Skyline – Reavers Slip Repair

ENVIRONMENTAL SITE INDUCTION REGISTER

Name	Organisation	Date Inducted	Induction Delivered by	Signature

APPENDIX 5 Weekly Environmental Site Inspection Form

Skyline – Reavers Slip Repair

WEEKLY ENVIRONMENTAL SITE INSPECTION FORM

Environmental Representative: Date:

Item	Yes	No	Comment
General			
Is the EMP available onsite?	☐	☐	
Have any environmental incidents occurred during the week? If so, provide details	☐	☐	*If yes, complete environmental incident report.
Complete description of weather for upcoming week – circle applicable			

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
						

Are there any rain events forecasted for the coming week?	☐	☐	
Have pre rain event inspections been completed?	☐	☐	
Have post rain event inspections been completed?	☐	☐	
Water Quality			
Is water quality monitoring occurring when water is flowing across the site boundaries?	☐	☐	*If yes, complete water quality monitoring form
Is there visual evidence of sediment from the construction site entering Reavers Creek?	☐	☐	
Erosion and Sediment Control			
Are works contained within the current stage and site boundaries?	☐	☐	
Are completed areas being progressively stabilised?	☐	☐	
Is there any new evidence of erosion?	☐	☐	
Are erosion and sediment controls installed as per the ESCP?	☐	☐	
Is dirty water entering ditches during rain events?	☐	☐	
Do sediment controls have over 80% capacity?	☐	☐	
Cultural Heritage			
Have any finds of cultural significance been found?	☐	☐	

Skyline – Reavers Slip Repair

Item	Yes	No	Comment
Noise and Vibration			
Have any complaints been received during the week?	☐	☐	*If yes, complete Complaints Register
Are nearby sensitive receptors being notified before significant noise and/or vibration causing activities?	☐	☐	
Are works only occurring within the hours of operation?	☐	☐	
Dust			
Have any complaints been received during the week?	☐	☐	*If yes, complete Complaints Register
Have completed areas been revegetated or stabilised?	☐	☐	
Is dust suppression of disturbed work areas and stockpiles occurring?	☐	☐	
Are works ceasing during high winds?	☐	☐	
Are only designated access points and haul routes being used?	☐	☐	
Is the site access and surrounding roads swept clean of sediment?	☐	☐	
Vegetation			
Are vegetated surfaces being maintained as far as reasonably possible?	☐	☐	
Contaminated Soils			
Have any contaminants been uncovered during excavations?	☐	☐	
Chemicals and Fuels			
Are all hazardous substances on site stored, transported and used according to the safety data sheet requirements?	☐	☐	
Are vehicles and plant being refuelled in the refuelling bay?	☐	☐	
Is concrete washing being undertaken in the concrete wash-out pit?	☐	☐	
Is there an adequate supply of spill kits onsite? Have any used materials been replaced?	☐	☐	
Waste			
Is the site in a safe, clean and tidy state?	☐	☐	
Are wastes segregated into labelled bins with lids?	☐	☐	
Are skip bins not overfilled?	☐	☐	

Item	Yes	No	Comment
Is waste removed from open drains and drainage paths?	☐	☐	

Actions resulting from this inspection must be forwarded to the Project Manager any actions should be recorded in the Non-Conformance Register – Appendix 8.

Additional Comments:

Names and Signatures of inspection attendees:

APPENDIX 6 Environmental Incident Report Form

Skyline – Reavers Slip Repair

ENVIRONMENTAL INCIDENT REPORT FORM

Project Address: 53 Brecon Street, Queenstown 9300	**Consent Number:** TBC
Brief Project Description: Debris removal and remedial works for the upper reavers landslip at Skyline	

Instructions- Complete this form for all environmental incident that cause contaminants (including sediment) or environmental nuisance to leave the site. Be succinct, stick to known facts and do not make assumptions. Once completed submit to Queenstown Lakes District Council at RCMonitoring@qldc.govt.nz and Otago Regional Council at pollution@orc.govt and compliance@orc.govt.nz. Call the QLDC Regulatory team immediately on 03 441 0499 and ORC's Pollution Hotline on 0800 800 033 for any serious or ongoing incidents that cannot be brought under immediate control.

Date and Time	Date: XX/XX/XXX Time: XX:XX hours
Description? Provide a brief and factual description of what happened during the incident, include relevant details such as: - The activity being undertaken when the incident occurred - The estimated distance to nearest waterway (include stormwater and dry courses) - The estimated distance to the nearest sensitive receiver Sketches/diagrams/photos may be referenced and appended to this report to aid in the description of the incident.	
Exact Location of the incident? Include address, landmarks, features, nearest tree, etc. Maps and plans can be attached.	
Quantity or volume of material escaped or causing incident? (provide and estimate quantity)	
Who identified the incident?	Contractor ☐ Council ☐ Community ☐ Other ☐

What immediate actions/control measures were taken to rectify or contain the incident?
What initial corrective action will be taken to prevent similar incidents recurring in the near future?
Has the Queenstown Lakes District Council been notified? Yes ☐ No ☐ Will be notified ☐ **Has the Otago Regional Council been notified?** Yes ☐ No ☐ Will be notified ☐

Role of person making report: Project Manager / Site Supervisor / Environmental Representative / SQEP	
Name……..	Signature……
Organisation……..	Date……
Mobile phone number……	

APPENDIX 7 Environmental Complaints Register

Skyline – Reavers Slip Repair

ENVIRONMENTAL COMPLAINTS REGISTER

Complaint #	Date and Time Received	Complainant details (name, address, phone number)	Details of Complaint	Investigation and Findings	Outcome	Close out Date

APPENDIX 8 Environmental Non-Conformance Register

Skyline – Reavers Slip Repair

ENVIRONMENTAL NON-CONFORMANCE REGISTER

Ref Number	Date Observed	Found via (e.g., inspection, monitoring, complaint?)	Details of Non-conformance	Corrective Actions	Updated by	Close out Date

APPENDIX 9 Water Quality Monitoring Results Form

Skyline – Reavers Slip Repair

WATER QUALITY MONITORING RESULTS FORM

Date		Monitoring Trigger		Location Description	
			Yes	No	Measurement
Has there been any conspicuous change in colour or visual clarity in receiving waters below the works extent?			☐	☐	
Is the pH of the water between 5.5-8.5?*			☐	☐	pH ____
Are hydrocarbons visible?			☐	☐	
Are tannins visible in the water?			☐	☐	
Is there any waste in the water?			☐	☐	
Description of any non-conformance and actions required: •					
Include images of sampling location:					

*Enviroscope can provide Water Quality Monitoring services to measure turbidity and pH.

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HOW TO: WATER QUALITY SAMPLING

1. Select a Sampling Location

Sampling a discharge

Collect sample where water crosses the site boundary or enters a sensitive receptor from a retention device. Always photograph the location you sample from.

Sampling a waterway

Collect sample from the centre of the flow and the top third of the water column where possible.

Sampling a from a Sediment Retention Device

Collect sample from the discharge location, this is either near the decanting arms, spillway, hose or the outlet pipe.

Skyline – Reavers Slip Repair

2. Collect a Water Sample

Taking a Water Sample

- ➔ Label container with site name, sampling location, date and time taken.
- ➔ Fill the container with water from the surface of your sampling location.

If you wade into the water to collect the sample, always collect the sample 'upstream' of where you're standing to avoid contamination by disturbed sediment.

Always ensure your meters are calibrated regularly to ensure accurate sampling results.

3. Measure and Record Clarity, and pH

Measuring Clarity

- ➔ Lower the seechi disc into the water sample until you can no longer see the disc. Then lift the seechi disc back up until the disc is just visible. Record the number where the water level sits.

Measuring pH using a pH Meter

- ➔ Submerge the probe of the pH meter into the water sample. Keep the probe in the water until the value on the meter is fixed. Swirling the probe can help the value fix faster. Record the pH value.

APPENDIX 10 Archaeological Discovery Protocol

HERITAGE NEW ZEALAND
POUHERE TAONGA

Heritage New Zealand Pouhere Taonga Accidental Discovery Protocol

This protocol does not apply when an archaeological authority issued under the Heritage New Zealand Pouhere Taonga Act 2014 is in place.

Under the Heritage New Zealand Pouhere Taonga Act (2014) an archaeological site is defined as any place in New Zealand that was associated with human activity that occurred before 1900 and provides or may provide, through investigation by archaeological methods, evidence relating to the history of New Zealand. For pre-contact Māori sites this evidence may be but is not limited to, bones, shells, charcoal, stones etc. In later sites of European/Chinese origin, artefacts including but not limited to bottle glass, crockery etc. may be found, or evidence of old foundations, well, drains, or similar structures. Burials/kōiwi may be found in association with any of these cultural groups.

In the event that an unidentified archaeological site is located during works, the following applies;

1. Work shall cease immediately at that place and within 20m around the site.

2. The contractor must shut down all machinery, secure the area, and advise the Site Manager.

3. The Site Manager shall secure the site and notify the Heritage New Zealand Regional Archaeologist. Further assessment by an archaeologist may be required.

4 If the site is of Māori origin, the Site Manager shall notify the Heritage New Zealand Regional Archaeologist and the appropriate papatipu rūnaka of the discovery and ensure site access to enable appropriate cultural procedures and tikaka to be undertaken, as long as all statutory requirements under legislation are met (*Heritage New Zealand Pouhere Taonga Act*, *Protected Objects Act*).

5. If human remains (kōiwi) are uncovered the Site Manager shall advise the Heritage New Zealand Regional Archaeologist, NZ Police and the appropriate papatipu rūnaka and the above process under 4 shall apply. Remains are not to be moved until such time as papatipu rūnaka and Heritage New Zealand have responded.

6. Works affecting the archaeological site and any human remains (kōiwi) shall not resume until Heritage New Zealand Pouhere Taonga gives written approval for work to continue. Further assessment by an archaeologist may be required.

7. Where iwi so request, any information recorded as the result of the find such as a description of location and content, is to be provided for their records.

8. Heritage New Zealand Pouhere Taonga will advise if an archaeological authority under the *Heritage New Zealand Pouhere Taonga Act* 2014 is required for works to continue.

It is an offence under S87 of the *Heritage New Zealand Pouhere Taonga Act 2014* to modify or destroy an archaeological site without an authority from Heritage New Zealand irrespective of whether the works are permitted or consent has been issued under the Resource Management Act.

Heritage New Zealand Pouhere Taonga Archaeologist contact details:

Nikole Wills
Regional Archaeologist Otago/Southland
Heritage New Zealand
PO Box 5467
Dunedin
Ph. +64 3 470 2364, mobile 027 240 8715
Fax. +46 3 477 3893
nwills@heritage.org.nz

Appendix H: QLDC Letter

14 February 2024

Skyline Enterprises
Level 3, 30 Camp Street
Queenstown, 9300

Dear / Tēnā koe

Steve McLean / Paul Embleton-Muir

RE: Expectations of Andrew's Haulage Track Reinstatement

Background

As part of the works to enable the removal of the introduced soil in the upper Reavers Lane catchment, a methodology and outline plan has been submitted to Queenstown Lakes District Council (QLDC) on Monday 22nd January 2024.

One of the key items within the proposed methodology was the reinstatement of the Andrew's Haulage Track (**AHT**) to enable the movement of vehicles across the front face of the Ben Lomond Recreational Reserve whilst the works to remove the debris is completed (referred to in this letter as the "**Task 1 Works**").

QLDC have confirmed that the Task 1 Works are able to be completed under the Forestry Outline Plan, RM160956, issued on 14 December 2016.

Against that background, QLDC are issuing this letter to Skyline Enterprises Limited (**SEL**) to both confirm the ability to complete the Task 1 Works under RM160956, but also to communicate our expectations for the Task 1 Works. We appreciate the Task 1 Works have now been completed, but it remains important to confirm these expectations in respect of the completed works.

Our Expectations – Task 1 Works

Our expectations are summarised as follows:

1. **Familiarisation and demonstrated understanding of the site.**

    a. SEL to demonstrate an understanding of appropriate decision-making required in completing the Task 1 Works, i.e., based on experience and knowledge of the 'front face' of the Reserve, what conditions were encountered and how this influenced methodologies. Written documentation demonstrating this understanding is required.

2. **The standard that the AHT (and other roads during the works) has been designed to.**

    a. QLDC's expectation is that the road has been designed to the described standards within the NZ Forest Road Engineering Manual (2020).

    b. SEL to demonstrate to what classification within the NZ Forest Road Engineering Manual the road has been designed to and why that is suitable for its intended purpose.

c. SEL to demonstrate how all facets of roading design, i.e., drainage, grade, etc. have been designed.

3. Demonstration to QLDC that the works are being designed and completed appropriately.

a. QLDC's expectation is that, suitably qualified person(s) have been engaged by SEL to design all facets of the road (incl. water management and control of stormwater). This should then have been peer reviewed (by suitably qualified person(s) per component), with the work to be provided to QLDC. If the peer review has not yet happened, please arrange that now.

b. Following provision of the above, QLDC will have the work further peer-reviewed (as we have across other work streams) and this feedback will be passed onto SEL for consideration.

As communicated to us by SEL, the AHT roading design is of a 'temporary nature' and is only to be in place during the completion of the debris removal from the upper Reaver's catchment. On that basis we note that the expectations set out above are specific to the Task 1 Works only – we will be in touch separately to outline the approval pathway for the remainder of the works to be undertaken on Ben Lomond.

Once all works have been completed, it is QLDC's expectation that end-of-life management of the road is able to be demonstrated and agreed between both parties (SEL and QLDC) by way of a formal agreement. We will be in touch shortly regarding that agreement.

If SEL has any comments or queries on any of the above, we are happy to arrange a meeting to discuss this further. Otherwise, we will treat the above expectations as being understood/acknowledged by you, and we look forward to receiving relevant documents from you shortly.

Yours sincerely / Nāku noa nā

Dave Winterburn
Parks Manager, QLDC

Appendix I: Site Inspection Records (Task 1)

Site Inspection Record-03_9 February 2024

Address: Brecon Street Debris Flow Event- Remedial Works			
Inspected by: ☒ GeoSolve ☐ Contractor		☐ Client ☐ Other:	
Project:	Brecon Street Debris Flow Event- Remedial Works	**GeoSolve Job No:**	160073.03
Contractor:	Beavers, Mike Hurring Logging & Contracting. Heads Up Access	**Date & Time**	5-9-02-2024 various
Report By:	SR		

- **Progress Inspection- Andrews Haulage Track Gully Reinstatement**
- A remedial works report was prepared for the site entitled "Andrews Haulage Track Reinstatement, dated 29 January 2024.
- The report details that geotechnical construction phase services will be provided by GeoSolve.
- The works comprise reinstatement of a fit for purpose temporary forestry track and GeoSolve's recommendations and have been provided on this basis. If alternative performance criteria are required, please advise.
- Works to finalise the reinstatement of the gully area have been ongoing between the 5 and 9th of February. These works include confirming ground conditions underlying the northern and southern ramps and within the gully. Works also include design and installation of drainage (culverts) within the gully. Locations of the key areas are shown in Figure 1 below.
- The reinstatement works follows the philosophy of:
- Constructing tracks on competent rock where feasible,
- Limiting volumes of uncontrolled/controlled fill,
- Reducing the angle slope batters,
- Installing a culvert sized by specific catchment analysis.
- A final inspection to confirm recommendations will be required once items are completed.
- **Southern Ramp to Gully**
- Ground conditions generally consisted of schist bedrock on the upslope section of the track (cut) and uncontrolled fill material on the downslope section and batter slope.
- Schist bedrock was exposed for the full width of the track for most of the south ramp however the contact generally tapers back into the slope adjacent to the gully. (Photograph 1)
- Current slope angle for the downside slope outside the gully area is approximately 40 degrees.
- In the culvert location fill material was present and has been excavated to a level bench, with schist bedrock at the base. The fill has been replaced with compacted site won material placed in 300mm lifts and compacted using an excavator mounted plate compactor. The fill has been benched into the slopes during placement. (Photograph 2).

- The compacted fill is primarily excavated rock, is typically angular, and well graded. Compaction was completed until there was little to no indentation of the compaction plate.
- The fill was placed to achieve a minimum of 2:1 (H:V) fill batter slope from the toe of the batter to the outside shoulder of the proposed 4m wide track. The track was also lowered to remove excess fill material and organic material (Photograph 2).
- It is recommended that the downslope fill batters are hydroseeded for erosion protection.
- The upslope cut batter excavations from the widening works are likely to be subject to ongoing low volume fretting and users should be aware of this possibility. Ongoing maintenance to clear this fretting material will likely be required.
- **Gully- Culvert Design**
- Ground conditions comprise schist bedrock at installation depth.
- The culvert design comprises 2x 300mm HDPE culvert pipes installed centrally in the gully flow path. Having 2 pipes provides some redundancy in the system. The pipes have been installed immediately adjacent to each other, see Photograph 3 below.
- The piles are to be at least 300mm depth below the reinstated surface level (preferably more), and a minimum of 300mm depth to the crown of the pipe shall be maintained during the use of the track.
- The pipes have been installed to comply a minimum gradient of 2.5% and a maximum gradient of no more than 10%.
- Excavation will be required for the headworks. This excavation should be undertaken in a way that directs flow into the inlets as smoothly as possible, but minimises the risk of the inlets becoming blocked by debris falling into the inlet depression. Rip rap comprising cobbles and gravels should be installed at the inlet.
- The track should be constructed to drain surface flows into the culvert.
- A flume to schist bedrock down slope of outflow location should be used, to be confirmed by Geosolve.
- The area is to be inspected following each of the first 3 significant rainfall events after its installation by a GeoSolve staff member or other suitably qualified person, and works to improve/ensure its continuing performance are to be undertaken if necessary. Ongoing regular assessment of its condition is to be undertaken for the rest of its working life.
- Note that it has been assumed that the culvert is to have an up to 5-year design life only, and if it is intended to become a permanent fixture then adaptions may be required.
- The culverts have been backfilled with compacted site won material. (Photograph 3).
- It is noted that these works are mostly complete with the flume still required to be installed to complete the culvert installation. (Photograph 3).
- **Gully to Northern Ramp**
- Ground conditions generally consisted of schist bedrock on the upslope and downslope sections of the track and a veneer of uncontrolled fill material on the lower slope (beyond the track) see Photographs 4 & 5.
- Current slope angle for the downside slope outside the gully area is approximately 40 degrees.

- The upslope cut batter excavations from the widening works are likely to be subject to ongoing moderate volume fretting and users should be aware of this possibility. Ongoing maintenance to clear this fretting material will likely be required. Photograph 4 & 5.
- It is recommended that the upslope batter is hydroseeded for erosion protection.
- It is recommended that the downslope fill batters (beyond the track) are hydroseeded for erosion protection.

- **Attachments-** Schematic Sections of the Northern & Southern Ramps

SITE PHOTOGRAPHS – Brecon Street Debris Flow Event- Remedial Works

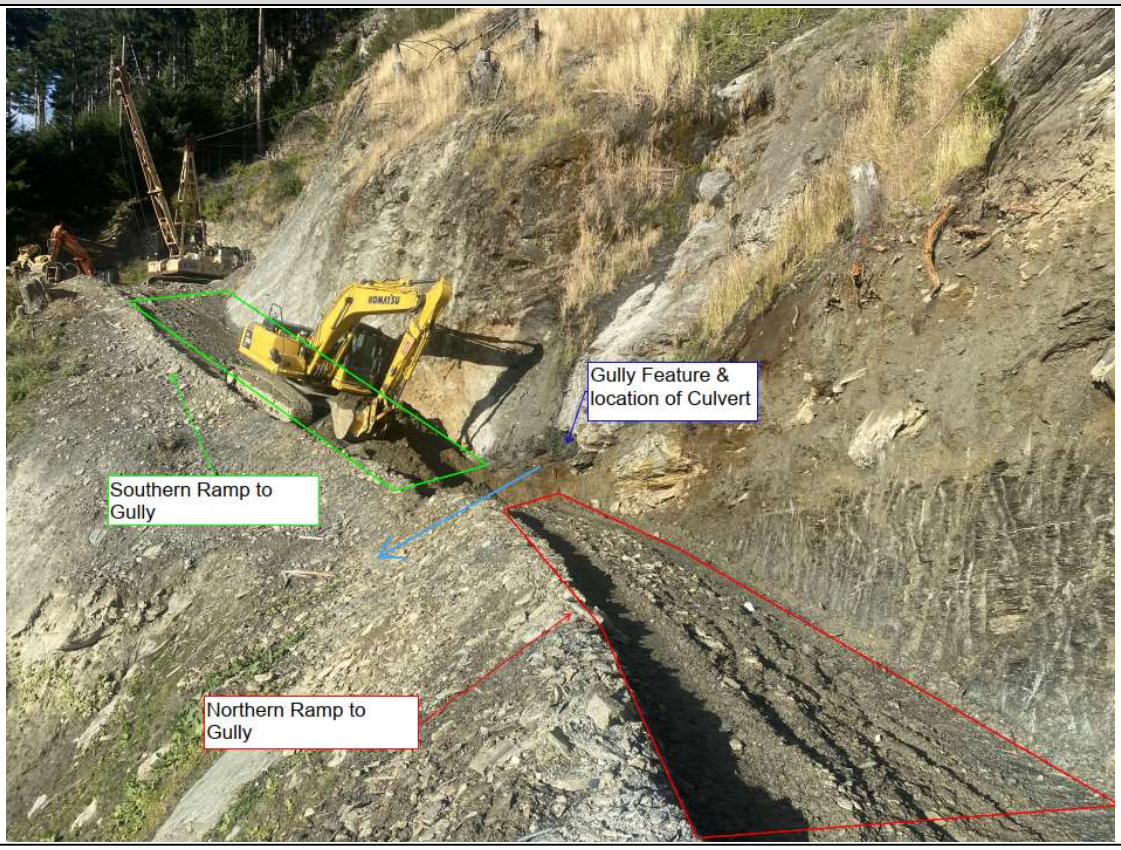


Figure 1- Site Plan

Photograph 1-: Inferred rock contact on track surface.

