unlikely** There are extensive rock outcrops at higher elevations. Open joints and isolated blocks are common. There is no obvious evidence of recent rockfalls caused by the detachment of blocks although they are thought to have occurred in geological time scales.	**Minor** May cause damage to existing tracks/trails and require removal	Low		N/A	N/A	N/A

Hazard	Location	Initial Risk Rating			Control Measures	Residual Risk Rating		
		Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
Shallow landslide transitioning into a debris flow	Within topographic gully features generally associated with drainage lines.	**Rare** Have occurred in the past based on presence of colluvial deposits. Lidar hillshade imagery indicates these are likely to have happened in the historical past.	**Major** Could impact existing infrastructure suggest as trails, roads and small buildings at the base of the broad gully.	Low		N/A	N/A	N/A
During Construction								
Shallow failure/ slumping of slope (within extremely weathered soil or colluvium)	Along the entire trail alignment	**Possible** If excavation works undertaken during or following significant rainfall. If unstable batter angles are adopted in soil strength materials.	**Minor** Failure may cause damage to the trail requiring reinstatement/ remediation. Delays to construction.	Moderate	Manage surface drainage. Control and redirect water runoff from trails. Cut batter angles should be no greater than 2H:1V. Rock armouring should be used or considered in steep sections of the trail. Construction activities creating any soil disturbance should cease during or immediately after extreme rainfall events. Avoid excessive excavation when working near waterways or gully systems.	**Unlikely**	**Minor**	**Low**
Rockfall from moderate to steep slopes (dislodgement from soil matrix)	Along the entire trail alignment	**Possible** If loose boulders are left exposed in cut areas or on slopes during significant vegetation removal. If construction occurs during or after significant rainfall	**Minor** May impact trail and construction equipment requiring remediation resulting in delays to trail completion	Moderate	Removal of loose boulders during the batter face construction. Ensuring boulders are not placed at the slope crest. Limit excess vegetation removal. Construction activities should not be undertaken during or immediately after heavy rainfall.	**Unlikely**	**Medium**	**Low**
Rockfall from outcropping rock	Upper section of the trail alignment	**Possible** Several rock outcrops are located upslope of the	**Minor** May cause damage to existing track and	Moderate	Ensure minimal disturbance of rock outcrops during construction, limiting excavation	**Unlikely**	**Medium**	**Low**

Hazard	Location	Initial Risk Rating			Control Measures	Residual Risk Rating		
		Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
		proposed trail. Rock fall may result from excess vegetation removal, construction disturbance and heavy rainfall.	require removal leading to temporary trail closure		to hand tools only, where possible. Realign trail within permissible limits to avoid proximity to steep rock outcrops. If trail passes immediately downslope of loose blocks, secure by bolting or removal. Construction activities should not be undertaken during or immediately after heavy rainfall.			
Post Construction								
Shallow failure/ slumping of slope (within extremely weathered soil or colluvium)	Along the entire trail alignment	**Possible** If batters are formed on steep slopes or in unstable or deeply weathered soils. If sufficient slope protection is not established where unstable slopes exposed. If unfavourable drainage conditions created by trail construction	**Minor** Failure may cause damage to existing trail infrastructure and require reinstatement /maintenance. Leading to temporary trail closure	**Moderate**	Trail design and construction is to minimise any changes to surface water flows. Manage surface drainage and divert away from the slope. Rock armouring should be considered on steep sections of trails. Cut batters angles no greater than 2H:1V.	**Unlikely**	**Minor**	**Low**
Rockfall from moderate to steep slopes (dislodgement from soil matrix)	Along the entire trail alignment	**Possible** If loose boulders are left exposed in cut areas or on slopes during significant vegetation removal.	**Minor** May impact trail requiring removal. Leading to temporary trail closure	**Moderate**	Remove loose boulders where identified and limit further vegetation removal during trail design life.	**Unlikely**	**Minor**	**Low**
Rockfall from outcropping rock	Upper section of the trail alignment	**Possible** Several rock outcrops are located upslope of the proposed trail. Rockfall may result from vegetation removal and disturbance during	**Minor** May impact trail requiring removal. Leading to temporary trail closure	**Moderate**	Removal or stabilisation of and identified loose boulders adjacent to trail. Undertake a geotechnical assessment of the trail following completion of construction to assess whether the trail is	**Unlikely**	**Minor**	**Low**

Hazard	Location	Initial Risk Rating			Control Measures	Residual Risk Rating		
		Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
		construction triggered by heavy rainfall at a later date.			downslope of any potentially high risk rockfall hazards that may require remediation. Report any observed significant rockfall incidents to a geotechnical practitioner for further assessment.			

4.5 Risk control measures

To reduce, manage and maintain the assessed risk ratings of the proposed works, it is advised that the risk control measures provided in Table 5 above are implemented.