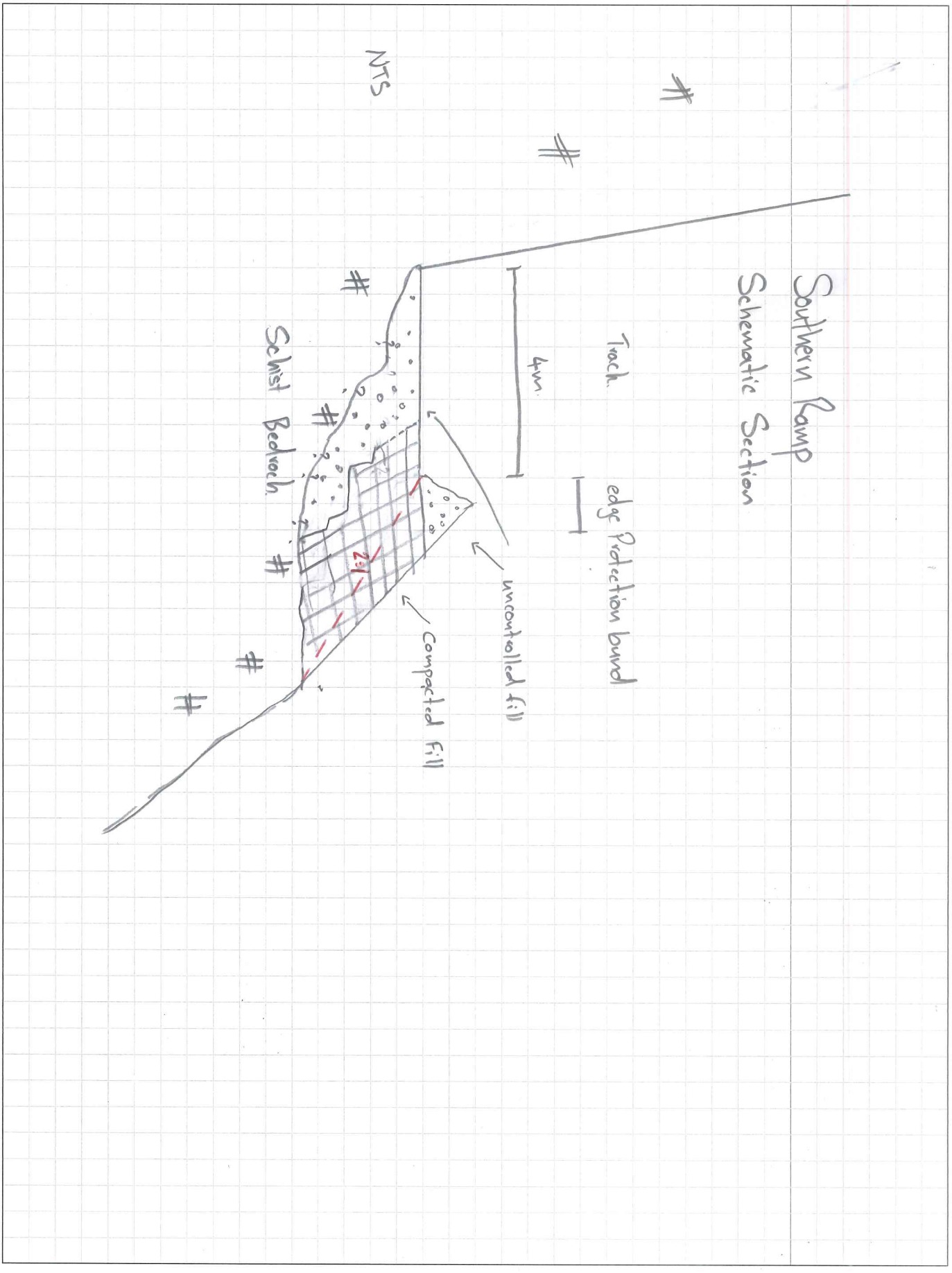
*Photograph 2-: Site won fill (crushed rock) on southern ramp benched into slope (yellow *), Road lowered to remove fill material- Red outlined*

Photograph 3-: Progress of culvert installation

Photograph 4-: Northern Ramp showing underlying schist bedrock and upslope cut batter.

Photograph 5-: Northern Ramp showing underlying schist bedrock and upslope cut batter.

GEOSOLVE ENGINEERING CONSULTANTS www.geosolve.co.nz	Project			Job Number	
	Part			Page /	Revision
	Drawing Ref	Calc by	Date	Check by	Date



GEOSOLVE ENGINEERING CONSULTANTS www.geosolve.co.nz	Project			Job Number	
	Part			Page /	Revision
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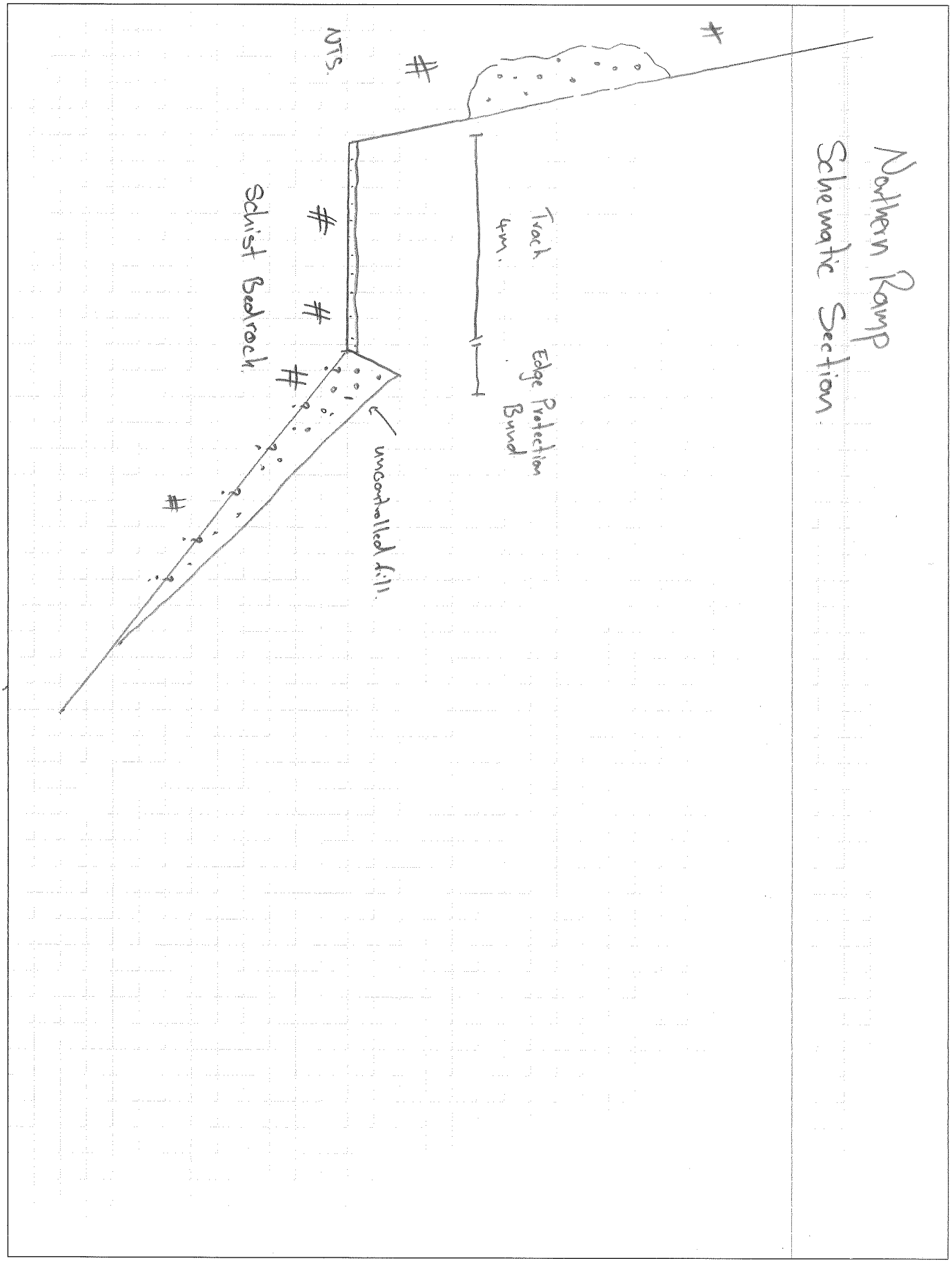


Site Inspection Record-04_14 February 2024

Address: Brecon Street Debris Flow Event- Remedial Works			
Inspected by:	☒ GeoSolve ☐ Contractor	☐ Client ☐ Other:	
Project:	Brecon Street Debris Flow Event- Remedial Works	**GeoSolve Job No:**	160073.03
Contractor:	Beavers, Mike Hurring Logging & Contracting. Heads Up Access	**Date & Time**	14-02-2024 various
Report By:	SR/NW		

- **Progress Inspection- Northwest Ramp**
- See Figure 1 for a site plan of the Northwest Ramp, this is the remining area of "Task One", as per SEL outline plan.
- The receipt of the QLDC report "Expectations of Andrew's Haulage Track Reinstatement", dated 14th February 2024 has been acknowledged in preparation of the SIR.
- The works comprise reinstatement of a fit for purpose temporary access track in general agreement with the described standards within the NZ Forest Road Engineering Manual (NZFREM) (2020). GeoSolve's recommendations have been provided on this basis, though it is noted that the material to be removed via this track is to be in smaller loads than those typically carried by logging trucks.
- It is understood that the proposed track is to be used by off-highway or other specialist vehicles, and that as per the NZFREM the steepness of the track can exceed the recommend 20% provided that those vehicles are designed to cope with the steeper gradient, and the operation has a written site-specific hazard control procedure. This will be provided by Beavers Contracting and is outside GeoSolve's scope of works.
- Site works comprise the cut and fill to form a track of approx. 20-degree (max) in grade for the extent of the northwestern ramp.
- To form the ramp a 3-4m fill batter has been constructed on an existing bench that is underlain by colluvium/introduced fill material and schist bedrock at shallow depths.
- The fill was placed with a fill batter of 3:1 (H:V) and intermittently track rolled and finished with a plate compactor. (Photograph 1).
- A 300mm culvert was installed through this fill slope with an outlet to a suitable area (Photograph 2).
- The remaining track formation was benched into the existing road. The downslope fill batter for the remaining track was generally formed at approx. 2:1 (H:V).
- A water table, a.k.a drainage ditch was formed on the upslope edge of the track and the track grade slopes to this water table suitably.
- The track has been partially completed and the following **recommendations** are provided to finalise these works:
- Replace the existing 300mm culvert **with a minimum 325mm ID culvert, as per** NZ Forest Road Engineering Manual (2020) requirements.
- The culvert backfill should be plate compacted in 300mm lifts.

- As the fill batter (photograph 1) was placed by track rolling, it will be required to be replaced with plate compacted fill in 300mm (until there is little to no indentation of the compaction plate), as per NZFREM requirements.
- Install an additional culvert (325mm culvert or greater) at the midpoint of the northwestern ramp and backfill material as above.
- The upper culvert will require a flume due to the outlet being located on the track fill batter slope.
- Batter the track upslope cut batter (Photograph 3) to 1.5:1.0 (H:V) for inspection.
- Install rip-rap at the culvert intakes & outlets and within the water table drainage ditch. It is understood that site won material is available to be used as rip-rap (Photograph 4). This material is considered appropriate, though some pieces will require breaking-up (e.g. by track rolling) to reduce its size prior to use. See Photograph 5 for recommended water table drainage ditch rip rap lining as per NZFREM. The smaller rip-rap is to be placed at the invert of the water table drainage ditch, covered by the larger rip-rap, in order to maximise scour protection and rip-rap stability.
- Cut and fill batter to be hydroseeded when seasonally appropriate.

- **Attachments- None**

SITE PHOTOGRAPHS – Brecon Street Debris Flow Event- Remedial Works

Figure 1- Site Plan

Photograph 1-: Fill batter of northwestern ramp

Photograph 2-: Fill batter of northwestern ramp and culvert intake/outlet and flow direction

Photograph 3-: Water table and upslope track cut batter

Photograph 4-: Site won rip-rap to be used for lining water table drainage ditch (once reduced was appropriate)

Photograph 5-: Suggested rip-rap lining configuration of a water table drainage ditch, as per NZFREM

Appendix J: Material Removal Zone Design

GeoSolve Ref: 160073.03-600s
5 July 2024

Skyline Enterprises Limited
PO Box 17
Queenstown 9348

Attention: Steve McLean & Paul Embleton-Muir

Material Removal Zone Design
Reavers Access Track, Queenstown

1.0 Introduction

In accordance with your request, GeoSolve have undertaken the geotechnical assessment and design of a geogrid reinforced material removal zone within the proposed Reavers Access Track alignment. The design is proposed to be used to allow fill material to be removed from above the debris fence (design as per GeoSolve's letter 160073.03-500s rev1 – dated 7 March 2024).

2.0 Proposed Solution and Background

To prevent the requirement of a 'hairpin' turn in steep terrain and construction of a significant mechanically stabilised earth (MSE) structure it is proposed to construct a geogrid reinforced zone on one section of the existing track to allow controlled transportation of fill material from one stretch of track to the adjacent lower level track. To ensure trucks, proposed to be Hydrema 912ES Standard Tip, are able to safely reverse and transport the material load from the upper track an MSE structure has been designed. The MSE structure has been designed based on the guidelines provided within Part C, Chapter 8 of Worksafe's "Health and Safety at Opencast Mines, Alluvial Mines and Quarries"[1].

Additional to the guidance provided within "Health and Safety at Opencast Mines, Alluvial Mines and Quarries" which provides static target FOS requirements for such a design, the seismic performance has been assessed.

3.0 Scope of Work

The scope of work completed as part of the design of the material removal zone is outlined below:

- Review of available information, topographical survey contour data and information to ascertain the alignment of tipping head.
- Inspection and geomorphological mapping of tipping head to establish geological model for the material removal zone stability assessment.
- Review of relevant Worksafe guidance.
- Slope stability assessment to assess required geogrid reinforcement.

[1] https://www.worksafe.govt.nz/topic-and-industry/extractives/guidance-position-statements/health-and-safety-at-opencast-mines-alluvial-mines-and-quarries/

- Rock catchment bund assessment to dimension the downslope catchment area.
- Complete a letter report with MSE structure drawings and a construction specification for the works.
- Preparation of in-service monitoring plan for the material removal zone.

Geotechnical Upper Track MSE Design

GeoSolve have undertaken a specific design for the upper area of the material removal zone. The design was undertaken in Geostudio's SlopeW assessing both a circular and block failure for the upper material removal zone .

As the slope is currently in place onsite parameters were assigned to the geological model to achieve a baseline FOS of 1.0. The following parameters were assumed for the design.

Table 1: *Soil Properties Assumed*

Soil Type	Unit Weight	Friction Angle	Cohesion
Uncontrolled Fill	16 kN/m^3	25 °	N/A
Glacial Till	19 kN/m^3	36 °	2 kPa
Schist Bedrock	27 kN/m^3	30 °	50 kPa
Engineered Fill*	19 kN/m^3	34 °	N/A
*Engineered Fill proposed to comprise debris bulb material which is predominately described as sub-angular silty sandy GRAVEL – properties have been compared to Table 5.8, Handbook of Geotechnical Investigation and Design Tables, Burt Look (2007) – outtake within Appendix B.			

As part of the assessment, we have also assumed the following:

- Groundwater seepages are proposed to be captured and directed away from the material removal zone therefore the slope has been modelled as dry.
- A surcharge from the Hydrema model 912es Std Tip has been modelled as follows (specification sheet and calculation summary within Appendix B):
    - Half of the machine weight (3.77 t) on the front tires (upslope and away from the crest of the upper material removal zone) applied at the wheelbase (3.1 m) offset upslope from the base of the upper material removal zone bund = 37 kN;
    - Remaining half of the machine weight (3.77 t) plus full capacity weight (10 t) applied at upslope edge of upper material removal zone bund = 135.1 kN.
    - An additional sensitivity check has been completed with a reduced offset between point loads if the truck was to reverse in a non-perpendicular orientation to the slope crest. This sensitivity analysis showed similar results to the point loads being applied at the truck's full wheelbase.
- We have assumed an importance level 2 structure with a 6 month to 5 year design life.
- We have considered design earthquakes based on the MBIE/NZGS Module 1 guidance document.

- Miragrid GX100 has been adopted in the design, the following design values have been adopted for the Miragrid:
    - Interface shear angle – 30 degrees – based on 34 degree soil friction angle * 0.9 pullout reduction factor (as per supplier guidance – attached in Appendix B);
    - Long term factored design strength considering 125 mm maximum particle size installation damage factor = 63 kN/m (datasheet attached in Appendix B);

Based on the above assumptions we have designed the MSE structure for the upper material removal zone to meet the following requirements:

- Static FOS > 1.2 in accordance with Worksafe guidance document;
- SLS seismic FOS > 1;
- No ULS seismic FOS target however displacement estimate to assess potential implications to the structure. ULS seismic displacement have been estimated in accordance with the recommendations of Jibson (2007)[2]. The estimated displacement range based on the calculated yield acceleration of 0.12g was determined to be 5-41 mm (lower and upper bound respectively).

The SlopeW results are attached within Appendix C.

The design drawings and specification are attached in Appendices D and E respectively.

Downslope Catch Bund

A downslope catch bund is proposed to prevent material transported from the upper track of the material removal zone from travelling further downslope. The downslope catch bund has been sized based on the methodology described within Appendix B, Attachment E of Rockfall: Design Considerations for Passive Protection Structures[3] based on the following assumptions:

- Boulder of 1 m width;
- Boulder radius of 0.5 m;
- Bounce Height (to centre of boulder) = 1 m;
- Bund height required to be minimum 1 m plus 2x radius = 2 m;
- Maximum kinetic energy 100 kJ;
- Bund width based on Figure 1 within Appendix B, Rockfall: Design considerations for Passive Protection Structures – 0.5 m penetration (at impact height) therefore minimum width at impact is 5x penetration = 2.5 m.

Any boulder in excess of the above design assumption (greater than 1 m^3) should be broken into smaller pieces prior to loading onto the Hydrema.

The bund has been drawn as per the following dimensions within the drawing set attached within Appendix D.

The bund stability has been assessed in slopeW based on the following principles:

- A maximum of four truck loads of material sitting behind the bund at one time before being cleared and loaded as per contractors methodology. Maximum truck payload is 10 t – therefore 40 t (~393 kN), assuming spread across a minimum width of 5 m results and considering the base area of the catch bund is approximately 3 m this would result in a surcharge from the stockpile of approximately 393/(5*3) = 26 kPa.

[2] R.W. Jibson, Regression models for estimating coseismic landslide displacement.
[3] https://www.building.govt.nz/assets/Uploads/building-code-compliance/b-stability/b1-structure/rockfall-design-consideration/rockfall-design-passive-protection-structures.pdf

- Outside edge of bund to match existing slope performance – assumed to be FOS of approximately 1.0 based on adopted soil parameters;
- Stability from the inside (upslope) edge of the bund to match performance of geogrid reinforced upper material zone – minimum static FOS of 1.2 and SLS FOS of 1.

The slope stability analysis results for the bund are provided within Appendix C.

The bund should be constructed upon a subgrade of glacial till throughout and benched into sloping ground as required. The bund fill should be constructed in accordance with the methodology outlined within the GeoSolve specification.

Future Maintenance and Design Life

The system is proposed to be constructed to allow for safe removal of the existing 'Zone A' fill material and is expected to have a design life of approximately 6 months once constructed.

Due to the high consequence of the upper material removal zone MSE structure and downslope catch bund failure, the following in service inspections will be required. Findings of the inspections shall be reported to and reviewed by a suitably qualified engineer. The inspection should include, but are not limited to, the following:

Table 2 – Tipping head monitoring details and frequency.

Components	Recommended Minimum Inspection Interval*
Examination of mechanical components (e.g. geogrid and facing matting etc) for damage. Inspection of condition of tipping head surface ground condition. Inspection of condition of downslope stockpile area (below upper material removal MSE area) including the bund.	**Daily Inspection Prior to First Load Entering Upper Material Removal MSE Area during Service:** Walkover by contractor to confirm all mechanical components are not damaged from material removal works and no observed ground movement/scour/damage, slope and catchment bund.
	Weekly Inspection in Service: Walkover by designer to confirm all mechanical components and ground around the upslope material removal MSE structure and bund are not being damaged by material removal works and are working effectively.
*A round of monitoring should also be undertaken by the designer during or immediately following rainfall events exceeding the following amounts or any seismic event: 1. Rainfall exceeding 9 mm per hour; and, 2. Daily cumulative rainfall amounts exceeding 47 mm.	

Applicability

This report has been prepared for the sole use of our client, Skyline Enterprises Ltd, with respect to the particular brief and on the terms and conditions agreed with our client. It may

not be used or relied on (in whole or part) by anyone else, or for any other purpose or in any other contexts, without our prior review and written agreement.

Report Prepared by:

.....

Mike Plunket
Geotechnical Engineer (CPEng)
GeoSolve Limited

Reviewed for GeoSolve Ltd by:

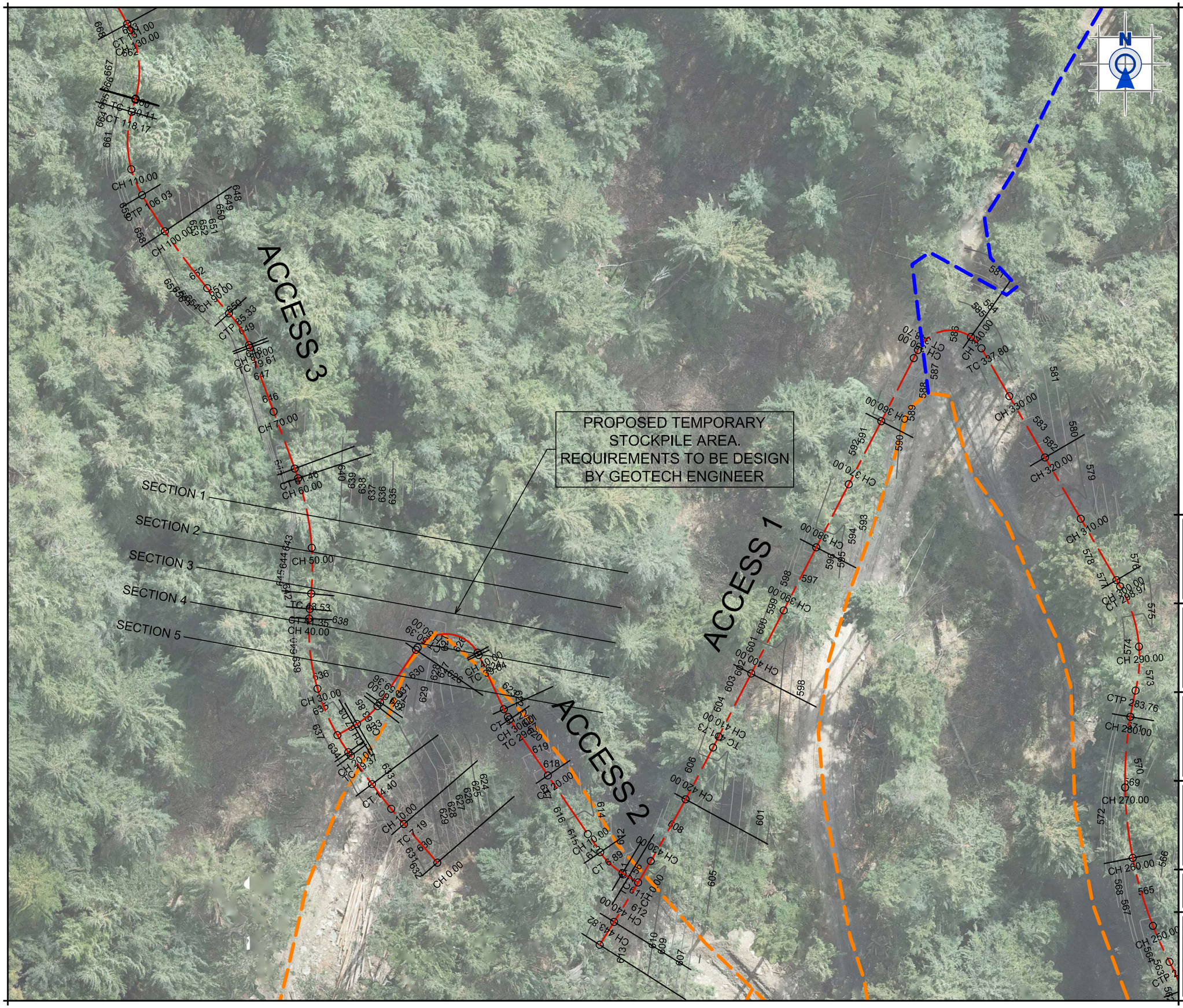
.....

Paul Faulkner
Senior Engineering Geologist

Attachments:

Appendix A – Geological Model and Cross-section
Appendix B – Calculation Inputs
Appendix C – SlopeW Outputs
Appendix D – Construction Drawings
Appendix E – Construction Specification

Appendix A – Geological Model and Cross-section



LEGEND

- 5m DESIGN CONTOURS
- 1m DESIGN CONTOURS
- EXISTING TRACKS
- EXISTING TRACKS (TO BE REHABILITATED)
- PROPOSED ACCESS
- BOUNDARY
- EASEMENTS
- CATCH FENCE FILL AREA

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F alexandra@ppgroup.co.nz

Client & Location:

SKYLINE ENTERPRISES LIMITED

QLDC BEN LOMOND RECREATION RESERVE

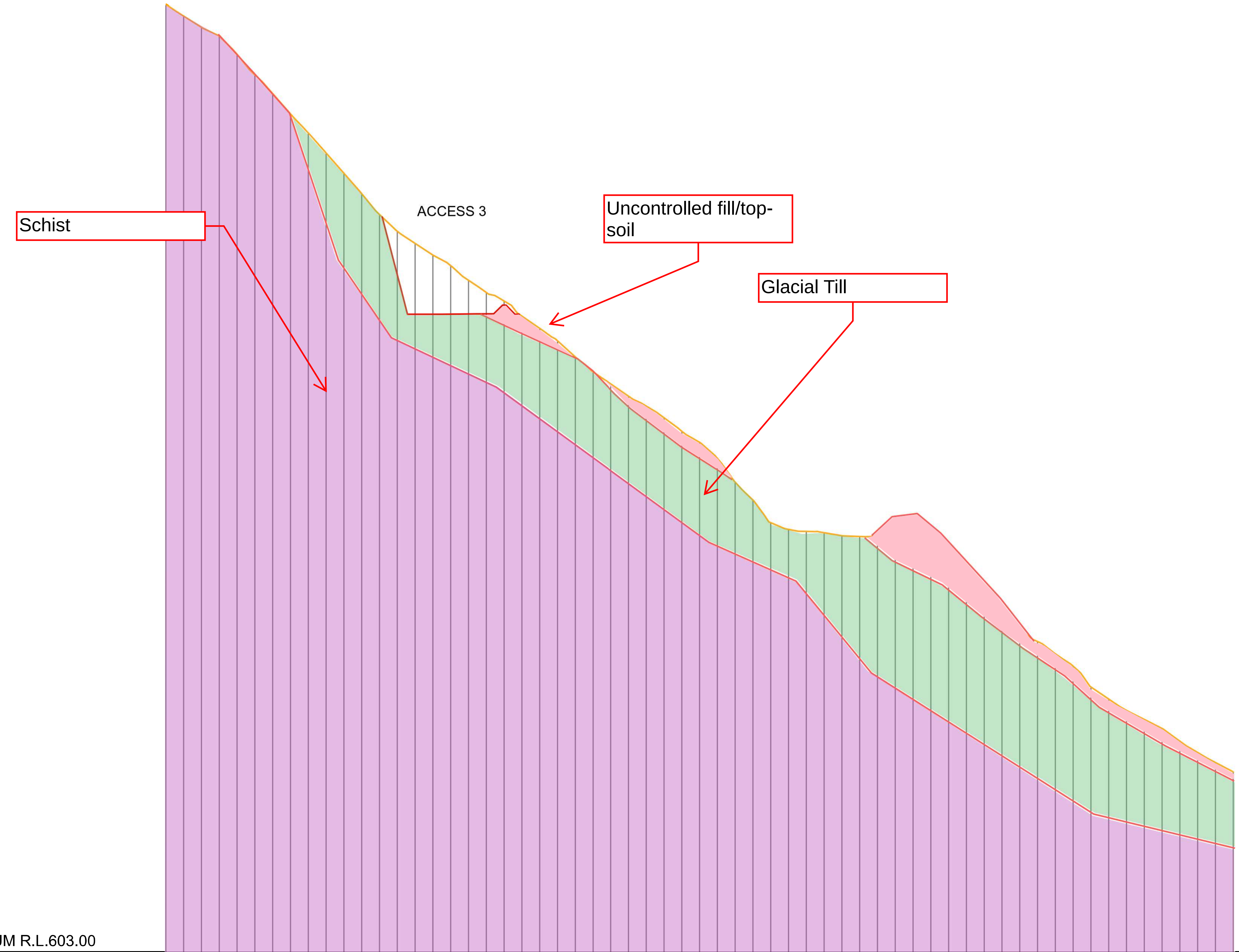
Purpose & Drawing Title:

REAVERS DEBRIS REMOVAL

DESIGN CONTOURS DETAIL SHEET 3 OF 4

FOR CONSTRUCTION

Surveyed by:	AWJ	Original Size:	Scale:
Designed by:	SAM	A3	1:500
Drawn by:	SAM		
Checked by:	SAM		DO NOT SCALE
Approved by:			
Job No:	Drawing No:	Sheet No:	Revision No: / Date:
Q4115	7-6-2	214	F / 23/05/2024



DATUM R.L.603.00

CHAINAGE	AUG 2023 LIDAR LEVEL
0.00	656.30
1.00	655.64
2.00	655.01
3.00	654.51
4.00	653.49
5.00	652.35
6.00	651.29
7.00	650.15
8.00	649.07
9.00	647.94
10.00	646.81
11.00	645.66
12.00	644.49
13.00	643.55
14.00	642.86
15.00	642.20
16.00	641.61
17.00	640.79
18.00	640.10
19.00	639.62
20.00	638.77
21.00	638.09
22.00	637.39
23.00	636.48
24.00	635.64
25.00	634.96
26.00	634.27
27.00	633.72
28.00	633.06
29.00	632.30
30.00	631.68
31.00	630.78
32.00	629.44
33.00	628.44
34.00	627.16
35.00	626.79
36.00	626.67
37.00	626.60
38.00	626.43
39.00	626.39
40.00	626.39
41.00	626.46
42.00	626.36
43.00	625.84
44.00	624.84
45.00	623.76
46.00	622.88
47.00	621.83
48.00	621.09
49.00	620.48
50.00	619.79
51.00	619.10
52.00	617.92
53.00	617.25
54.00	616.61
55.00	616.10
56.00	615.59
57.00	614.88
58.00	614.24
59.00	613.68
60.00	613.15

SCALE 1:250 HORIZ
1:250 VERT

LEGEND
- DESIGN LEVEL
- EXISTING GROUND LEVEL
- OVERVIEW SURVEYING
- LIDAR FLOWN 23/08/23

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E queenstown@ppgroup.co.nz

Client & Location:
SKYLINE ENTRPRISES LIMITED
QLDC BEN LOMOND RECREATION RESERVE

Purpose & Drawing Title:
REAVERS DEBRIS REMOVAL
TEMPORARY STOCKPILE AREA
SECTION 3 OF 5

FOR CONSTRUCTION

Surveyed by:	AWJ	Original Size: A3	Scale: 1:250
Designed by:	SAM		
Drawn by:	SAM		
Checked by:	SAM		
Approved by:			DO NOT SCALE

Job No:	Drawing No:	Sheet No:	Revision No:	Date:
Q4115	7-6-2	373	E	23/05/2024

Appendix B – Calculation Inputs

TABLE 3.3

ANNUAL PROBABILITY OF EXCEEDANCE

Design working life	Importance level	Annual probability of exceedance for ultimate limit states			Annual probability of exceedance for serviceability limit states	
		Wind	Snow	Earthquake	SLS1	SLS2 Importance level 4 only
Construction equipment, e.g., props, scaffolding, braces and similar	2	1/100	1/50	1/100	1/25	
Less than 6 months	1	1/25	1/25	1/25	—	
	2	1/100	1/50	1/100	1/25	
	3	1/250	1/100	1/250	1/25	
	4	1/1000	1/250	1/1000	1/25	
5 years	1	1/25	1/25	1/25	—	—
	2	1/250	1/50	1/250	1/25	—
	3	1/500	1/100	1/500	1/25	—
	4	1/1000	1/250	1/1000	1/25	1/250
25 years	1	1/50	1/25	1/50	—	—
	2	1/250	1/50	1/250	1/25	—
	3	1/500	1/100	1/500	1/25	—
	4	1/1000	1/250	1/1000	1/25	1/250
50 years	1	1/100	1/50	1/100	—	—
	2	1/500	1/150	1/500	1/25	—
	3	1/1000	1/250	1/1000	1/25	—
	4	1/2500	1/500	1/2500	1/25	1/500
100 years or more	1	1/250	1/150	1/250	—	—
	2	1/1000	1/250	1/1000	1/25	—
	3	1/2500	1/500	1/2500	1/25	—
	4	*	*	*	1/25	*

* For importance level 4 structures with a design working life of 100 years or more, the design events are determined by a hazard analysis but need to have probabilities less than or equal to those for importance level 3.

Design events for importance level 5 structures should be determined on a case by case basis.

LOCATION ID NUMBER[a]	TOWN/CITY	PEAK GROUND ACCELERATION (a_{max})[b] AND RECOMMENDED FOR USE FOR ALL SITE CLASSES — RETURN PERIOD								EARTHQUAKE MAGNITUDE (M)[c],[d],[e] VALUES (A, B, C, D AND E) — WITHOUT MODIFICATION[f] — RETURN PERIOD								BASIS OF DATA (REFER NOTES BELOW FOR DETAIL)[g]	GROUP ID NUMBER[h]
		25-YEAR		50-YEAR		100-YEAR		250-YEAR		250-YEAR	500-YEAR		1000-YEAR		2500-YEAR				
		a_{max}(g)	M	a_{max}(g)	M	a_{max}(g)	M	a_{max}(g)		M	a_{max}(g)	M	a_{max}(g)	M	a_{max}(g)	M			
100	Cromwell	0.08	6.2	0.12	6.2	0.17	6.2	0.25		6.2	0.34	6.2	0.44	6.2	0.61	6.2		(1)	36
101	Fairlie																		
102	Alexandra	0.07	6.3	0.10	6.3	0.15	6.3	0.22		6.3	0.30	6.3	0.39	6.3	0.53	6.3		(1)	37
103	Queenstown	0.10	6.5	0.14	6.5	0.20	6.5	0.31		6.5	0.41	6.5	0.53	6.5	0.74	6.5		(1)	38
104	Arrowtown																		
105	Milford Sound	0.16	6.1	0.22	6.1	0.32	6.1	0.48		6.1	0.63	7.1	0.82	7.1	1.14	7.1		(1)	39
106	Dunedin	0.06	6	0.08	6	0.11	6	0.17		6	0.29	6	0.41	6	0.59	6		(1)	40
107	Temuka																		
108	Timaru																		
109	Waimate																		
110	Oamaru																		
111	Palmerston																		
112	Mosgiel																		
113	Balclutha																		
114	Te Anau	0.11	6.4	0.15	6.4	0.22	6.4	0.33		6.4	0.44	6.4	0.57	6.4	0.79	6.4		(1)	41
115	Riverton	0.07	6.2	0.09	6.2	0.13	6.2	0.20		6.2	0.27	6.2	0.35	6.2	0.48	6.2		(1)	42
116	Winton																		
117	Gore																		
118	Mataura																		
119	Invercargill	0.05	6.1	0.08	6.1	0.11	6.1	0.16		6.1	0.21	6.1	0.28	6.1	0.39	6.1		(1)	43
120	Bluff																		
121	Oban																		

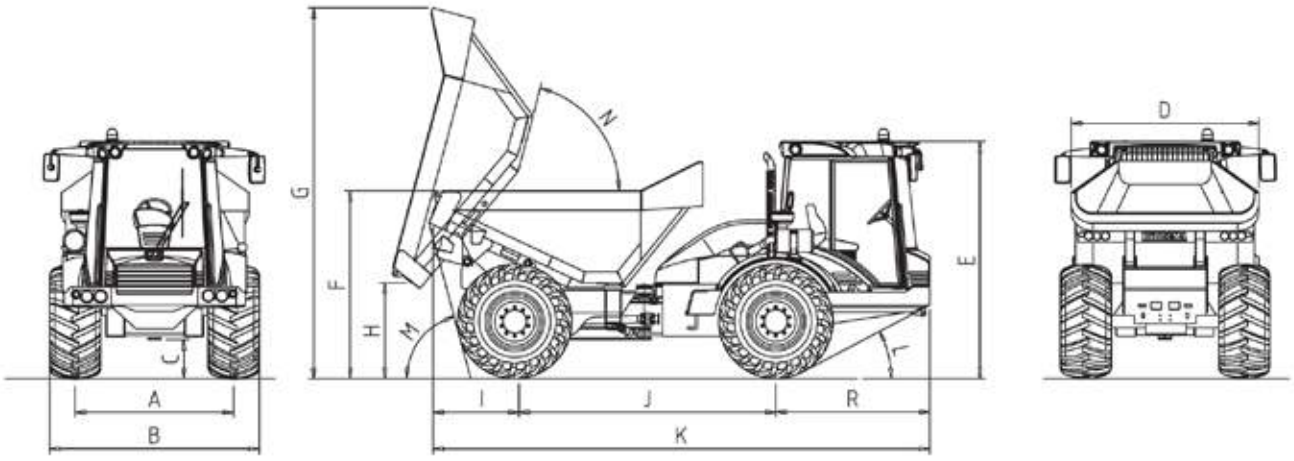
Footnotes

(a) Numbering for locations, refer to Table A2 for alphabetical list of locations (Note: not identical numbering of locations in Table 3.3 of NZS 1170.5)
(b) a_{max} estimated for Class C shallow soil (NZTA-BM; 2018) or V_{s30} = 300m/s (NZGS-2020)
(c) Meff—effective magnitude is used for all data based on (NZTA-BM; 2018)—ie Basis of Data (1) in right hand column of Table A1
(d) M_w—Mean moment magnitude is used for all data based on (NZGS-2020)—ie Basis of Data (3) to (8) in right hand column of Table A1
(e) M_w—Mean moment magnitude for RP=500 years (NZGS-2020) are adopted for use for RP>500 years for Basis of Data (3) to (8) in right hand column of Table A1
(f) a_{max} and M values listed in the table apply to all site classes without any scaling or modification; a_{max} estimated for Class C shallow soil (NZTA-BM, 2018; Locations (1)) or V_{s30} = 300m/s (NZGS-2020; Locations (3) to (8)); Note: a_{max} estimates are for level ground conditions (ie effects of basin edge and topographic features are not included)
(g) Origin of data, refer Notes (g) below
(h) Grouping of locations, towns and cities sharing very similar hazard
(i) Canterbury Earthquake Region (CER)—MBIE Guidance for M = 7.5
(j) Canterbury Earthquake Region (CER)—MBIE Guidance for M = 6.0

Notes [g]—Origin of Data presented

(1) a_{max} and Meff values for subsoil Class C based on NZTA Bridge Manual (2018), Table C6.1; R-value based on NZS1170.5, Table 3.5;
(1)* (1) a_{max} and M_w values (not in brackets) for subsoil Class C based on NZTA Bridge Manual (2018), Table 6.3; R-value based on NZS1170.5, Table 3.5;
(2) For R ≥ 500yr: a_{max} = 0.19g and M_w=6.5 (values in brackets) based on lower bound ULS load (6.5 earthqauke magnitude at 20km distance) specified in NZTA Bridge Manual (2018)
(2) Parameters based on MBIE 2014 Canterbury Earthquake Region guidance
(3) Parameters based on NZGS-2020 Hazard study
(4) Location associated with NZGS-2020 hazard for Gisborne
(5) Location associated with NZGS-2020 hazard for Napier
(6) Location associated with NZGS-2020 hazard for Palmerston North
(7) Location associated with NZGS-2020 hazard for Wellington
(8) Location associated with NZGS-2020 hazard for Blenheim

Dimensions.



			912E		912ES		912HM			
			Std.tip	MultiTip	Std.tip	MultiTip	Std.tip	Std.tip	MultiTip	MultiTip
	Tires		600/55-26,5	600/55-26,5	600/55-26,5	600/55-26,5	800/45x30.5	600/60x30.5	800/45x30.5	600/60x30.5
	Total weight	kg	17270	17730	17540	18000	18260	17970	18720	18430
	Unladen weight	kg	7270	7730	7540	8000	8260	7970	8720	8430
	Load capacity	kg	10000	10000	10000	10000	10000	10000	10000	10000
	Ground pressure (full load)	kg/cm²	1.24	1.25	1.25	1.27	0.87	1.15	0.88	1.16
A.	Track	mm	1860	1860	1860	1860	2060	1940	2060	1940
B.	Total width	mm	2470	2470	2470	2470	2870	2540	2870	2540
C.	Ground clearance	mm	450	450	450	450	520	520	520	520
D.	Width, dump body	mm	2210	2210	2210	2210	2210	2210	2210	2210
E.	Total height	mm	2750	2750	2790	2790	2865	2865	2865	2865
F.	Loading height	mm	2170	2320	2210	2360	2330	2330	2480	2480
G.	Max. height for tipping	mm	4215	4450	4255	4490	4370	4370	4610	4610
H.	Tipping clearance	mm	1050	1200	1090	1240	1210	1210	1360	1360
I.	Overhang, rear	mm	1000	920	1000	920	1000	1000	920	920
J.	Wheelbase	mm	3080	3080	3080	3080	3080	3080	3080	3080
K.	Overall length	mm	5870	5950	5870	5950	5870	5870	5950	5950
L.	Approach angle, front	°	27	27	28	28	30	30	30	30
M.	Departure angle, rear	°	73	73	73	79	74	74	74	74
N.	Tipping angle	°	75	67	75	67	75	75	67	67
R.	Overhang, front	mm	1870	1870	1870	1870	1870	1870	1870	1870
	Capacity	m³	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
	Turning radius	m	6.1	6.1	6.1	6.1	6.3	6.1	6.3	6.1
	Speed (empty)	mph								
	Speed (full load)	mph								

Hydrema Surcharge Calculation

Model	912es Std Tip	
Unladen weight	7540	kg
half	3770	kg
Weight on back wheel during tip	13770	kg
	13.77	t
	135.1	**kN**
Remainder - Front Tire Weight	**37.0**	**kN**

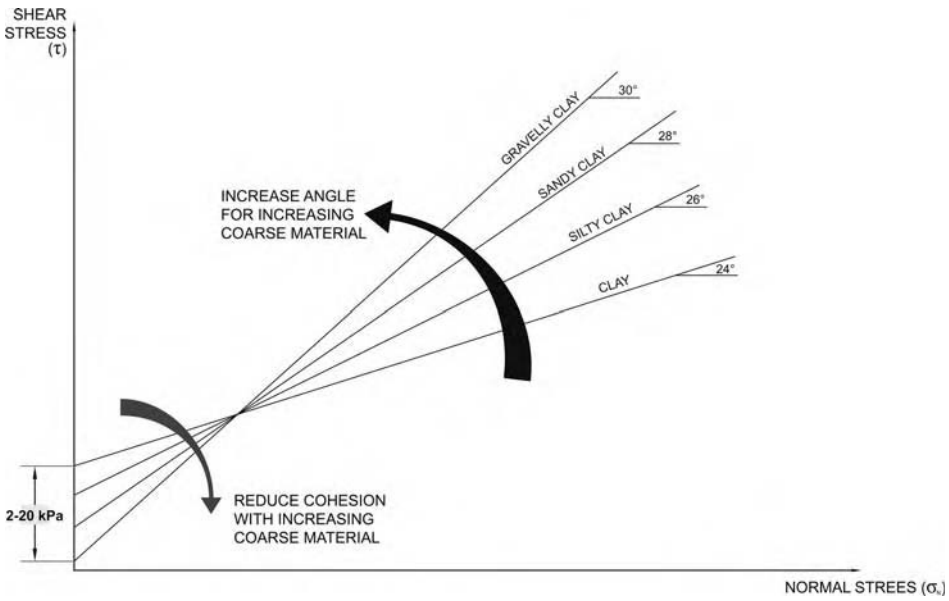


Figure 5.2 Indicative variation of clay strength with changing granular content.

5.8 Critical state angles in sands

- The critical state angle of soil (ϕ_{crit}) = 30 + A + B.
- This is the constant volume friction angle. The density of the soil provides an additional frictional value but may change depending on its strain level.

Table 5.8 Critical state angle.

Particle distribution	*Critical state angle of soil (ϕ_{crit}) = 30 + A + B*			
		Angularity		
		Rounded	Sub – Angular	Angular
Grading	B	A = 0	A = 2	A = 4
Uniform soil ($D_{60}/D_{10} < 2$)	B = 0	30	32	34
Moderate grading ($2 \leq D_{60}/D_{10} \leq 6$)	B = 2	32	34	36
Well graded ($D_{60}/D_{10} > 6$)	B = 4	34	36	38

5.9 Peak and critical state angles in sands

- The table a
- Using abov 0 + A + B + C.

Debris material comprises sub-angular silty sandy GRAVEL, 34 degrees conservatively assumed for analysis purposes

Mike Plunket

From: Eric Ewe <e.ewe@geofabrics.co.nz>
Sent: Thursday, 20 June 2024 4:21 pm
To: Mike Plunket
Cc: Simon Reeves; Mike van den Arend
Subject: RE: [160073.03] Skyline Debris Removal Access Track MSE concept
Attachments: image037.wmz; image043.wmz

Categories: Saved To Drive

Hi Mike,

You can use the same coefficient. The key is well graded granular fill of up to 125mm.

Regards,
Eric

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AUCKLAND 1061 NEW ZEALAND

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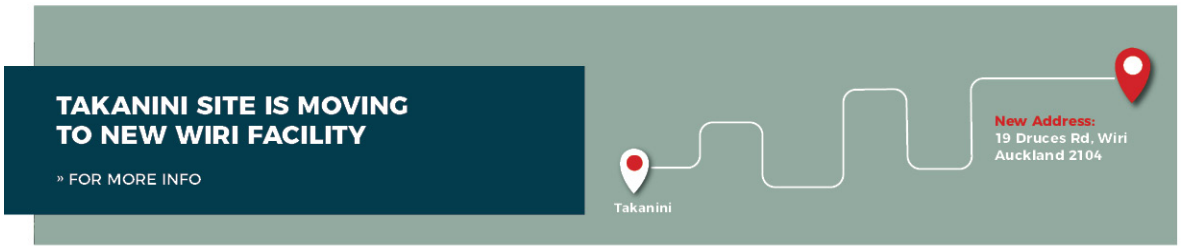

From: Mike Plunket <mplunket@geosolve.co.nz>
Sent: Thursday, June 20, 2024 4:06 PM
To: Eric Ewe <e.ewe@geofabrics.co.nz>
Cc: Simon Reeves <sreeves@geosolve.co.nz>; Mike van den Arend <m.arend@geofabrics.co.nz>
Subject: RE: [160073.03] Skyline Debris Removal Access Track MSE concept

Thanks Eric,

Can you confirm if there is a published interaction coefficient for pull-out resistance for <125 mm gravels and miragrid gx? Or just what is provided within your datasheet online? If not do you have any recommendations for the pull-out coefficient for up to 125 mm gravels.

Table 3. Interaction coefficients for direct sliding and pull-out resistance for different adjacent fill types.

Interaction Coefficient	Silt or Clay	Sand	Gravel (≤ 50mm)
For direct sliding, α_{ds}	0.7	0.9	0.95
For pull-out, α_{po}	0.7	0.9	0.9

References

ASTM D5818 : Standard practice for exposure and retrieval of samples to evaluate installation damage of geosynthetics.

ASTM D6992 : Standard test method for accelerated tensile creep and creep rupture of geosynthetic materials based on time-temperature

Thanks,

Mike Plunket | Geotechnical Engineer, CPEng

GeoSolve Ltd - Engineering Consultants | | M: 027 371 0803

25D Gordon Road, Wanaka 9305

TENCATE Miragrid®

Miragrid® GX Geogrids

Properties of TenCate Miragrid® GX Geogrids

Property			Unit	GX 40/40	GX 60/30	GX 80/30	GX 100/30
Initial Mechanical Properties							
Characteristic initial strength, T_u	(ISO 10319)	MD	kN/m	40	60	80	100
Characteristic initial strength	(ISO 10319)	CD	kN/m	40	30	30	30
Characteristic initial strength at 5% strain	(ISO 10319)	MD	kN/m	22	33	44	55
Strain at initial strength		MD	%	8	8	8	8
Material reduction factor creep-rupture, f_{cr}							
at 50 years design life				1.40	1.40	1.40	1.40
at 100 years design life				1.43	1.43	1.43	1.43
Creep limited strength based on creep-rupture, T_{CR}							
at 50 years design life			kN/m	28.6	42.9	57.1	71.4
at 100 years design life			kN/m	28.0	42.0	55.9	69.9
Material reduction factor - installation damage, f_{id}							
in clay, silt or sand				1.10	1.05	1.05	1.05
in gravel (125mm maximum size)				1.15	1.10	1.10	1.10
Material reduction factor - environmental effects (4 < pH < 9), f_{en}							
at 50 years design life				1.03	1.03	1.03	1.03
at 100 years design life				1.05	1.05	1.05	1.05
Long term design strengths, T_D							
at 50 years design life							
in clay, silt or sand			kN/m	25.2	39.6	52.8	66.0
in gravel (125mm maximum size)			kN/m	24.1	37.8	50.4	63.0
at 100 years design life							
in clay, silt or sand			kN/m	24.2	38.1	50.7	63.4
in gravel (125mm maximum size)			kN/m	23.2	36.3	48.4	60.5
Nominal roll width			m	5.2	5.2	5.2	5.2
Nominal roll length			m	100	100	100	100
Estimated roll weight			kg	155	155	170	189

** Estimated roll weight is a guidance for logistic purpose only.*

Other forms of supply as well as grades, adjusted to the requirements of specific projects, are available on request.