In summary, control measures to maintain or reduce all hazards to a low-risk rating may include:

- Employ good development practices for building on hillsides as outlined in AGS (2007) Landslide Risk Management. An extract from this AGS guide is provided in Appendix B.
- Ensure construction does not take place during or immediately after heavy rainfall events and ensure surface water is managed by redirecting from trail slopes.
- Avoid locating the trail through areas of disturbed/hummocky ground. Where soft / boggy soil is exposed, rock armouring should be used to promote stability and limit erosion, where necessary.
- Avoid locating trail directly adjacent to steep rock outcrops which may subject to disturbance during the trail design life.
- Where excavation works are undertaken in steep section of trails, rock armouring should be considered to stabilise cut batters. Cut batter angles should not exceed 2H:1V.
- Ensure the excavation of the side slope is gently blended to the existing slope and achieve a balance of cut to fill with limited fill embankments and exposed batters.
- Remove loose boulders exposed in the batter face during construction. These can be used as rock armouring at the base of the batter slope. Ensure loose boulders are not left at the crest of slopes.
- If large rockfall risks are not removed, they should be assessed during construction by a geotechnical engineer and stabilisation measures designed and installed prior to trail activation or major construction activities.
- Ensure switch back areas are appropriately graded, drained and retained.
- Minimise the removal of excess vegetation, particularly established trees which may aid slope stability.
- An assessment by a geotechnical practitioner is recommended following construction to assess whether the trail is downslope of any potential high risk rockfall hazards that may require remediation.
- Carry out regular monitoring and inspection as part of an ongoing trail management plan and identify and report any slope failures or potential hazards to a geotechnical practitioner for appropriate inspection.

5. Conclusions

The qualitative assessment recorded a residual risk rating of Low for the proposed mountain bike trails. In accordance with Clause 3.2 of the EMO, further quantitative or semi-qualitative risk assessment is not deemed necessary for this project and the site is considered suitable for the proposed development, subject to the control measures recommended are implemented.

Appendices

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Department of Environment, Land, Water and Planning

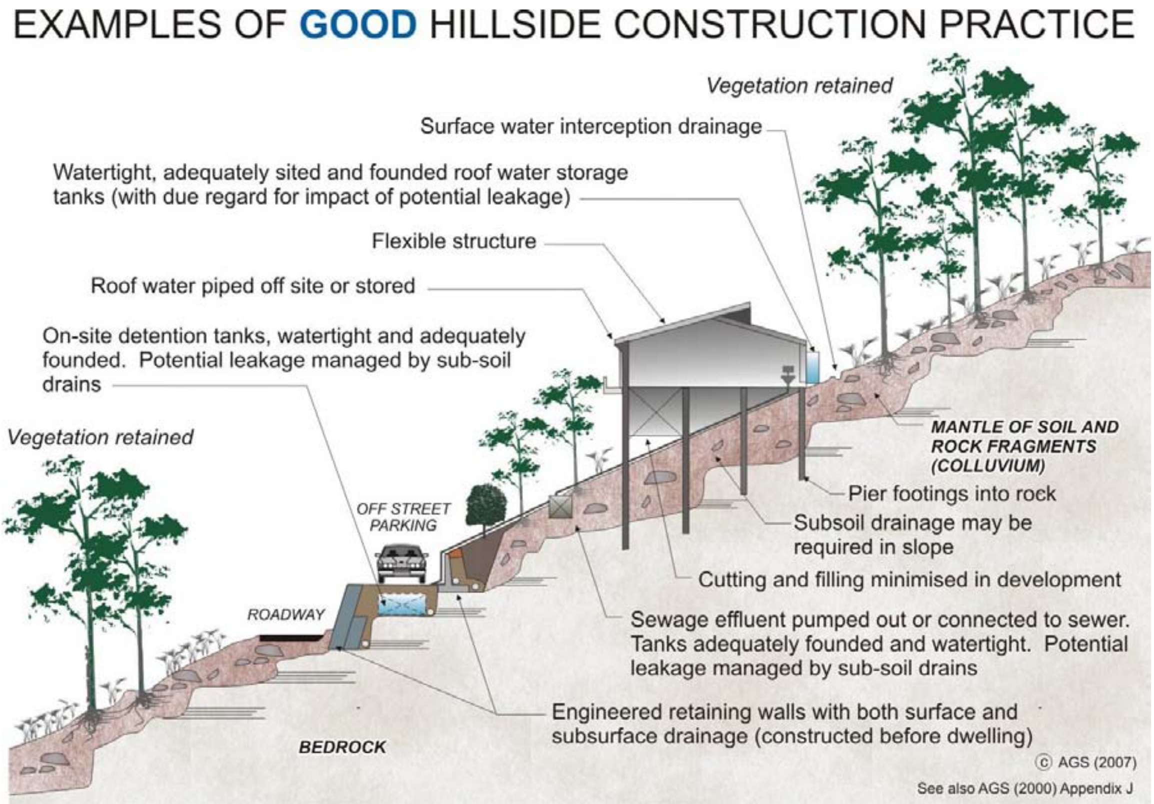
08/06/2024

Appendix A

Good Hillside Practice (Extract from AGS (2007) Landslide Risk Management

HILLSIDE CONSTRUCTION PRACTICE

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



WHY ARE THESE PRACTICES GOOD?