Adopted geogrid reinforcement tensile design value

TenCate Miragrid® *is a registered trademark of TenCate Geosynthetics.*

The technical values are obtained through testing in ***Geosynthetic Testing Laboratory, TenCate Geosynthetics Asia*** *edited scope*

Further details of this application and products can be obtained by contacting your nearest TenCate Technical Support Office. Unauthorized reproduction and distribution is prohibited. This document is provided as supporting service only. The information contained in this document is to the best of our knowledge true and correct. No warranty whatsoever is expressed or implied or given. Engineers wishing to apply this information shall satisfy themselves on the validity of the input data relative to the applicable soil and engineering conditions and in doing so assume design liability.

TenCate Geosynthetics Asia Sdn. Bhd. 199301009495 (264232-U)
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MS ISO/IEC 17025 TESTING SAMM NO. 207 ISO9001 : 2015 Accreditation #: GAI-LAP-45-02

TENCATE GEOSYNTHETICS

TENCATE Miragrid®

Design Strengths and Strains for TenCate Miragrid® GX Geogrids

1. Miragrid® GX geogrids design strengths and strains

Miragrid® GX geogrids are engineered materials suitable for short and long term soil reinforcement applications. They are composed of high modulus polyester yarns, assembled to form a directionally structured and stable geogrid that enables maximum load carrying efficiency.

Miragrid® GX geogrids are manufactured in a wide range of tensile strengths to suit different soil reinforcement conditions. Standard assessment procedures exist to determine the long term design strengths of Miragrid® GX geogrids. These rely on the application of material reduction factors to the initial tensile strength of the geosynthetic reinforcement in order to determine the appropriate long term design strength. For example, such procedures are standard practice in US Federal Highway Administration documentation and well-recognized Codes of Practice such as British Standard BS8006-1:2010.

The generic relationship for assessing the long term design strengths of geosynthetic reinforcements is shown below.

$$T_D = \frac{T_u}{f_{cr}\ f_{id}\ f_{en}} \qquad (1)$$

where,

- T_D is the long term design strength of the reinforcement;
- T_u is the initial tensile strength of the reinforcement;
- f_{cr} is the material reduction factor relating to creep effects over the required life of the reinforcement;
- f_{id} is the material reduction factor relating to installation damage of the reinforcement;
- f_{en} is the material reduction factor relating to environmental effects over the required life of the reinforcement.

The magnitudes of the material reduction factors f_{cr} and f_{en} are not only affected by time (the design life of the reinforcement) but also by temperature (the average in-ground temperature). In this datasheet a standard in-ground temperature of 20°C is used as the basis for measurement. This also agrees with in-ground conditions in many parts of the world and can also be considered to be conservative for colder climates.

2. Initial strengths and strains

All geosynthetic reinforcement materials should be described in terms of their characteristic initial strengths and not their mean initial strengths. This ensures the representation of initial tensile strength is statistically safe. The initial tensile strengths of Miragrid® GX geogrids shown at the front of this datasheet are expressed in terms of characteristic (95th percentile) values, which are statistically safe values.

The initial tensile loads and strains of Miragrid® GX geogrids can be represented by a single master curve covering all grades. This master curve is shown in Figure 1. Here the ordinate value is expressed as a percentage of the initial characteristic tensile strength. Because of the use of special high modulus PET yarns Miragrid® GX geogrids exhibit tensile loads of 55% of the initial tensile strength at only 5% strain which makes these materials very efficient in carrying tensile loads at relatively low strains.

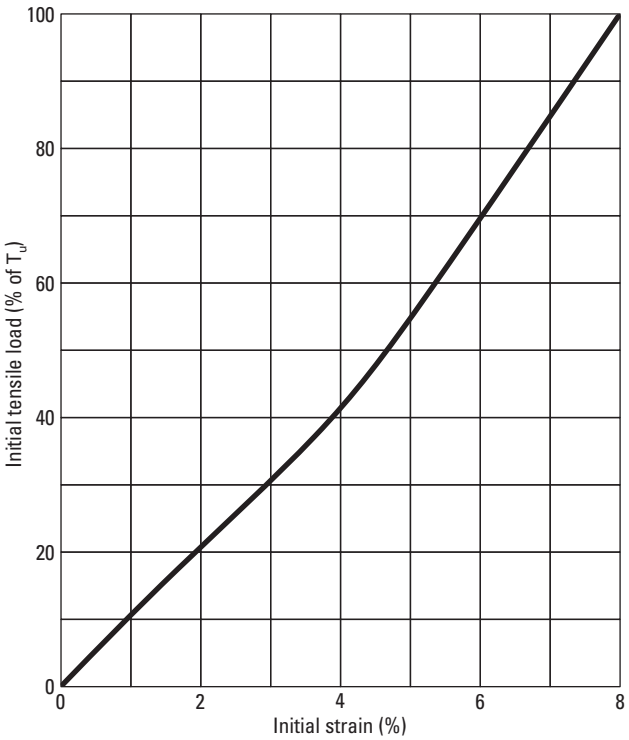

Figure 1. Initial tensile load – strain master curve for Miragrid® GX geogrids.

In prescribing suitable reinforcement strain limits to soil reinforcement applications reference is normally made to well-recognized Codes of Practice, e.g. BS8006-1:2010. Normally, for most soil reinforcement applications, reinforcement strains are limited to 5% or less over the design life of the reinforcement. Thus, the lower part of the tensile load – strain curve shown in Figure 1 (less than 5% strain) is the most important part of the curve when assessing allowable reinforcement strain levels.

TENCATE GEOSYNTHETICS

TenCate Miragrid®

Design Strengths and Strains for TenCate Miragrid® GX Geogrids

3. Material reduction factor for creep effects, f_{cr}

Creep effects can influence the behaviour of geosynthetic reinforcements in two ways – by decreasing the rupture load over time and by increasing the strain over time. Creep-rupture effects are associated with ultimate limit states (i.e. collapse modes) and are considered a critical case where reinforced soil walls, reinforced soil slopes and basal reinforced embankments constructed on soft foundations are concerned. Creep-strain effects are associated with serviceability limit states (i.e. deformation modes) and may be critical where maximum reinforcement strains need to be limited and controlled.

3a. Material reduction factors for creep-rupture effects, f_{cr1}

The material reduction factor for creep-rupture f_{cr1} is derived from the creep-rupture curve of the geosynthetic reinforcement. The creep-rupture curve for Miragrid® GX geogrids is shown in Figure 2. This curve has been generated from a combination of long term (in accordance with ISO 13431) and accelerated creep testing (in accordance with ASTM D6992). For example, from Figure 2, the material reduction factor for creep-rupture at 100 yrs is f_{cr1} = 100%/70% = 1.43. Table 1 below lists the creep-rupture material reduction factors for Miragrid® GX geogrids at 10 yrs, 50 yrs and 100 yrs design lives. Interpretation of the creep-rupture curve in Figure 2 can provide appropriate creep-rupture reduction factors for other reinforcement design lives.

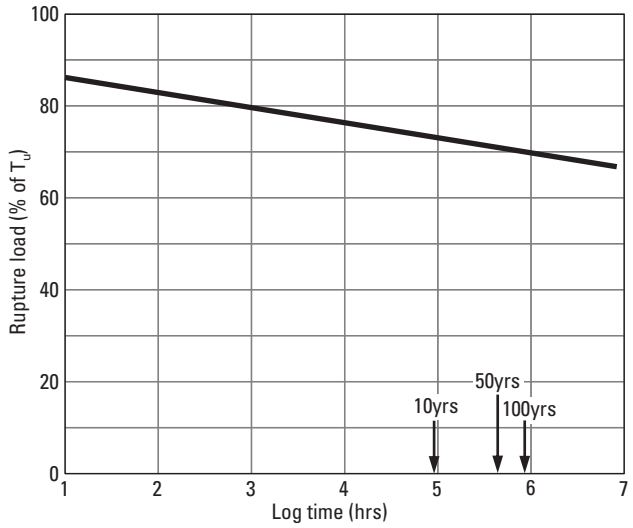

Figure 2. Creep-rupture curve at 20°C for Miragrid® GX geogrids.

Table 1. Material reduction factors f_{cr1} based on creep-rupture at 20°C for Miragrid® GX geogrids at three different reinforcement design lives.

f_{cr}	at 10 yrs	at 50 yrs	at 100 yrs
	1.37	1.40	1.43

3b. Material reduction factors for creep-strain effects, f_{cr2}

The material reduction factor for creep-strain f_{cr2} is derived from the isochronous creep curves of the geosynthetic reinforcement. These curves show the change in strain of the reinforcement over time at different load levels. The isochronous creep-strain curves for Miragrid® GX geogrids are shown in Figure 3. The isochronous curves show that Miragrid® GX geogrids exhibit low creep strains over long design lives.

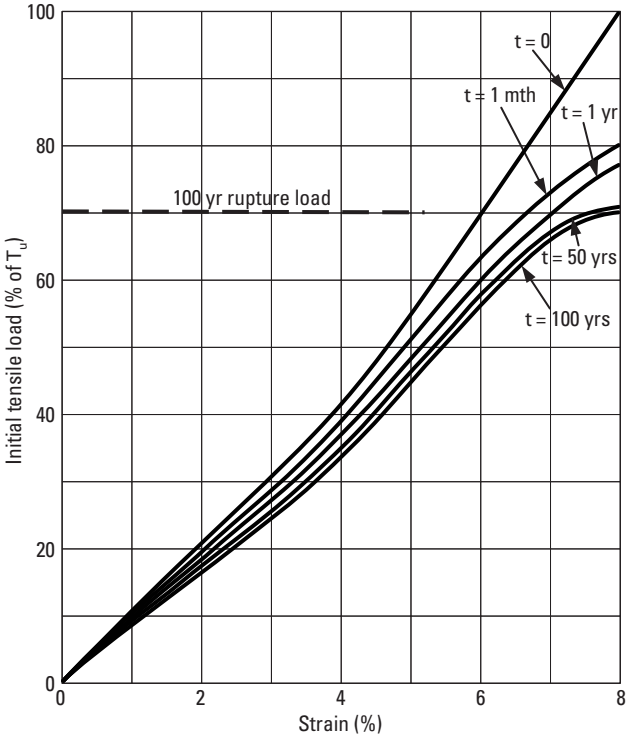

Figure 3. Isochronous creep-strain curves at 20°C for Miragrid® GX geogrids.

For example, if a design requires the total reinforcement strain to be limited to a maximum of 5% strain over a 100 year design life, then from Figure 3 a load level of 45% over 100 years will meet this requirement for Miragrid® GX geogrids. Thus, f_{cr2} = 100%/45% = 2.22.

In some cases, it may be required to limit the post-construction strain in the reinforcement to, say, 1% in order to prevent long term deformations in a reinforced soil structure. In this case the t = 1 mth curve shown in Figure 3 can be used as a good approximation of the time it takes to construct the structure, and if the design life is 100 years and the maximum creep-strain has to be limited to 1%, then a maximum load level of around 65% can be sustained. Thus, here f_{cr2} = 100%/65% = 1.54.

TenCate Geosynthetics

TENCATE Miragrid®

Design Strengths and Strains for TenCate Miragrid® GX Geogrids

3c. When to use f_{cr1} or f_{cr2} for the value f_{cr} in Equation 1

Whether to use f_{cr1} or f_{cr2} for the value f_{cr} in Equation 1 depends on the design method being used as well as the type of analysis being undertaken.

Where a design method based on a global factor of safety approach is being used then values of f_{cr1} based on reinforcement creep-rupture should be used as the value of f_{cr} in Equation 1.

Where a design method based on a limit state approach is being used then both f_{cr1} and f_{cr2} should be used as the value of f_{cr} in Equation 1 depending on whether an ultimate limit state analysis or a serviceability limit state analysis is being performed. In an ultimate limit state analysis f_{cr1} should be used as the value for f_{cr}, whereas in a serviceability limit state analysis f_{cr2} should be used as the value for f_{cr} in Equation 1.

4. Material reduction factor for installation damage effects, f_{id}

When the reinforcement is installed and fill is compacted against it, some loss in initial strength can be experienced by the reinforcement. This loss in strength due to installation damage is accounted for by use of a material reduction factor, f_{id}. The magnitude of the material reduction factor for installation damage effects depends on the reinforcement structure and the type of fill being compacted against the reinforcement. Normally, installation damage tests are carried out on sites, in accordance with established methods such as ASTM D5818 or BS8006-1:2010 Annex D, using different fill types.

Miragrid® GX geogrids exhibit material reduction factors for installation damage, the magnitude of which depends on the grade of product and the type of fill used. For example, when clay, silt or sand fill is compacted against Miragrid® GX geogrids a value of f_{id} = 1.10 is a conservative upper limit to be used for ultimate limit state design (rupture), and for coarser fills the material reduction factor will be greater. As for serviceability limit state design (strain), f_{id} = 1.05 can be adopted for all types of fill including clay, silt, sand, or gravel.

5. Material reduction factor for environmental effects, f_{en}

The chemical inertness of the high modulus PET yarns used in Miragrid® GX geogrids makes them highly durable when installed in a wide range of soil environments. For PET reinforcement to be used for long term design lives (100 years) the US Federal Highway Administration recommends that the PET molecular weight ≥ 25,000 g/mol and Carboxyl End Group count ≤ 30 mmol/kg. Miragrid® GX geogrids surpass these requirements.

Long term environmental testing in pH conditions ranging from 4 < pH < 9 at 20°C yield the material reduction factors listed in Table 2 for Miragrid® GX geogrids.

Table 2. Material reduction factors based on environmental effects at 20°C for Miragrid® GX geogrids at three different reinforcement design lives.

f_{en}	at 10 yrs	at 50 yrs	at 100 yrs
	1.00	1.03	1.05

6. Bond resistance - direct sliding and pull-out

For geosynthetic reinforced soil structures the reinforcement must behave in a composite manner with the adjacent soil. To accomplish this there must be a good bond resistance developed between the reinforcement and the adjacent soil. Two different forms of bond resistance can arise – bond resistance due to direct sliding and bond resistance due to pull-out. Direct sliding occurs when a potential failure plane coincides with the surface of the reinforcement layer. Pull-out occurs when a potential failure plane intersects reinforcement layers at an inclined angle.

The effectiveness of the reinforcement bond resistance is governed by the magnitude of the interaction coefficient between the reinforcement and the adjacent soil and its bond length. Miragrid® GX geogrids exhibit high bond resistance with a variety of soil types. This is demonstrated by the high interaction coefficients shown in Table 3 for a range of soil types.

Table 3. Interaction coefficients for direct sliding and pull-out resistance for different adjacent fill types.

Interaction Coefficient	Silt or Clay	Sand	Gravel (≤ 50mm)
For direct sliding, α_{ds}	0.7	0.9	0.95
For pull-out, α_{po}	0.7	0.9	0.9

References

ASTM D5818 : Standard practice for exposure and retrieval of samples to evaluate installation damage of geosynthetics.

ASTM D6992 : Standard test method for accelerated tensile creep and creep rupture of geosynthetic materials based on time-temperature superposition using the stepped isothermal method.

BS8006-1:2010 ... /reinforced soils and other fills, Brit...

ISO 13431 : G... oducts-Determination of tensile cree...

0.9 recommended reduction factor to shear interace angle in pull-out = phi * 0.9 = 34*0.9 = 30.6 degrees - adopt 30 degrees

100 603-tdANZ-04|22

Appendix C – SlopeW Outputs and Jibson ULS Displacement Calculations

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Glacial Soils	Mohr-Coulomb	19	2	36
	Schist Bedrock	Mohr-Coulomb	27	50	30
	Topsoil & Uncontrolled Fill	Mohr-Coulomb	16	0	25

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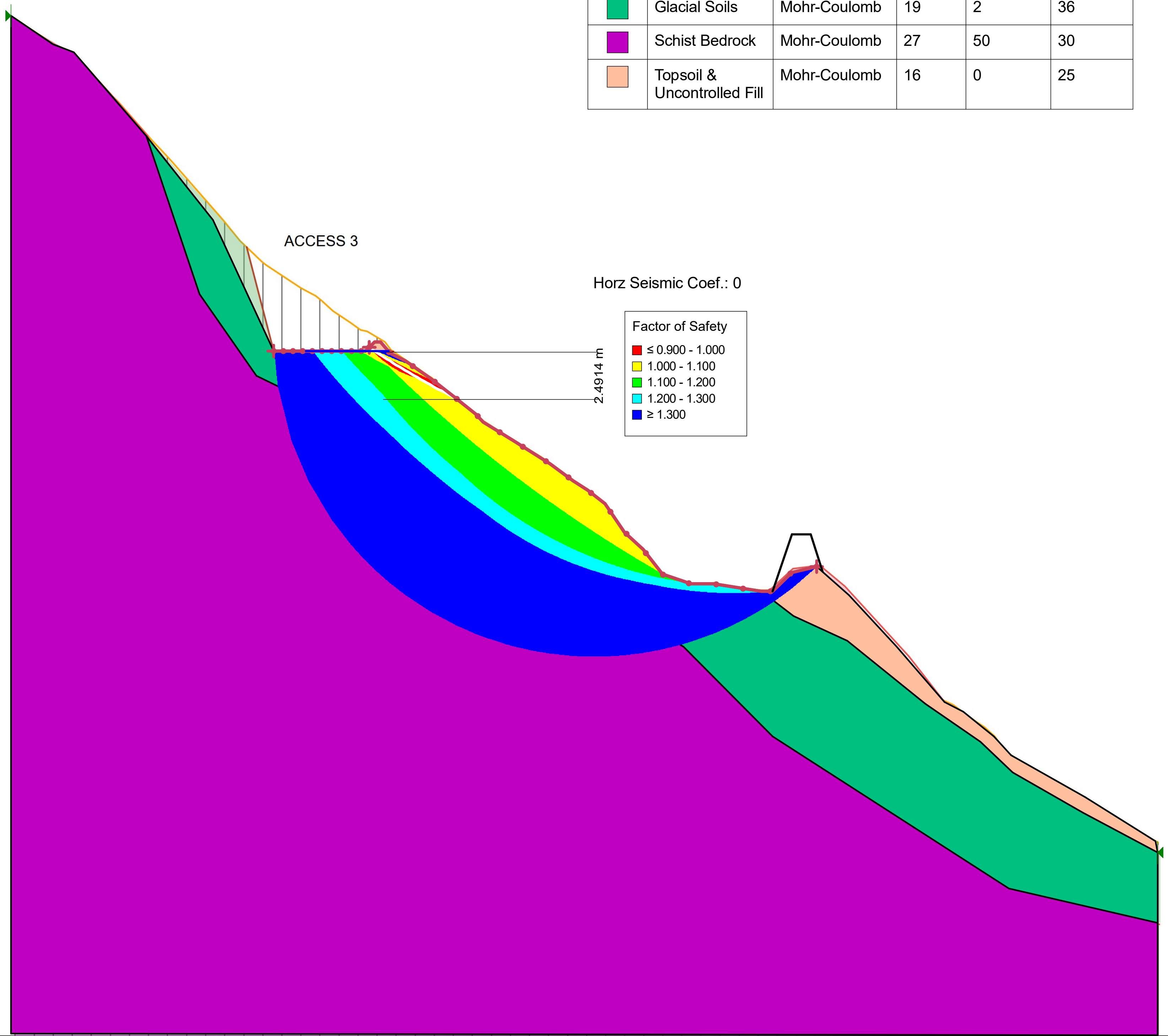
EXISTING GROUND LEVEL

OVERVIEW SURVEYING

LIDAR FLOWN 23/08/23



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37.00	626.60
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39.00	626.39
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42.00	626.36
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44.00	624.84
45.00	623.76
46.00	622.88
47.00	621.83
48.00	621.09
49.00	620.48
50.00	619.79
51.00	619.10
52.00	617.92
53.00	617.25
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Material Removal Zone - Final.gsz

25/06/2024

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Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Glacial Soils	Mohr-Coulomb	19	2	36
	Schist Bedrock	Mohr-Coulomb	27	50	30
	Topsoil & Uncontrolled Fill	Mohr-Coulomb	16	0	25

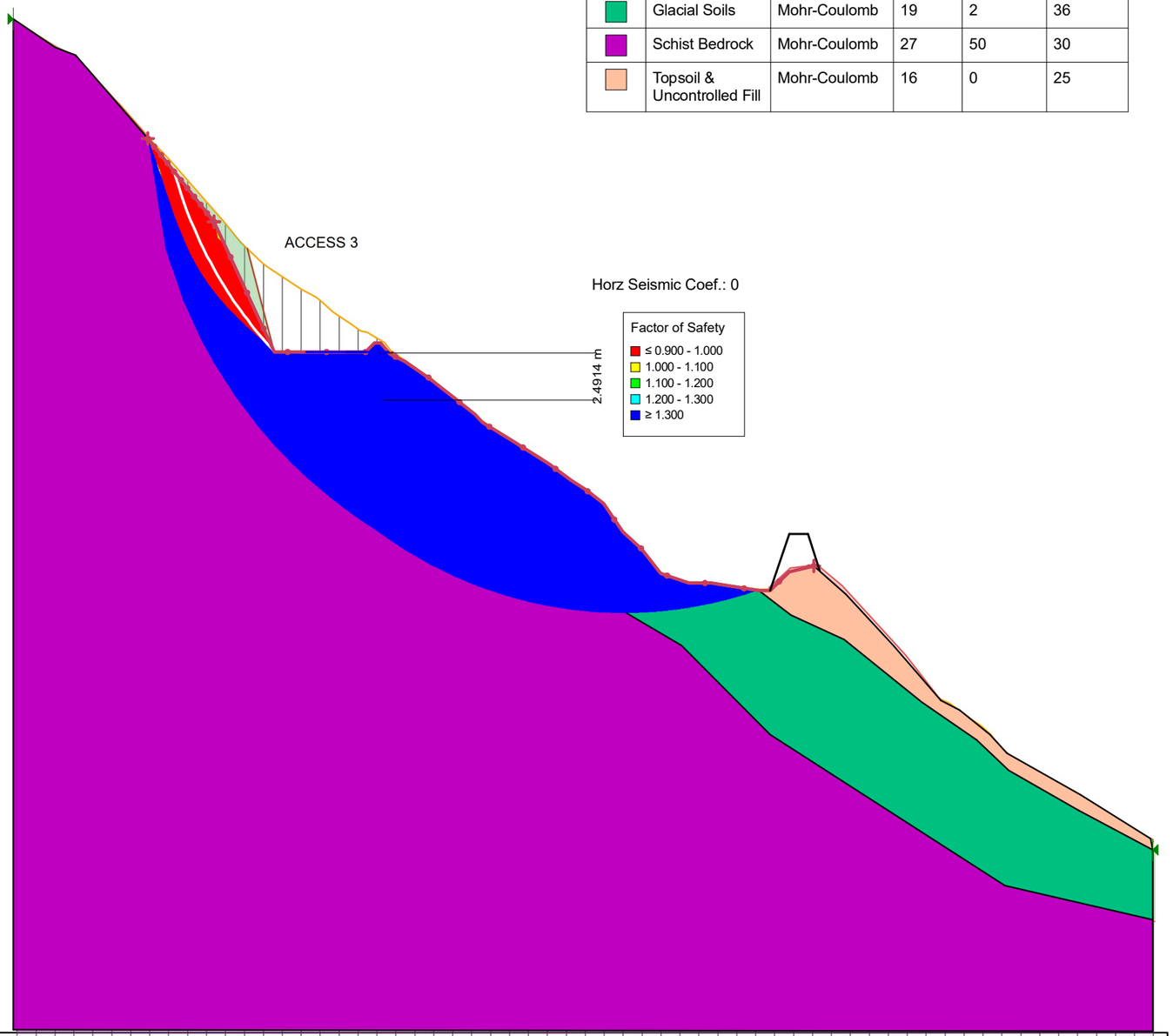
LEGEND

DESIGN LEVEL

EXISTING GROUND LEVEL

OVERVIEW SURVEYING

LIDAR FLOWN 23/08/23



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AUG 2023 LIDAR LEVEL	656.30	655.64	655.01	654.51	653.49	652.35	651.29	650.15	649.07	647.94	646.81	645.66	644.49	643.55	642.86	642.20	641.61	640.79	640.10	639.62	638.77	638.09	637.39	636.48	635.64	634.96	634.27	633.72	633.06	632.30	631.68	630.78	629.44	628.44	627.16	626.79	626.67	626.60	626.43	626.39	626.39	626.46	626.36	625.84	624.84	623.76	622.88	621.83	621.09	620.48	619.79	619.10	617.92	617.25	616.61	616.10	615.59	614.88	614.24	613.68	613.15	
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Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Engineered Fill	Mohr-Coulomb	19	0	34
	Glacial Soils	Mohr-Coulomb	19	2	36
	Schist Bedrock	Mohr-Coulomb	27	50	30
	Topsoil & Uncontrolled Fill	Mohr-Coulomb	16	0	25

Color	Name	Type	Interface Adhesion (kPa)	Interface Shear Angle (°)	Surface Area Factor	Tensile Capacity (kN)
	Miragrid 100GX	Geosynthetic	0	30	2	63
	Miragrid 100GX - Face anchorage	Geosynthetic	0	30	2	63

Horz Seismic Coef.: 0

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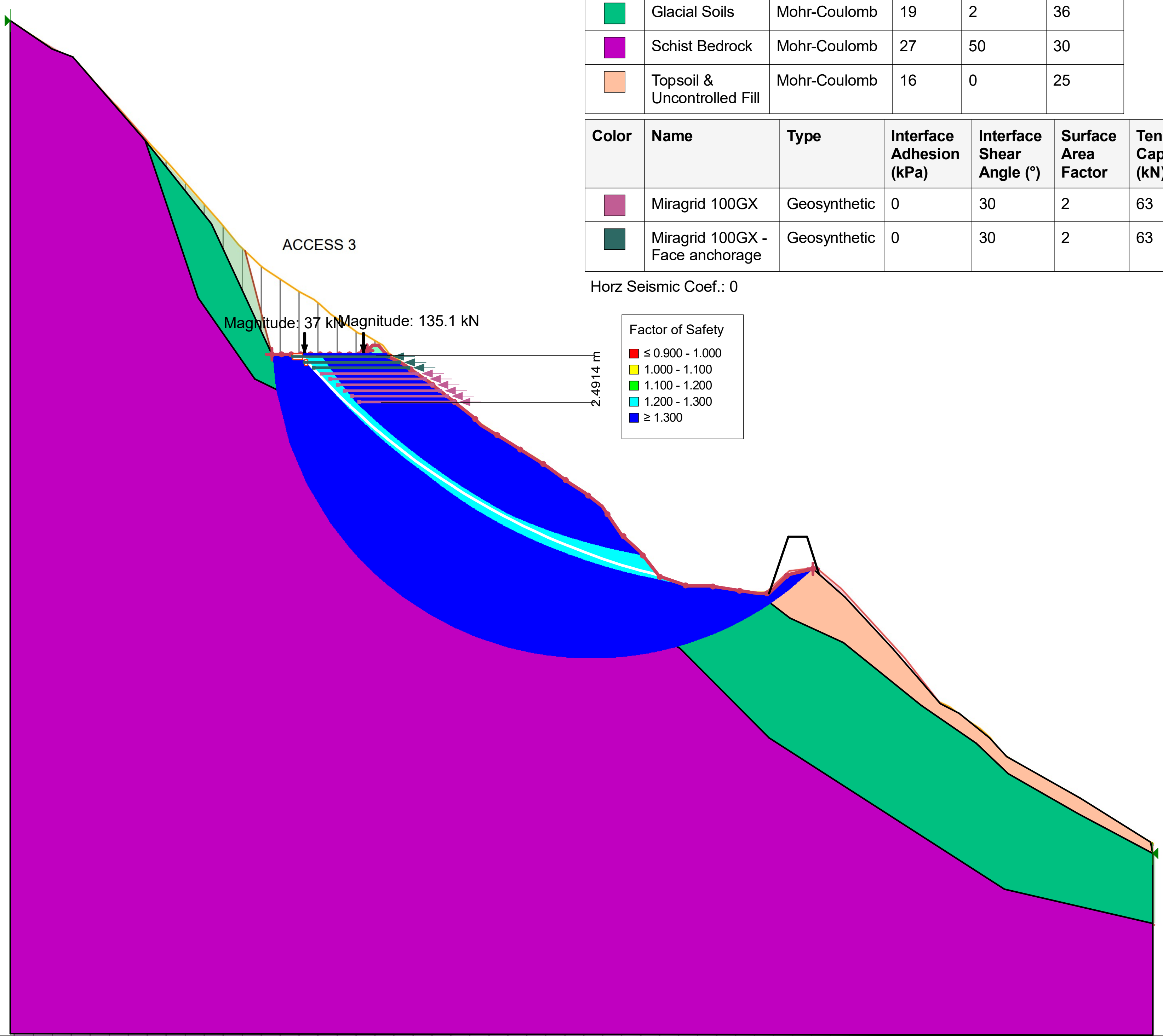
EXISTING GROUND LEVEL

OVERVIEW SURVEYING

LIDAR FLOWN 23/08/23



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Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Engineered Fill	Mohr-Coulomb	19	0	34
	Glacial Soils	Mohr-Coulomb	19	2	36
	Schist Bedrock	Mohr-Coulomb	27	50	30
	Topsoil & Uncontrolled Fill	Mohr-Coulomb	16	0	25

Color	Name	Type	Interface Adhesion (kPa)	Interface Shear Angle (°)	Surface Area Factor	Tensile Capacity (kN)
	Miragrid 100GX	Geosynthetic	0	30	2	63
	Miragrid 100GX - Face anchorage	Geosynthetic	0	30	2	63

Horz Seismic Coef.: 0

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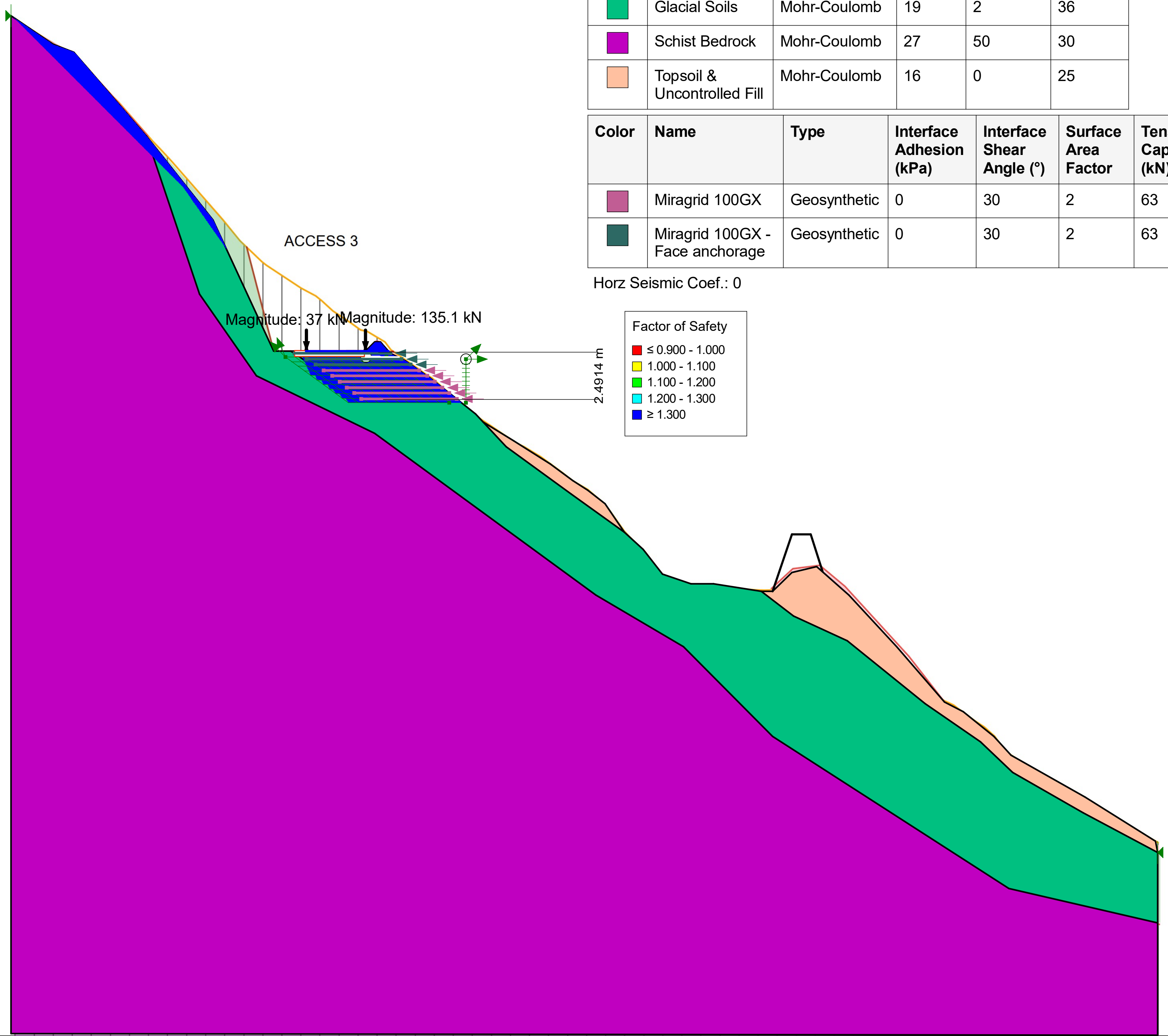
OVERVIEW SURVEYING
LIDAR FLOWN 23/08/23



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Material Removal Zone - Final.gsz

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Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Engineered Fill	Mohr-Coulomb	19	0	34
	Glacial Soils	Mohr-Coulomb	19	2	36
	Schist Bedrock	Mohr-Coulomb	27	50	30
	Topsoil & Uncontrolled Fill	Mohr-Coulomb	16	0	25

Color	Name	Type	Interface Adhesion (kPa)	Interface Shear Angle (°)	Surface Area Factor	Tensile Capacity (kN)
	Miragrid 100GX	Geosynthetic	0	30	2	63
	Miragrid 100GX - Face anchorage	Geosynthetic	0	30	2	63

Horz Seismic Coef.: 0

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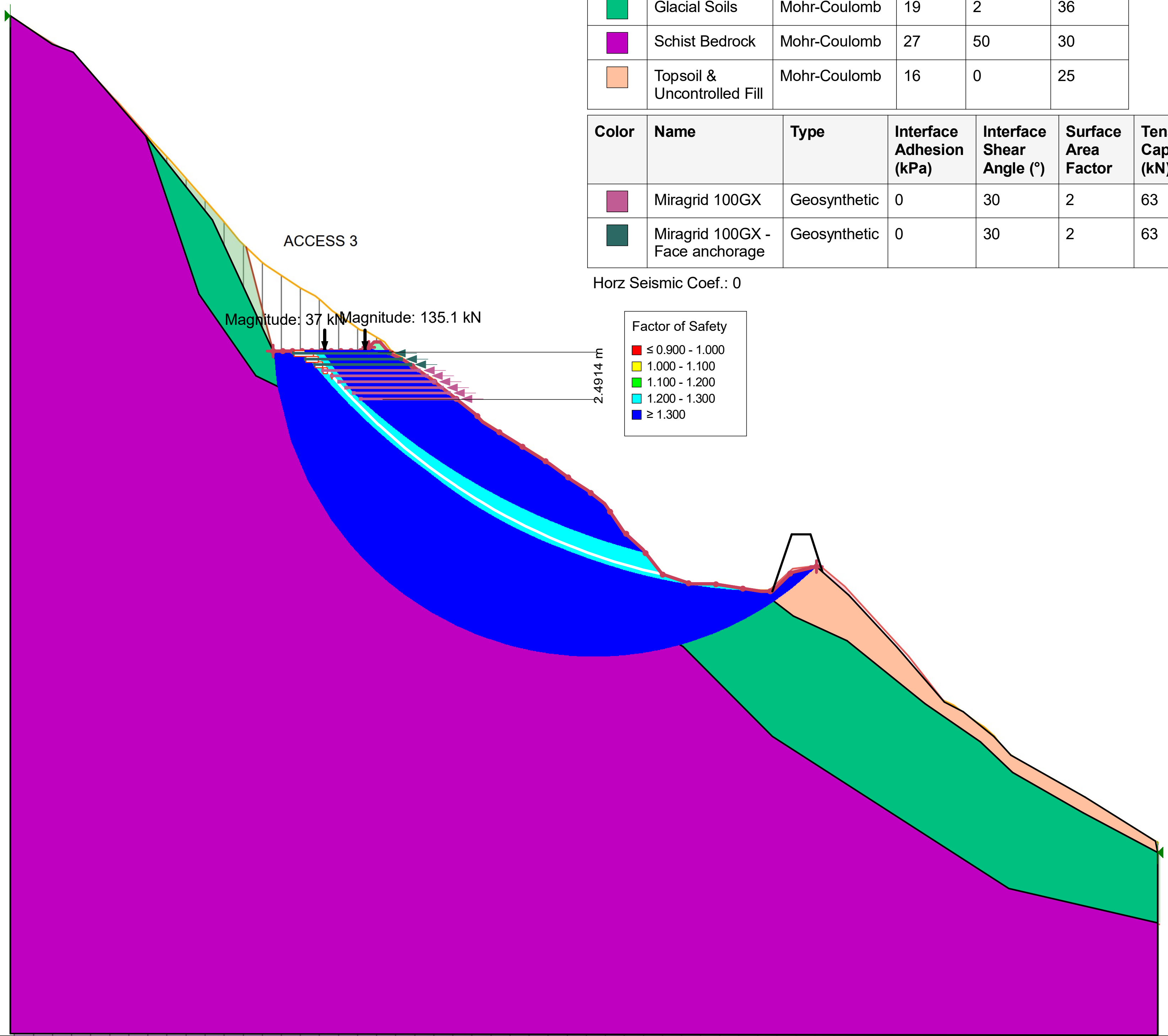
EXISTING GROUND LEVEL

OVERVIEW SURVEYING

LIDAR FLOWN 23/08/23



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12.00	644.49
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14.00	642.86
15.00	642.20
16.00	641.61
17.00	640.79
18.00	640.10
19.00	639.62
20.00	638.77
21.00	638.09
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24.00	635.64
25.00	634.96
26.00	634.27
27.00	633.72
28.00	633.06
29.00	632.30
30.00	631.68
31.00	630.78
32.00	629.44
33.00	628.44
34.00	627.16
35.00	626.79
36.00	626.67
37.00	626.60
38.00	626.43
39.00	626.39
40.00	626.39
41.00	626.46
42.00	626.36
43.00	625.84
44.00	624.84
45.00	623.76
46.00	622.88
47.00	621.83
48.00	621.09
49.00	620.48
50.00	619.79
51.00	619.10
52.00	617.92
53.00	617.25
54.00	616.61
55.00	616.10
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57.00	614.88
58.00	614.24
59.00	613.68
60.00	613.15

SCALE 1:250 HORIZ
1:250 VERT

User: sm

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2. Static - Geogrid GX100 - 0.3

-Material Removal Zone - Final.gsz

gger

25/06/2024

1:282

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Engineered Fill	Mohr-Coulomb	19	0	34
	Glacial Soils	Mohr-Coulomb	19	2	36
	Schist Bedrock	Mohr-Coulomb	27	50	30
	Topsoil & Uncontrolled Fill	Mohr-Coulomb	16	0	25

Color	Name	Type	Interface Adhesion (kPa)	Interface Shear Angle (°)	Surface Area Factor	Tensile Capacity (kN)
	Miragrid 100GX	Geosynthetic	0	30	2	63
	Miragrid 100GX - Face anchorage	Geosynthetic	0	30	2	63

Horz Seismic Coef.: 0

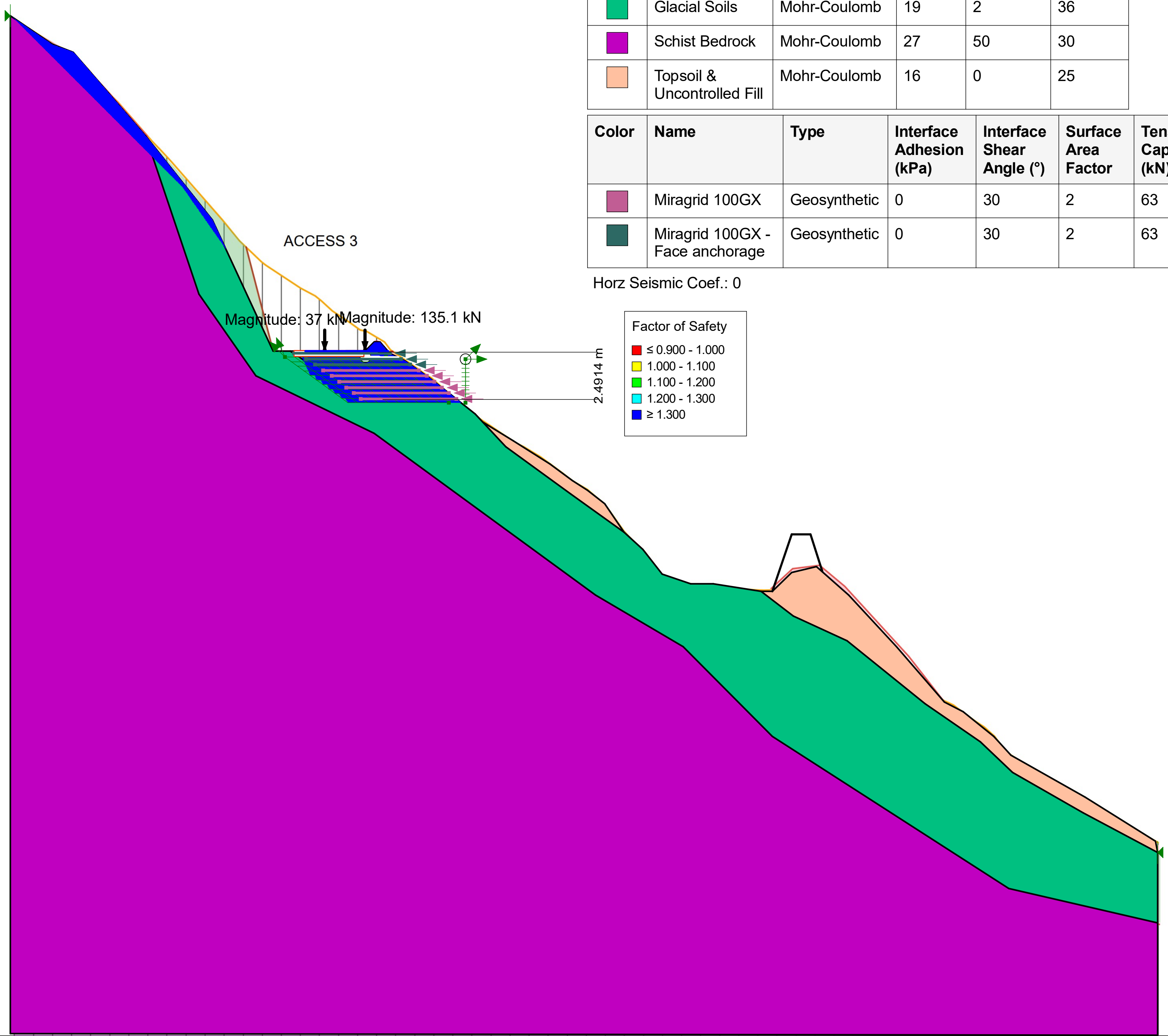
LEGEND

DESIGN LEVEL

EXISTING GROUND LEVEL

OVERVIEW SURVEYING

LIDAR FLOWN 23/08/23



DATUM R.L.603.00

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59.00	613.68
60.00	613.15

SCALE 1:250 HORIZ
1:250 VERT

User: sm

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2. Static - Geogrid GX60 - 0.3 … e Stagger

Material Removal Zone - Final.gsz

Filename: C:\12dS\data\QTSVR01\Q4115 - Skyline Queenstown Red

25/06/2024

1:282

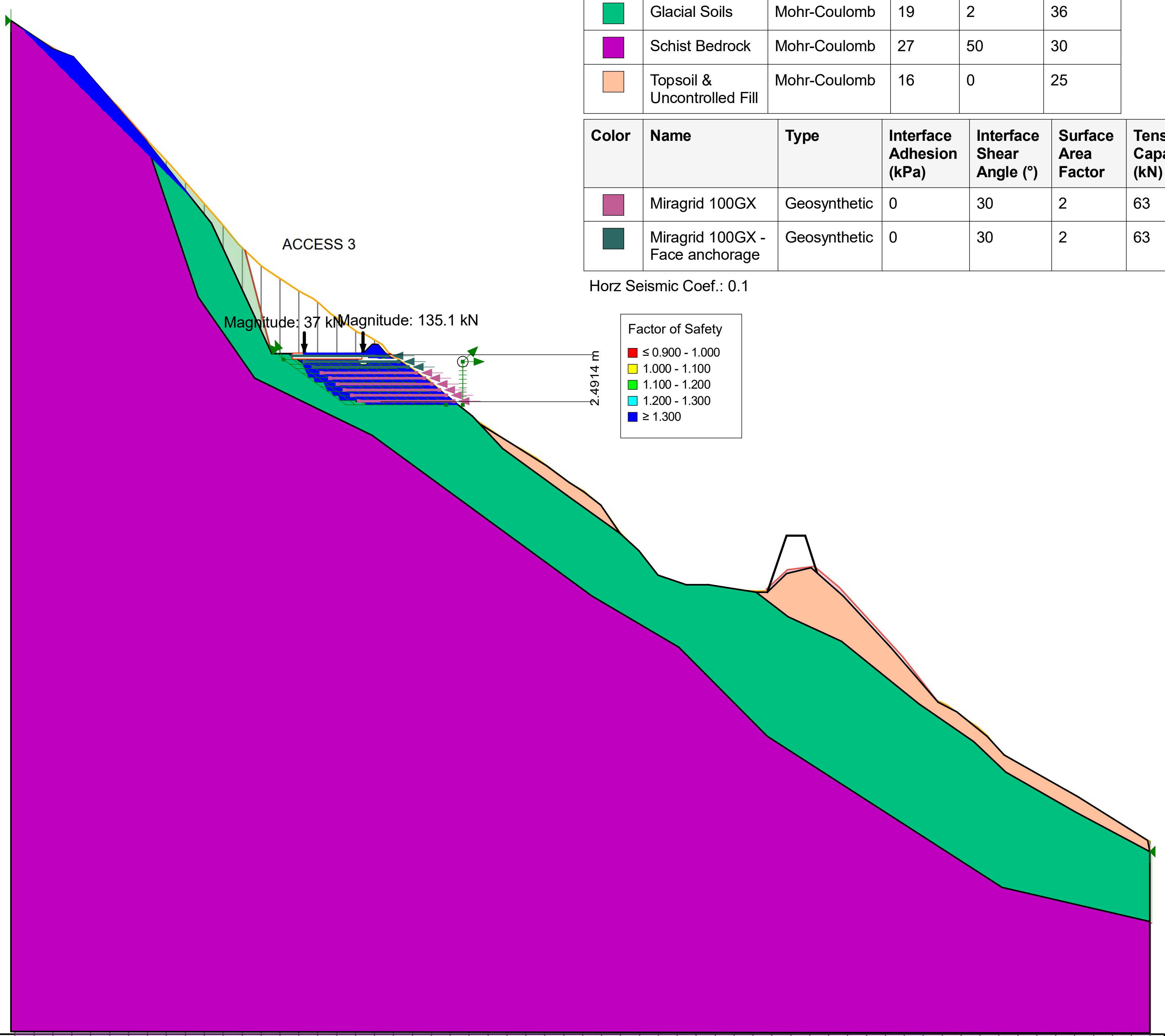
Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Engineered Fill	Mohr-Coulomb	19	0	34
	Glacial Soils	Mohr-Coulomb	19	2	36
	Schist Bedrock	Mohr-Coulomb	27	50	30
	Topsoil & Uncontrolled Fill	Mohr-Coulomb	16	0	25