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

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

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

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

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

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

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

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

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

ADOPT GOOD PRACTICE ON HILLSIDE SITES

Appendix B

Qualitative terminology for use in assessing risk to property

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}	$5x10^{-3}$	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-4}$	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-5}$	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-6}$	100,000 years	200,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}		1,000,000 years		The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

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

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.

Appendix C

EMO Schedule 1 Management of Geotechnical Hazard Form 1

DEPARTMENT OF ENVIRONMENT, LAND, WATER & PLANNING

ALPINE RESORTS PLANNING SCHEME
Erosion Management Overlay – Schedule 1 Management of Geotechnical Hazard

FORM 1
Declaration and/or verification made by geotechnical engineer or engineering geologist as part of a geotechnical report

Name of application: ___Summit to Gully Mountain Bike Trail, Falls Creek______________________________
Address of subject site: _Falls Creek, VIC ____________________
I, __Andrew Hunter_______________________ of _GHD Pty Ltd___________________________
(insert name) (trading or company name)
on ___________________12 March 2024___________________________________
(insert date)

certify that I am a geotechnical engineer or engineering geologist as defined by the Erosion Management Overlay (Schedule 1 – Management of Geotechnical Hazard) and I have: (tick appropriate box):

☐ prepared the Geotechnical Report referenced below in accordance with the Australian Geomechanics Society's Geotechnical Risk Management Guidelines and Clause 3 of the EMO1

or

☒ technically verified that the geotechnical report referenced below has been prepared in accordance with the AGS's Geotechnical Risk Management Guidelines and Clause 3 of the EMO1.

Geotechnical report details:

Report title: Summit to Gully Mountain Bike Trail Preliminary Geotechnical Risk Assessment

Report date: March 2024

Report reference: 12611582

Author: Ryan Hayes

Author's affiliation: Senior Engineering Geologist at GHD Pty Ltd

Documentation relied upon in report preparation:

Development Details
- 'Summit-Gully MTB Option 2' Spatial data provided by Alpine Resorts Victoria, dated 2023
- Bligh Gilding Consulting (2023) Falls Creek Apline Resort: Summit Gravity Mountain Bike Trail Cultural Heritage management plan (ref: 19838), draft report.

I am aware that the Geotechnical Report I have either prepared or am technically verifying for the above development is to be submitted in support of a development application for the proposed development Summit to Gully Mountain Bike Trail, Falls Creek Ski Resort, VIC requiring approval from the Minister for Planning.

Further, I hold a current professional indemnity insurance policy of at least $2 million, evidence of which is attached with this form.

Name _Andrew Hunter_______ Signature ______ [signature]_________________________

Date __12 March 2024____

State Government Victoria

Appendix D

GHD Professional Indemnity

Telephone: +61 2 9285 4000
Website: wtwco.com.au
Direct Line: +61 402 974 940
Email: genevieve.mathews@wtwco.com

Issue Date: 21 November 2023
To Whom It May Concern

Certificate of Placement – Professional Indemnity

In our capacity as Insurance Broker to the Named Insured shown below, we confirm having arranged the following insurance, the details of which are correct as at the Issue Date:

Named Insured:	GHD Group Limited and Subsidiaries including GHD Pty Ltd
Form:	Civil Liability Wording which includes coverage for the Trade Practices Act and the Competition and Consumer Act
Primary Policy Number:	B080113856P23
Limit of Indemnity:	AUD2,000,000 any one claim and in the aggregate
Period of Insurance:	1 December 2023 at 4.00pm to 1 December 2024 at 4.00pm
Insurer:	Certain Underwriters at Lloyd's of London

WILLIS AUSTRALIA LIMITED A.C.N. 000 321 237 PROFESSIONAL RISKS PRACTICE

ADVERTISED PLAN

Signed for and on behalf of
Willis Australia Ltd ("WTW")

RECEIVED
Department of Environment, Land, Water and Planning

08/06/2024

Disclaimer:
This document has been prepared at the request of our client and does not represent an insurance policy, guarantee or warranty and cannot be relied upon as such. All coverage described is subject to the terms, conditions and limitations of the insurance policy and is issued as a matter of record only. This document does not alter or extend the coverage provided or assume continuity beyond the Expiry Date. It does not confer any rights under the insurance policy to any party. WTW is under no obligation to inform any party if the insurance policy is cancelled, assigned or changed after the Issue Date.