Color	Name	Type	Interface Adhesion (kPa)	Interface Shear Angle (°)	Surface Area Factor	Tensile Capacity (kN)
	Miragrid 100GX	Geosynthetic	0	30	2	63
	Miragrid 100GX - Face anchorage	Geosynthetic	0	30	2	63

Horz Seismic Coef.: 0.1

LEGEND
- DESIGN LEVEL
- EXISTING GROUND LEVEL

OVERVIEW SURVEYING
LIDAR FLOWN 23/08/23



DATUM R.L.603.00

AUG 2023 LIDAR LEVEL	656.30	655.64	655.01	654.51	653.49	652.35	651.29	650.15	649.07	647.94	646.81	645.66	644.49	643.55	642.86
CHAINAGE	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00

AUG 2023 LIDAR LEVEL	642.20	641.61	640.79	640.10	639.62	638.77	638.09	637.39	636.48	635.64	634.96	634.27	633.72	633.06	632.30
CHAINAGE	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00	26.00	27.00	28.00	29.00

AUG 2023 LIDAR LEVEL	631.68	630.78	629.44	628.44	627.16	626.79	626.67	626.60	626.43	626.39	626.39	626.46	626.36	625.84	624.84
CHAINAGE	30.00	31.00	32.00	33.00	34.00	35.00	36.00	37.00	38.00	39.00	40.00	41.00	42.00	43.00	44.00

AUG 2023 LIDAR LEVEL	623.76	622.88	621.83	621.09	620.48	619.79	619.10	617.92	617.25	616.61	616.10	615.59	614.88	614.24	613.68	613.15
CHAINAGE	45.00	46.00	47.00	48.00	49.00	50.00	51.00	52.00	53.00	54.00	55.00	56.00	57.00	58.00	59.00	60.00

SCALE 1:250 HORIZ
1:250 VERT

User: sm

Printed: 2024-05-27 08:51:37

3. SLS - GX100 - Block-Material Removal Zone - Final.gsz

25/06/2024

1:282

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Engineered Fill	Mohr-Coulomb	19	0	34
	Glacial Soils	Mohr-Coulomb	19	2	36
	Schist Bedrock	Mohr-Coulomb	27	50	30
	Topsoil & Uncontrolled Fill	Mohr-Coulomb	16	0	25

Color	Name	Type	Interface Adhesion (kPa)	Interface Shear Angle (°)	Surface Area Factor	Tensile Capacity (kN)
	Miragrid 100GX	Geosynthetic	0	30	2	63
	Miragrid 100GX - Face anchorage	Geosynthetic	0	30	2	63

Horz Seismic Coef.: 0.1

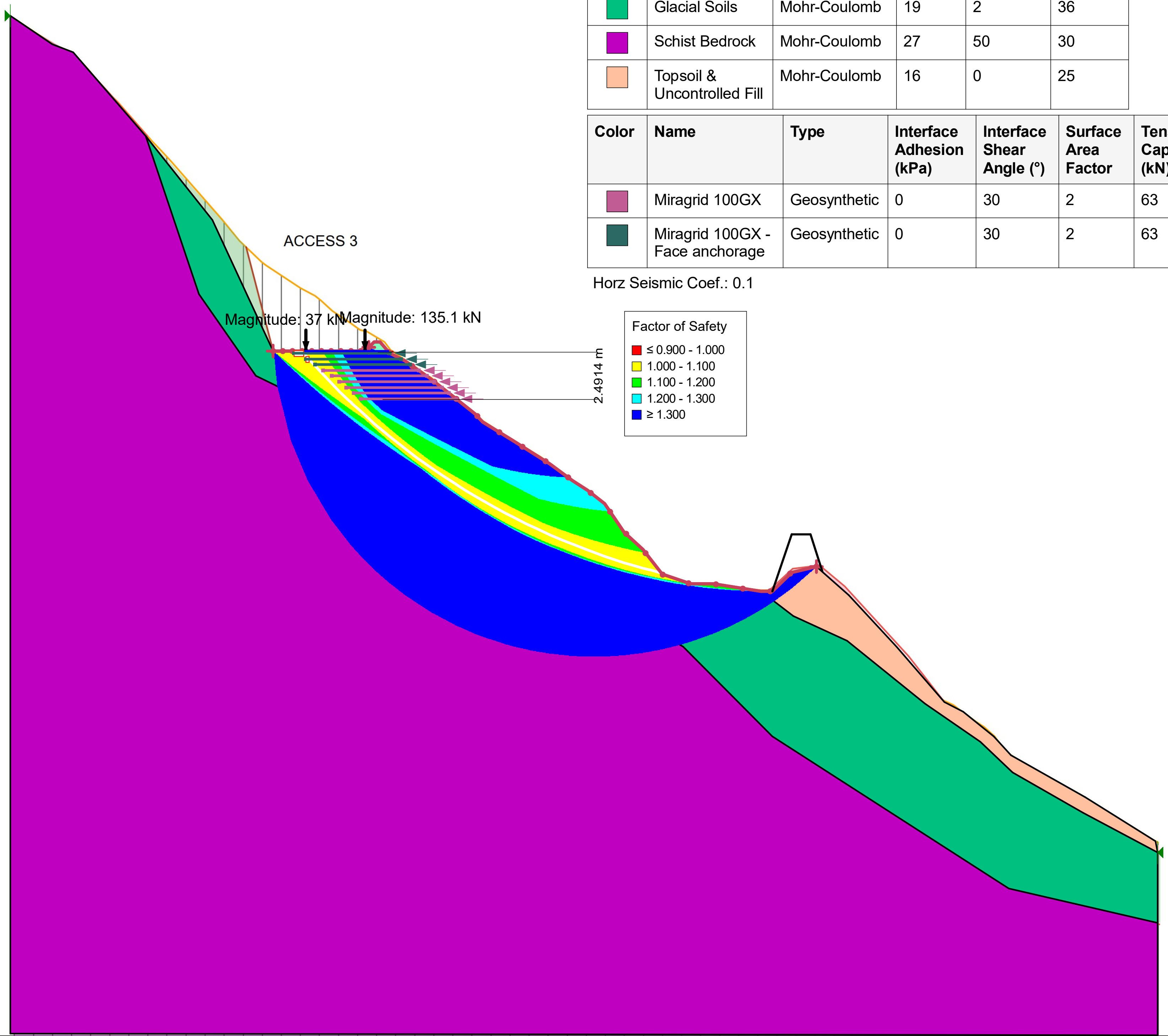
LEGEND

DESIGN LEVEL

EXISTING GROUND LEVEL

OVERVIEW SURVEYING

LIDAR FLOWN 23/08/23



DATUM R.L.603.00

CHAINAGE	AUG 2023 LIDAR LEVEL
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2.00	655.01
3.00	654.51
4.00	653.49
5.00	652.35
6.00	651.29
7.00	650.15
8.00	649.07
9.00	647.94
10.00	646.81
11.00	645.66
12.00	644.49
13.00	643.55
14.00	642.86
15.00	642.20
16.00	641.61
17.00	640.79
18.00	640.10
19.00	639.62
20.00	638.77
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50.00	619.79
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56.00	615.59
57.00	614.88
58.00	614.24
59.00	613.68
60.00	613.15

SCALE 1:250 HORIZ
1:250 VERT

User: sm

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3. SLS - GX100 - Circular

Material Removal Zone - Final.gsz

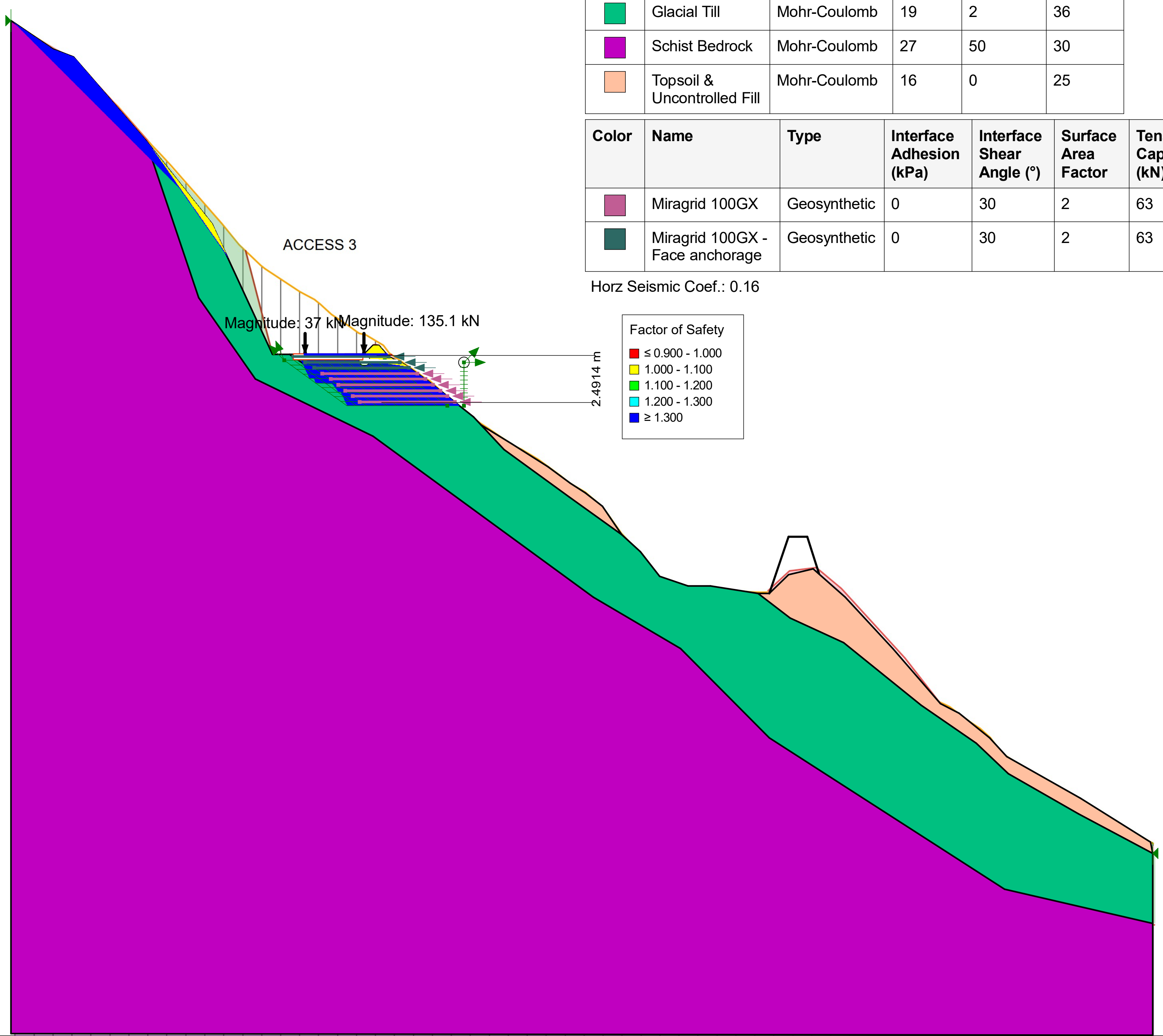
25/06/2024

1:282

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Engineered Fill	Mohr-Coulomb	19	0	34
	Glacial Till	Mohr-Coulomb	19	2	36
	Schist Bedrock	Mohr-Coulomb	27	50	30
	Topsoil & Uncontrolled Fill	Mohr-Coulomb	16	0	25

Color	Name	Type	Interface Adhesion (kPa)	Interface Shear Angle (°)	Surface Area Factor	Tensile Capacity (kN)
	Miragrid 100GX	Geosynthetic	0	30	2	63
	Miragrid 100GX - Face anchorage	Geosynthetic	0	30	2	63

Horz Seismic Coef.: 0.16



LEGEND

- DESIGN LEVEL
- EXISTING GROUND LEVEL
- OVERVIEW SURVEYING
- LIDAR FLOWN 23/08/23

DATUM R.L.603.00

AUG 2023 LIDAR LEVEL	656.30	655.64	655.01	654.51	653.49	652.35	651.29	650.15	649.07	647.94	646.81	645.66	644.49	643.55	642.86	642.20	641.61	640.79	640.10	639.62	638.77	638.09	637.39	636.48	635.64	634.96	634.27	633.72	633.06	632.30	631.68	630.78	629.44	628.44	627.16	626.79	626.67	626.60	626.43	626.39	626.39	626.46	626.36	625.84	624.84	623.76	622.88	621.83	621.09	620.48	619.79	619.10	617.92	617.25	616.61	616.10	615.59	614.88	614.24	613.68	613.15
CHAINAGE	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00	26.00	27.00	28.00	29.00	30.00	31.00	32.00	33.00	34.00	35.00	36.00	37.00	38.00	39.00	40.00	41.00	42.00	43.00	44.00	45.00	46.00	47.00	48.00	49.00	50.00	51.00	52.00	53.00	54.00	55.00	56.00	57.00	58.00	59.00	60.00

SCALE 1:250 HORIZ
1:250 VERT

User: sm

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4. Yield - GX100 - Block
-Material Removal Zone - Final.gsz

25/06/2024

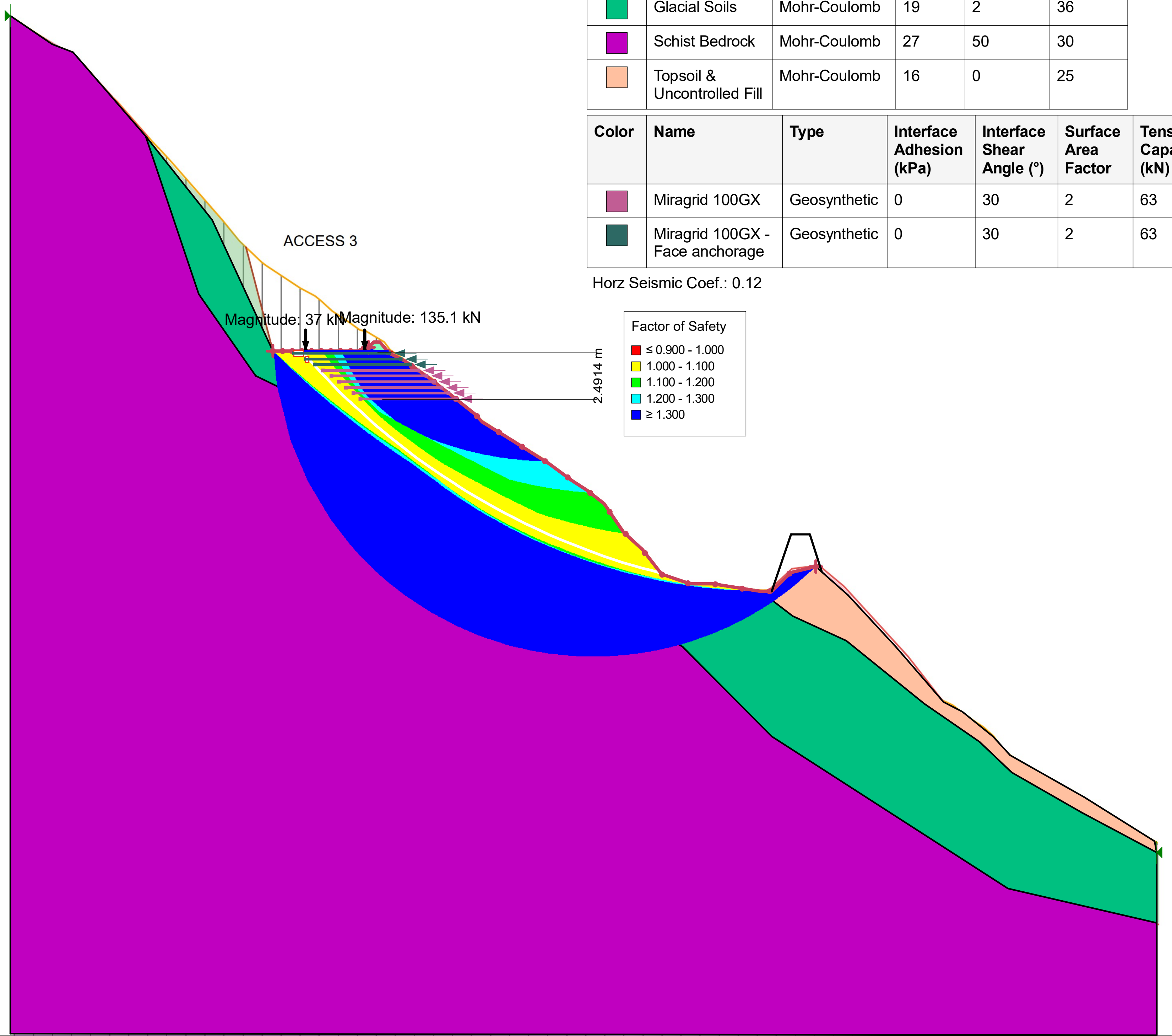
1:282

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Engineered Fill	Mohr-Coulomb	19	0	34
	Glacial Soils	Mohr-Coulomb	19	2	36
	Schist Bedrock	Mohr-Coulomb	27	50	30
	Topsoil & Uncontrolled Fill	Mohr-Coulomb	16	0	25

Color	Name	Type	Interface Adhesion (kPa)	Interface Shear Angle (°)	Surface Area Factor	Tensile Capacity (kN)
	Miragrid 100GX	Geosynthetic	0	30	2	63
	Miragrid 100GX - Face anchorage	Geosynthetic	0	30	2	63

Horz Seismic Coef.: 0.12

LEGEND
- DESIGN LEVEL
- EXISTING GROUND LEVEL
- OVERVIEW SURVEYING
- LIDAR FLOWN 23/08/23



DATUM R.L.603.00

CHAINAGE	AUG 2023 LIDAR LEVEL
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3.00	654.51
4.00	653.49
5.00	652.35
6.00	651.29
7.00	650.15
8.00	649.07
9.00	647.94
10.00	646.81
11.00	645.66
12.00	644.49
13.00	643.55
14.00	642.86
15.00	642.20
16.00	641.61
17.00	640.79
18.00	640.10
19.00	639.62
20.00	638.77
21.00	638.09
22.00	637.39
23.00	636.48
24.00	635.64
25.00	634.96
26.00	634.27
27.00	633.72
28.00	633.06
29.00	632.30
30.00	631.68
31.00	630.78
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44.00	624.84
45.00	623.76
46.00	622.88
47.00	621.83
48.00	621.09
49.00	620.48
50.00	619.79
51.00	619.10
52.00	617.92
53.00	617.25
54.00	616.61
55.00	616.10
56.00	615.59
57.00	614.88
58.00	614.24
59.00	613.68
60.00	613.15

SCALE 1:250 HORIZ
1:250 VERT

4. Yield - GX100 - Circular

Material Removal Zone - Final

25/06/2024

1:282

User: sm

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SEISMIC DISPLACEMENT ESTIMATION - JIBSON (2007)

References

Jibson, W. (2007) "Regression models for estimating cosesimic landslide displacement"

Parameters

Yield acceleration coefficient, ky:	Just the coefficients in terms of g, do not include the g term.	$k_y := 0.12$
Maximum acceleration coefficient, kmax:		$k_{max} := 0.31$
Moment Magnitude, M:		$M := 6.5$

Check input parameters

Check ky/kmax is within valid range:

$$Check := \begin{cases} \text{if } 0.05 \le \frac{k_y}{k_{max}} \le 0.95 \\ \quad \text{"OK: ky/kmax in valid range"} \\ \text{also if } \frac{k_y}{k_{max}} > 0.95 \\ \quad \text{"Negligible displacement expected"} \\ \text{else} \\ \quad \text{"ERROR: ky/kmax outside valid range"} \end{cases}$$

$Check = ?$

Equations

Yield acceleration ratio, Ry:

$$R_y := \frac{k_y}{k_{max}} \qquad R_y = 0.387$$

Peak ground acceleration, Apeak:

$$A_{peak} := k_{max} \cdot g \qquad A_{peak} = 0.31\ g$$

Permanent ground displacement, d:

$$D_{N\_Lwr}(M, R_y) := 10^{\left(-2.710 + \log\left(\left(1 - R_y\right)^{2.335} \cdot \left(R_y\right)^{-1.478}\right) + 0.424 \cdot M - 0.454\right)} \cdot cm$$

$$D_{N\_Mean}(M, R_y) := 10^{\left(-2.710 + \log\left(\left(1 - R_y\right)^{2.335} \cdot \left(R_y\right)^{-1.478}\right) + 0.424 \cdot M\right)} \cdot cm$$

$$D_{N\_Upr}(M, R_y) := 10^{\left(-2.710 + \log\left(\left(1 - R_y\right)^{2.335} \cdot \left(R_y\right)^{-1.478}\right) + 0.424 \cdot M + 0.454\right)} \cdot cm$$

Results

For input parameters

$k_y = 0.12$

$k_{max} = 0.31$

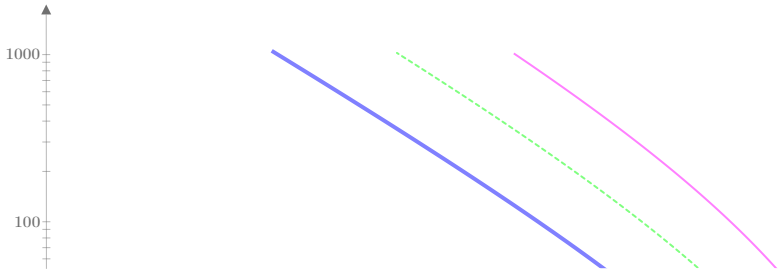
$\frac{k_y}{k_{max}} = 0.387$

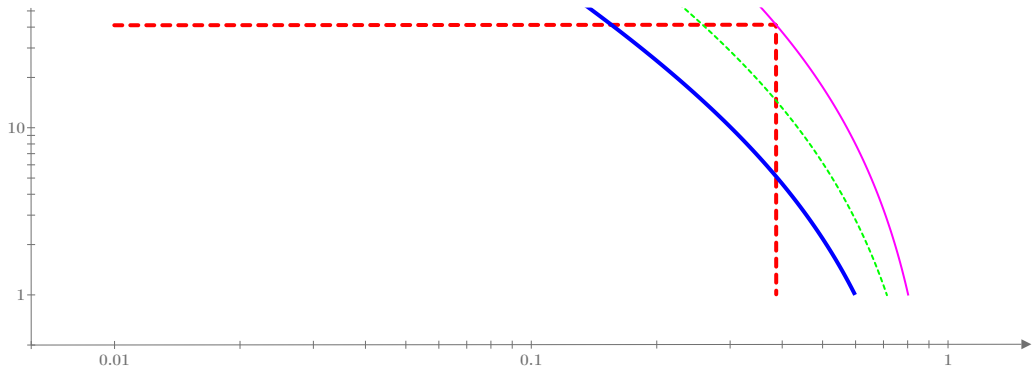
Estimated permanent displacement, d:

$D_{N\_Lwr}(M, R_y) = 5\ mm$

$D_{N\_Mean}(M, R_y) = 14\ mm$

$D_{N\_Upr}(M, R_y) = 41\ mm$




10
1
0.01
0.1
1

Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)
	Engineered Fill	19	1
	Glacial Till	19	2
	Schist Bedrock	27	50
	Topsoil & Uncontrolled Fill	16	0

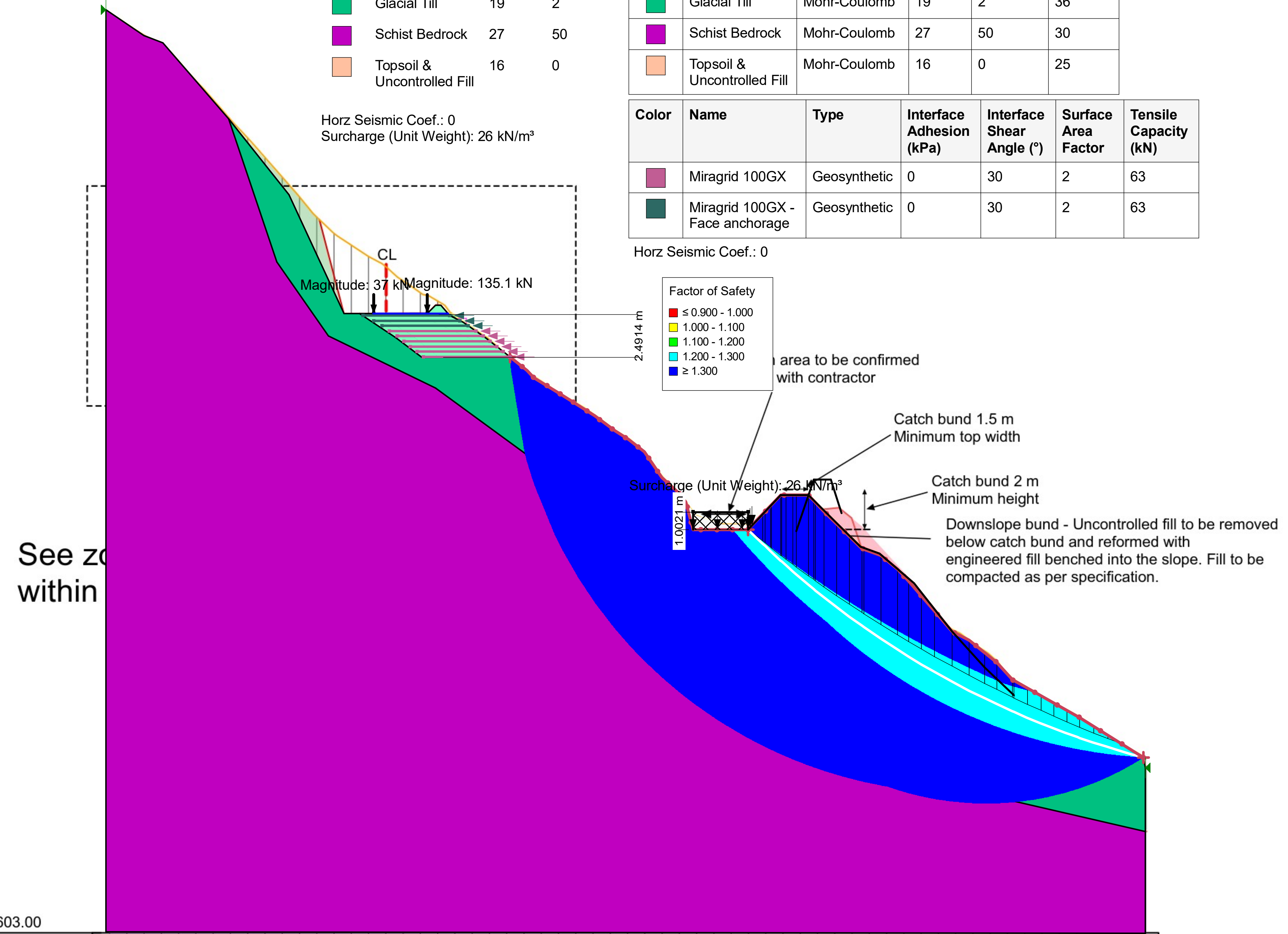
Horz Seismic Coef.: 0
Surcharge (Unit Weight): 26 kN/m³

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Engineered Fill	Mohr-Coulomb	19	1	34
	Glacial Till	Mohr-Coulomb	19	2	36
	Schist Bedrock	Mohr-Coulomb	27	50	30
	Topsoil & Uncontrolled Fill	Mohr-Coulomb	16	0	25

Color	Name	Type	Interface Adhesion (kPa)	Interface Shear Angle (°)	Surface Area Factor	Tensile Capacity (kN)
	Miragrid 100GX	Geosynthetic	0	30	2	63
	Miragrid 100GX - Face anchorage	Geosynthetic	0	30	2	63

Horz Seismic Coef.: 0

LEGEND
DESIGN LEVEL
EXISTING GROUND LEVEL
OVERVIEW SURVEYING
LIDAR FLOWN 23/08/23



DATUM R.L.603.00

CHAINAGE	AUG 2023 LIDAR LEVEL
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4.00	653.49
5.00	652.35
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9.00	647.94
10.00	646.81
11.00	645.66
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16.00	641.61
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56.00	615.59
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59.00	613.68
60.00	613.15

250
10 12.5 (m)

DESIGNED :	MDP	Jun.24
DRAWN :	MDP	Jun.24
DESIGN CHECKED :	CEM	Jun.24
DRAFTING CHECKED :	CEM	Jun.24
CADFILE :		
APPROVED : CEMacdonald		26/06/2024

Notes:
1. These drawings have been prepared for the benefit of Skyline Enterprises Limited with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.
2. Drawings to be read in conjunction with GeoSolve's specification and design report

GEOSOLVE
Level 1, 70 MacAndrew Road, South Dunedin

CLIENT, PROJECT
Skyline Enterprises Ltd
Material Removal Access Track
TITLE
Material Removal Zone Design
Section 1

1. Static Inside Edge
Catch Bund.gsz
05/07/2024
1:282

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CREATION RESERVE

Title:
VERS DEBRIS REMOVAL
ORARY STOCKPILE AREA
SECTION 3 OF 5

R CONSTRUCTION

AWJ	Original Size: A3	Scale: 1:250	
SAM			
SAM			
SAM		DO NOT SCALE	
Drawing No: 7-6-2	Sheet No: 3/3	Revision No: E	Date: 23/05/2024

ngs\1 - DWG\04 - Rehab Areas\Q4115-7-6-2 Debris RC LS&XS.dwg

Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)
	Engineered Fill	19	1
	Glacial Till	19	2
	Schist Bedrock	27	50
	Topsoil & Uncontrolled Fill	16	0

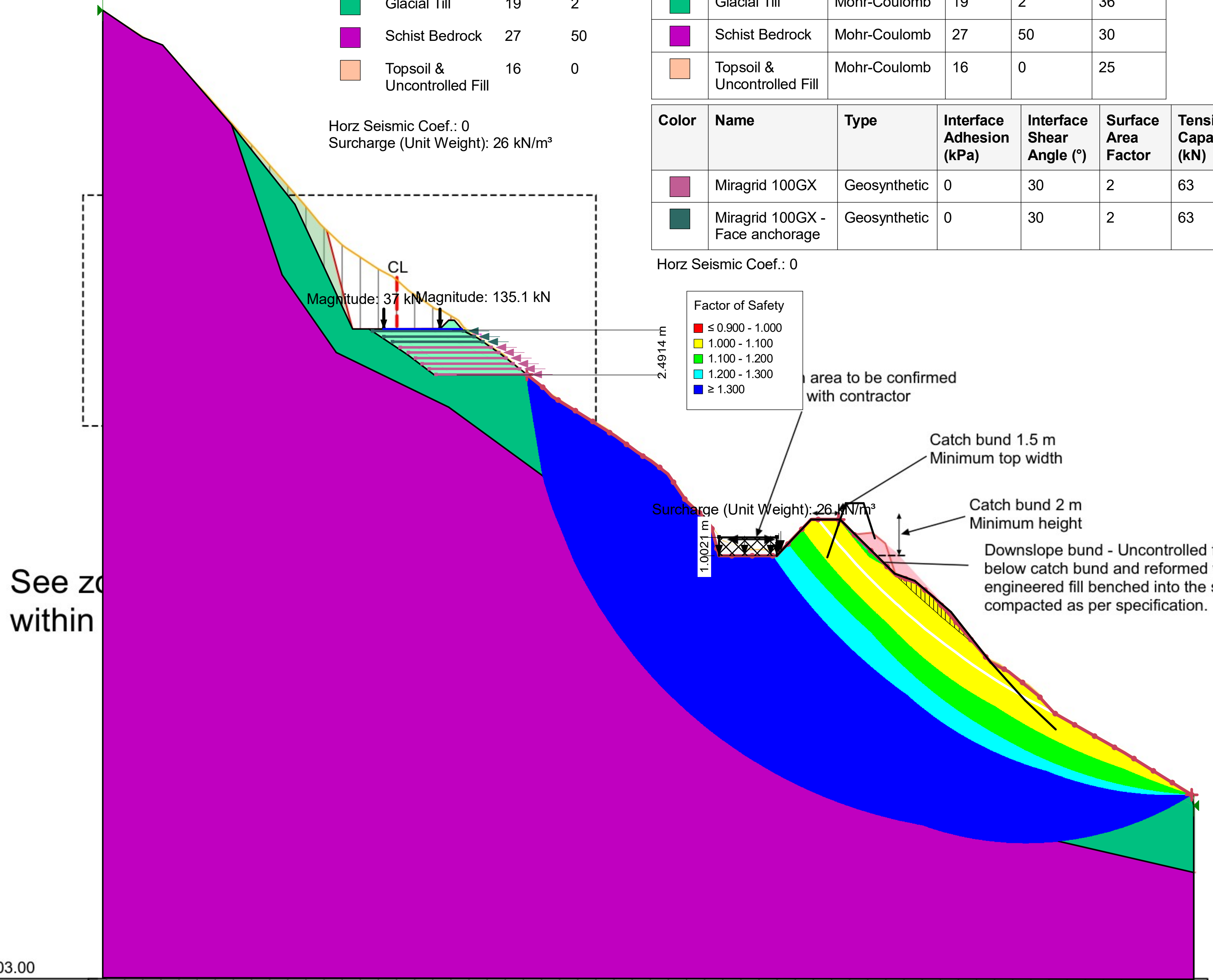
Horz Seismic Coef.: 0
Surcharge (Unit Weight): 26 kN/m³

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Engineered Fill	Mohr-Coulomb	19	1	34
	Glacial Till	Mohr-Coulomb	19	2	36
	Schist Bedrock	Mohr-Coulomb	27	50	30
	Topsoil & Uncontrolled Fill	Mohr-Coulomb	16	0	25

Color	Name	Type	Interface Adhesion (kPa)	Interface Shear Angle (°)	Surface Area Factor	Tensile Capacity (kN)
	Miragrid 100GX	Geosynthetic	0	30	2	63
	Miragrid 100GX - Face anchorage	Geosynthetic	0	30	2	63

Horz Seismic Coef.: 0

LEGEND
- DESIGN LEVEL
- EXISTING GROUND LEVEL
- OVERVIEW SURVEYING
- LIDAR FLOWN 23/08/23



DATUM R.L.603.00

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12.00	644.49
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14.00	642.86
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17.00	640.79
18.00	640.10
19.00	639.62
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21.00	638.09
22.00	637.39
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60.00	613.15

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DESIGNED :	MDP	Jun.24
DRAWN :	MDP	Jun.24
DESIGN CHECKED :	CEM	Jun.24
DRAFTING CHECKED :	CEM	Jun.24
CADFILE :		
APPROVED :		26/06/2024

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GEOSOLVE
Level 1, 70 MacAndrew Road, South Dunedin

CLIENT, PROJECT
Skyline Enterprises Ltd
Material Removal Catch Bund

TITLE
Material Removal Zone 1
Section 1

1. Static Outside Edge
Catch Bund.gsz
05/07/2024
1:282

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QLDC BEN LOMOND
CREATION RESERVE

Title:
ERS DEBRIS REMOVAL
ORARY STOCKPILE AREA
SECTION 3 OF 5

R CONSTRUCTION

AWJ / SAM / SAM / SAM	Original Size: A3	Scale: 1:250	
Drawing No: 7-6-2	Sheet No: 373	Revision No: E	Date: 23/05/2024

DO NOT SCALE

Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)
	Engineered Fill	19	1
	Glacial Till	19	2
	Schist Bedrock	27	50
	Topsoil & Uncontrolled Fill	16	0

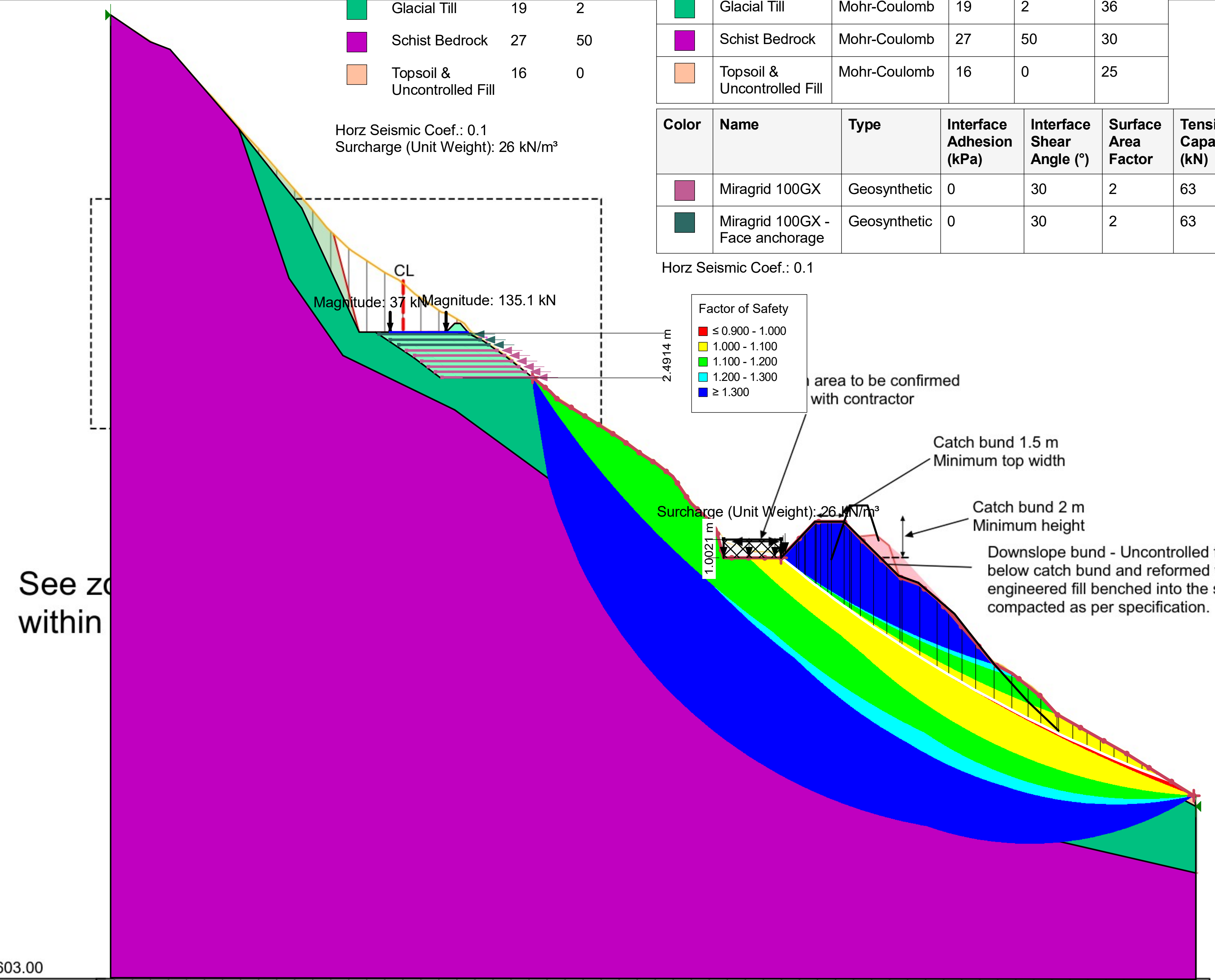
Horz Seismic Coef.: 0.1
Surcharge (Unit Weight): 26 kN/m³

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Engineered Fill	Mohr-Coulomb	19	1	34
	Glacial Till	Mohr-Coulomb	19	2	36
	Schist Bedrock	Mohr-Coulomb	27	50	30
	Topsoil & Uncontrolled Fill	Mohr-Coulomb	16	0	25

Color	Name	Type	Interface Adhesion (kPa)	Interface Shear Angle (°)	Surface Area Factor	Tensile Capacity (kN)
	Miragrid 100GX	Geosynthetic	0	30	2	63
	Miragrid 100GX - Face anchorage	Geosynthetic	0	30	2	63

Horz Seismic Coef.: 0.1

LEGEND
DESIGN LEVEL
EXISTING GROUND LEVEL
OVERVIEW SURVEYING
LIDAR FLOWN 23/08/23



DATUM R.L.603.00

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54.00	616.61
55.00	616.10
56.00	615.59
57.00	614.88
58.00	614.24
59.00	613.68
60.00	613.15

250
10 12.5 (m)

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Title:
VERS DEBRIS REMOVAL
ORARY STOCKPILE AREA
SECTION 3 OF 5

R CONSTRUCTION

DESIGNED :	MDP	Jun.24
DRAWN :	MDP	Jun.24
DESIGN CHECKED :	CEM	Jun.24
DRAFTING CHECKED :	CEM	Jun.24
CADFILE :		
APPROVED :		26/06/2024

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GEOSOLVE
Level 1, 70 MacAndrew Road, South Dunedin

CLIENT, PROJECT
Skyline Enterprises Ltd
Material Removal Access Track
TITLE
Material Removal Zone 7 Section 1

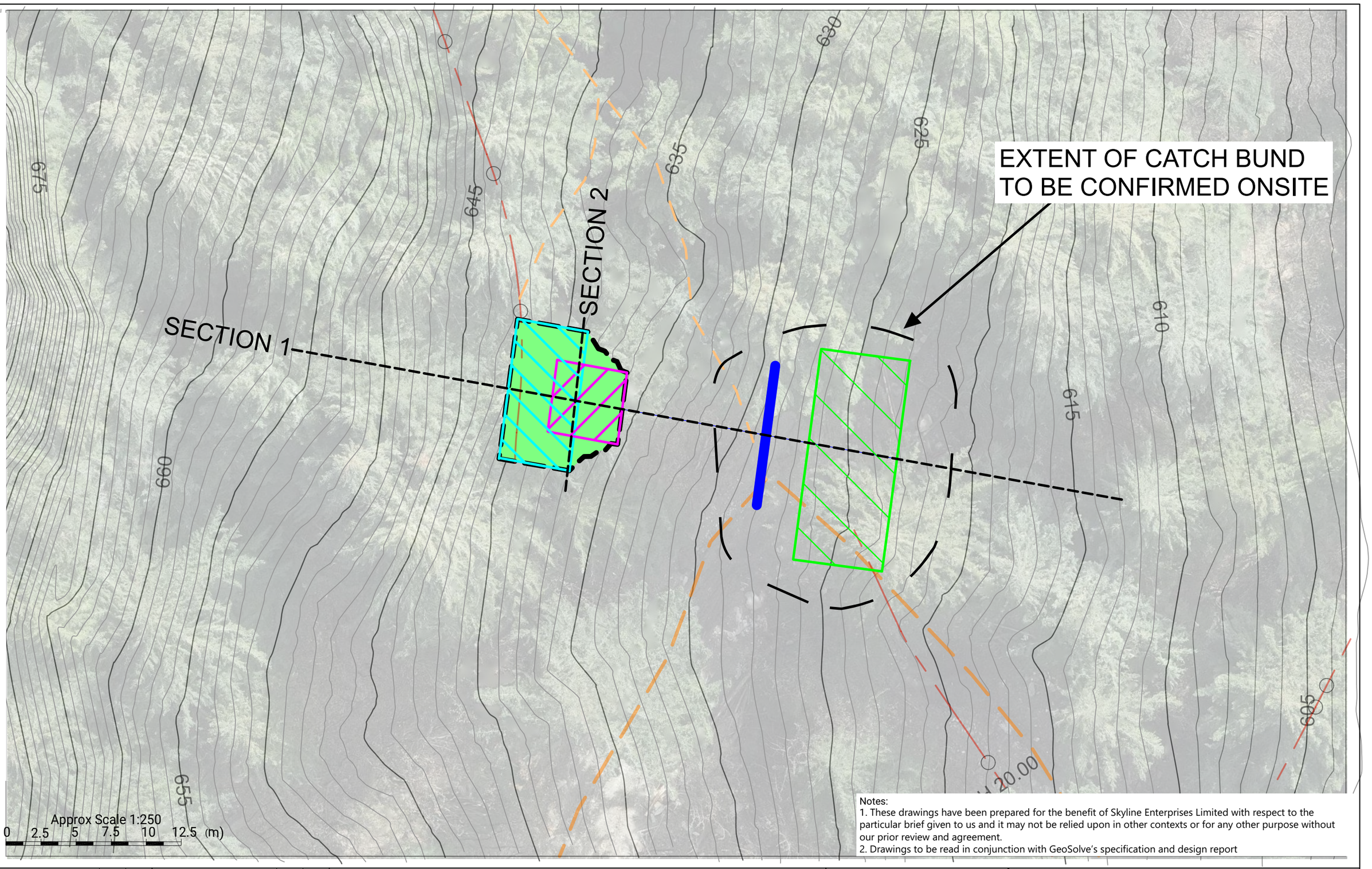
2. SLS Inside Edge
Catch Bund.gsz
05/07/2024
1:282

Original Size:	Scale:
A3	1:250

DO NOT SCALE

Drawing No:	Sheet No:	Revision No:	Date:
7-6-2	373	E	23/05/2024

Appendix D – Construction Drawings



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REVISION	DESCRIPTION	BY	DATE
0	FOR CONSTRUCTION	MDP	Jul.24

DESIGNED :	MDP	Jul.24
DRAWN :	MDP	Jul.24
DESIGN CHECKED :	CEM	Jul.24
DRAFTING CHECKED :	CEM	Jul.24
CADFILE :		
APPROVED :		05/07/2024

This drawing is not to be used for construction purposes unless signed as approved

KEY
= Geogrid Reinforced Area Extent
= Bottom Geogrid Layer Extent
= Upper Geogrid Layer Extent
= Approx Upslope Extent of Catch Area
= Indicative Bund Extent

REFERENCE :

GEOSOLVE
Level 1, 70 MacAndrew Road, South Dunedin
www.geosolve.co.nz

CLIENT, PROJECT
Skyline Enterprises Ltd
Material Removal Access Track

TITLE
Material Removal Zone Design
Site Plan

SCALES (AT A3 SIZE)	DWG. No.	REV.
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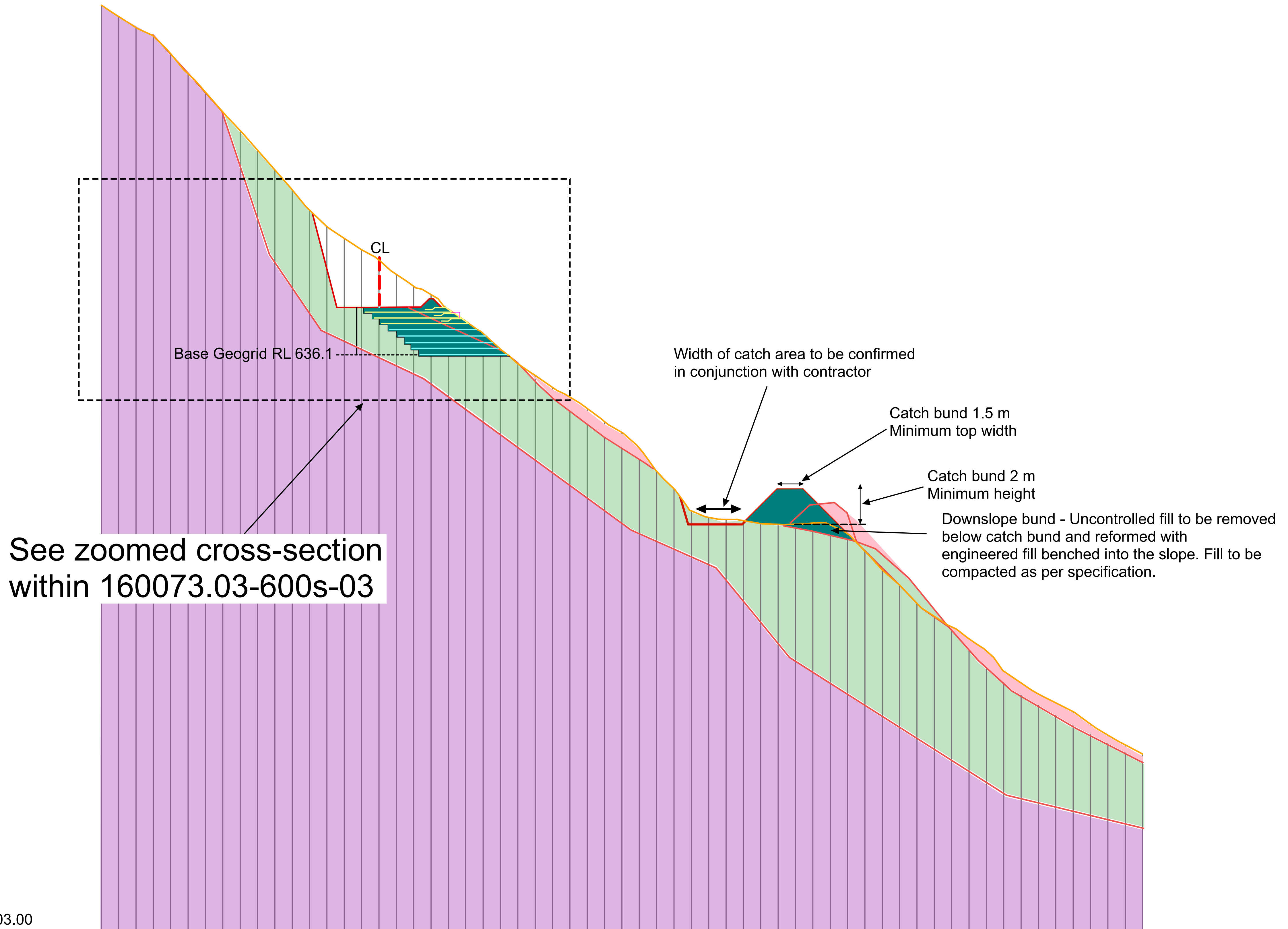

DATUM R.L.603.00

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CHAINAGE	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00

AUG 2023 LIDAR LEVEL	641.61	640.79	640.10	639.62	638.77	638.09	637.39	636.48	635.64	634.96	634.27	633.72	633.06	632.30	631.68	630.78
CHAINAGE	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00	25.00	26.00	27.00	28.00	29.00	30.00	31.00

AUG 2023 LIDAR LEVEL	629.44	628.44	627.16	626.79	626.67	626.60	626.43	626.39	626.39	626.46	626.36	625.84	624.84	623.76	622.88
CHAINAGE	32.00	33.00	34.00	35.00	36.00	37.00	38.00	39.00	40.00	41.00	42.00	43.00	44.00	45.00	46.00

AUG 2023 LIDAR LEVEL	621.83	621.09	620.48	619.79	619.10	617.92	617.25	616.61	616.10	615.59	614.88	614.24	613.68	613.15
CHAINAGE	47.00	48.00	49.00	50.00	51.00	52.00	53.00	54.00	55.00	56.00	57.00	58.00	59.00	60.00

Approx Scale 1:250
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0	FOR CONSTRUCTION	MDP	Jul.24	DESIGNED :	MDP	Jul.24
	REVISION DESCRIPTION	BY	DATE	DRAWN :	MDP	Jul.24
				DESIGN CHECKED :	CEM	Jul.24
				DRAFTING CHECKED :	CEM	Jul.24
				CADFILE :		
				APPROVED :		5/07/2024

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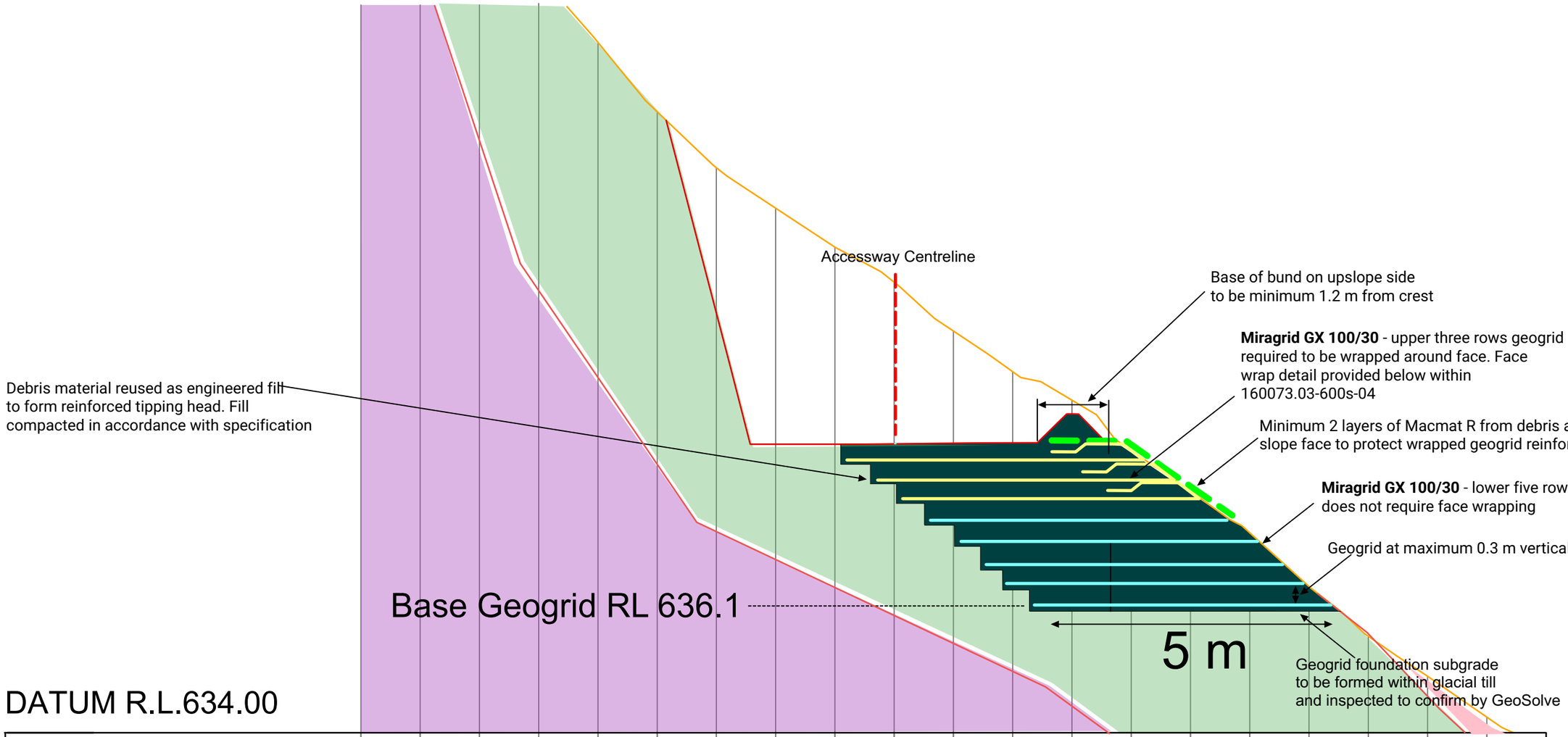
REFERENCE :

GEOSOLVE
Level 1, 70 MacAndrew Road, South Dunedin
www.geosolve.co.nz

CLIENT, PROJECT
Skyline Enterprises Ltd
Material Removal Access Track

TITLE
Material Removal Zone Design
Section 1

SCALES (AT A3 SIZE): 1:250
DWG. No.: 160073.03-600s-02
REV.: 0



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DRAWN :	MDP	Jul.24	
DESIGN CHECKED :	CEM	Jul.24	
DRAFTING CHECKED :	CEM	Jul.24	
CADFILE :			
APPROVED :		05/07/2024	

0	FOR CONSTRUCTION	MDP	Jul.24
REVISION DESCRIPTION		BY	DATE

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REFERENCE :

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Level 1, 70 MacAndrew Road, South Dunedin
www.geosolve.co.nz

CLIENT, PROJECT
Skyline Enterprises Ltd
Material Removal Access Track

TITLE
Material Removal Zone Design
Zoomed Section 1

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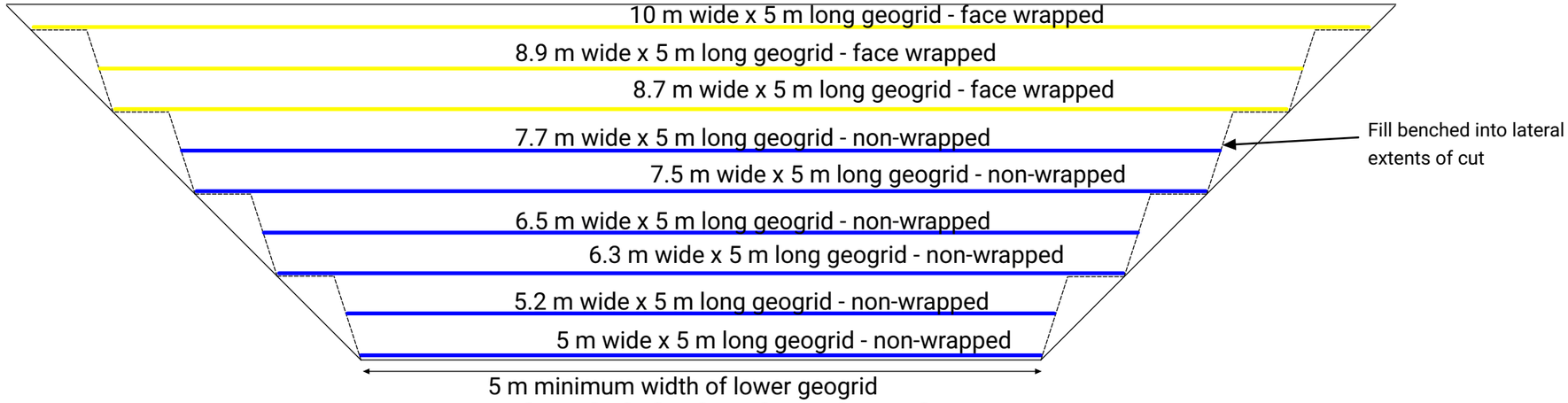
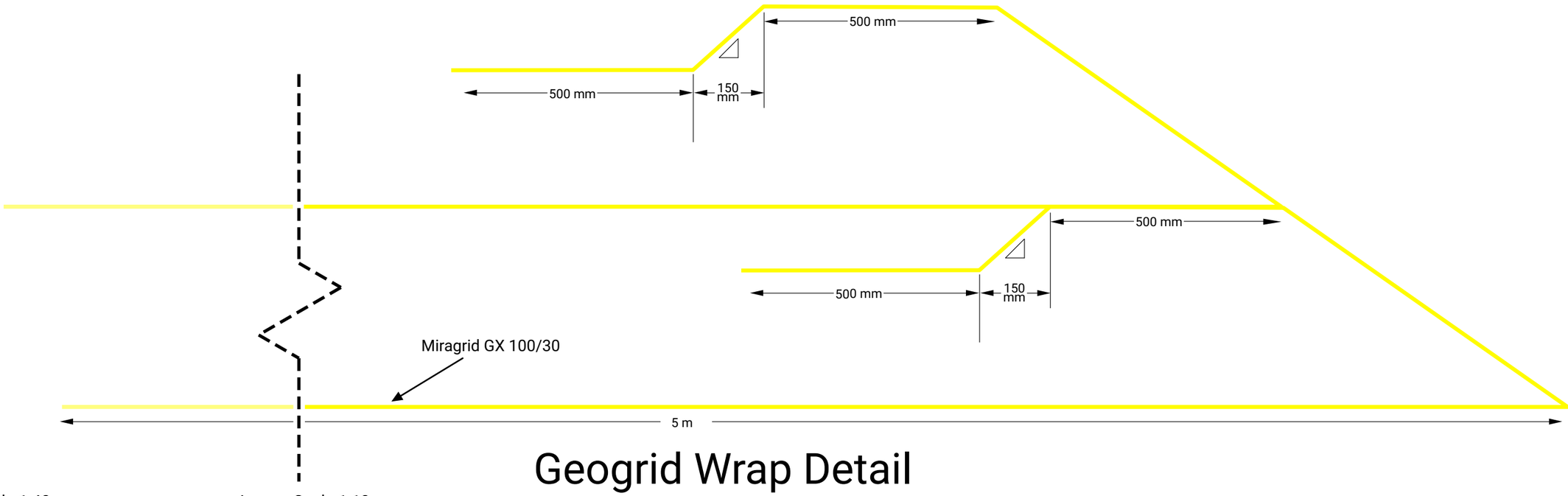


CROSS-SECTION 2

SCALE 1:40



Geogrid Wrap Detail

SCALE 1:10

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Approx Scale 1:10
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0	FOR CONSTRUCTION	MDP	Jul.24
REVISION DESCRIPTION		BY	DATE

DESIGNED :	MDP	Jul.24
DRAWN :	MDP	Jul.24
DESIGN CHECKED :	CEM	Jul.24
DRAFTING CHECKED :	CEM	Jul.24
CADFILE :		
APPROVED : 05/07/2024		

REFERENCE :

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2. Drawings to be read in conjunction with GeoSolve's specification and design report

GEOSOLVE
Level 1, 70 MacAndrew Road, South Dunedin
www.geosolve.co.nz

CLIENT, PROJECT
Skyline Enterprises Ltd
Material Removal Access Track

TITLE
Material Removal Zone Design
Section 2 and Geogrid Wrap Detail

SCALES (AT A3 SIZE)	DWG. No.	REV.
1:40 and 1:10	160073.03-600s-04	0

Appendix E – Construction Specification

Geogrid Reinforced Fill Removal Zone Specification

Fill Removal Zone Design,
Skyline, Queenstown

Report prepared for:
Skyline Enterprises Limited

Report prepared by:
GeoSolve Limited

Distribution:
Skyline Enterprises Ltd
GeoSolve Limited (File)

July 2024
GeoSolve Ref: 160073.03-600s

Revision	Issue Date	Purpose	Author	Reviewed
1	27/06/2024	FOR PM REVIEW	MDP	
2	5/07/2024	FOR CONSTRUCTION	MDP	CEM

GEOTECHNICAL WATER RESOURCES PAVEMENTS

Table of Contents

1 Introduction

1.1 Location

The works included within this Specification and associated Drawings refer to the construction of a geogrid stabilised earth embankment and downslope catchment bund as part of the proposed material removal downslope of the upper Skyline development in Queenstown. The embankment is proposed to stabilise the proposed track sufficiently to allow the proposed trucks to complete the proposed material removal task connecting the upper and lower access tracks. The bund is proposed to catch the material on the downslope side of the material removal zone.

Once the fill material reaches the lower access track the fill material will be excavated out and loaded onto a subsequent truck on continued to be transported downslope.

1.2 General

A Schedule of Drawings (Appendix A) is attached to give the layout and details of various elements necessary for the Works described herein. Note that revisions to Drawings and Design may be issued over time.

The contractor should satisfy themselves that they have provided an accurate estimate of construction costs and wholly understand what is required for the programmed works.

1.3 Role Definitions

The following definitions apply:

Principal – Owner of the works to be conducted, Skyline Enterprises Ltd.

Engineer – Design consultant, GeoSolve Ltd, who prepared the design and will conduct technical supervision and provide advice to the Principal and Contractor as required during the construction.

Contractor – Beaver Contractors Ltd, Entity who is to construct the works in accordance with the Drawings and this technical Specification, together with any further instructions that may be issued by the Engineer.

1.4 Scope

The Contractor shall carry out all of the Works defined below in accordance with this Specification and the Drawings. In the event of any contradiction clarification from the Engineer shall be sought.

The Works comprise construction of a mechanically stabilised earth embankment and catch bund, up to approximately 3 m and 2 m in height respectively. This Specification includes but is not limited to:

- Bulk excavations and stockpiling;
- Supply and installation of a Geogrid Reinforced Embankment.
- Construction of an earth catchment bund.

1.5 Related Specification

Construction works performed under this Specification shall:

a) Be carried out in accordance with the latest revisions of the New Zealand Building Code Handbook and Approved Documents (NZBC).
b) Comply with the general requirements of the latest revisions of the following documents:

- NZS 4431 - Code of Practice for Earthfill for Residential Development, 1989
- NZS 4404 - Code of Practice for Urban Land Subdivision, 2004, including TA Amendments
- TNZ F/1 - Earthworks Construction,1997
- Geofabrics Miragrid Installation Guideline

c) Comply with the general requirements of the latest revisions of all other Standards, Specifications and Codes of Practice referenced in these Contract Documents
d) Comply with the specific requirements of this section and the Contract Drawings.

This Specification shall be read in conjunction with the above Standards and documents, which shall be deemed to form part of this Specification. In the event of any requirements of this Specification being at variance with any of the above Standards and documents then the requirements of this Specification take precedent.

1.6 Construction Drawings

The Drawings that form part of this Technical Specification are part of the GeoSolve drawing set as follows:

- Material Removal Zone Design – Site Plan 160073.03-600s-01
- Material Removal Zone Design – Section 1 160073.03-600s-02
- Material Removal Zone Design – Zoomed Section 1 160073.03-600s-03
- Material Removal Zone Design – Section 2 and Geogrid Wrap Detail 160073.03-600s-04

The Contractor shall inform the Engineer immediately of any apparent errors, inconsistencies or omissions in any of the Drawings. The Engineer will respond to any such information within two working Days by means of clarification, confirmation or instruction.

Where there are conflicting requirements between the above drawings and this specification, then Clarification from the Engineer shall be sought.

1.7 Survey and Setting Out

The exact location of the geogrid embankment shall be set out on site in conjunction with the Contractor, Surveyor and Engineer.

The Contractor is fully responsible for ensuring that the proposed works are correctly surveyed and set out, and, that the construction tolerances stipulated in the specification and drawings have been met.

The Contractor shall be responsible for setting out the Contract Works from these initial marks (shown on the drawings) and organisation of all Inspection and Approval.

1.8 Inspection and Approval

The Contractor shall review the consent documentation and shall be wholly responsible for organisation of all QLDC inspections.

In addition to the requirements for inspection contained elsewhere in the contract, GeoSolve will be required to inspect and approve construction of the embankment at the following key stages:

1. **Pre-construction site meeting** *(Joint meeting with the Contractor to discuss identified geotechnical issues, soil water content relative to optimum, compaction methodology, groundwater, drainage, Miragrid construction and downslope bund construction, geogrid installation and set out)*
2. **Upon completion of the excavations** *(To confirm the ground conditions and inspect the subgrade before any fill and geogrids are placed) – inspection required for both the reinforced removal zone area and the bund.*
3. **On site during testing of a trial pad** *(usually formed before or as part of the first layer of fill to prove compaction methodology).*
4. **Upon completion of the Geogrid embankment set out.** *(With respect to this inspection it should be noted that the Contractor is fully responsible for ensuring that the proposed works are correctly surveyed and set out, and, that the construction tolerances stipulated in the specification and drawings have been met).*
5. **Upon completion of three layers of geogrid (i.e. after a 0.6 m depth of fill has been placed)** *(to confirm that the prescribed construction methodology is being followed, that tolerances are being met, and that the embankment is being constructed to a high quality).*
6. **Upon completion of first wrapped geogrid layer** *(to confirm geogrid installed in accordance with supplier guidelines).*
7. **A final inspection of completed Geogrid Embankment.**
8. **A final inspection of completed downslope catch bund.**
9. **At any other time as required by the Engineer.**

The Engineer must be given a minimum of 2 working days' notice of the Contractor's need for a site inspection. Failure to provide adequate notice and/or covering of any works prior to an inspection may mean that these items will be excluded from the Engineer's signoff.

Upon completion of the proposed works, and prior to sign off of the works, the Contractor shall supply GeoSolve with a copy of his Producer Statement (NZS3910 – Form of Producer Statement –Construction) certificate for the as-built works.

The Contractor will be fully and solely liable to the Principal for all costs and consequences arising from:

- His failure to ensure adequate notice for any inspection is provided to the Engineer.
- His failure to ensure all necessary inspections are completed in a timely manner.
- The covering of any works prior to the Engineer confirming all necessary inspections are complete and the inspected works have been approved by the Engineer, and/or,
- His failure to provide the Engineer with a copy of the producer certificate for construction.

The Contractor shall not proceed to any stage of the Works until the Engineer has inspected, approved and where necessary measured the Works at the previous stage (above mentioned as stages 1-8).

The contractor shall not put the material removal zone into service until the geogrid reinforcement and downslope catch bund has been verified to be constructed in accordance with the design documentation provided by GeoSolve.

1.9 Approved Materials

In all cases where plant, materials or equipment of "approved" design or make is required by the terms of the Specification and/or Drawings, the Contractor shall obtain the approval of the Engineer in writing before such plant, materials or equipment is constructed or ordered.

Where the Contract requires the Contractor to work in accordance with a given manufacturer's recommendations or requirements, the Contractor shall contact the manufacturer(s) and/or supplier(s) concerned, ascertain the relevant criteria and where appropriate arrange for the manufacturer's representative to be on Site while the relevant work is undertaken.

In all cases where a particular brand or product is specified, the Contractor may, subject to the approval of the Engineer, and at no additional cost to the Principal, substitute an alternative product or brand of the same kind, size and equal or better quality.

1.10 As-built Drawings

The Contractor shall maintain one full set of drawings at the Site at all times specifically for recording as-built locations and details. One full set of the marked-up drawings shall be supplied to the Engineer by the Contractor on completion of construction with all as-built information marked up legibly in red.

1.11 Existing Services

The Contractor shall be responsible for the location of all services and shall have the services marked out on site by the appropriate utility authorities. The Contractor shall proceed with all due care to avoid disruption to or damage to any of the services or utilities on the Site and shall be responsible for the care of all utilities in accordance with the Conditions of Contract.

1.12 Temporary Stability

The Contractor is responsible for ensuring temporary stability of any excavated slopes, fill slopes or temporary retention implemented during construction.

The contractor may seek advice from the Engineer during construction if required.

The Contractor shall provide temporary support to or shall batter slopes back to ensure stability is maintained.

The Contractor shall provide barriers at the top of cut slopes to ensure protection to the public. The Contractor shall undertake temporary measures to divert stormwater away from all areas of earthworks.

Any slips which, in the opinion of the Engineer, are caused by the construction activities, shall be removed and the affected area made good to the direction of the Engineer at the Contractors cost.

1.13 Cleaning Up and Reinstatement

During the course of construction the Site shall be kept as clean and as tidy as possible, and any damage caused to any property or existing works or services shall be reinstated immediately.

On completion of the Works the Contractor shall remove all temporary access or storage facilities, construction plant and debris and shall leave the Site in a neat and tidy condition throughout to the satisfaction of the Engineer.

1.14 Environmental Considerations

In all areas where the Contractor intends to refuel plant or park plant overnight he shall provide such temporary stormwater contamination control provisions that will prevent pollution of stormwater courses, or natural water.

No hydrocarbons will be allowed to drain to ground during any operation; all are to be collected in drain trays or collection vessels. Any soils that may have been hydrocarbon contaminated must not be transferred off Site or spread in any uncontrolled manner to other areas of the Site. Any contaminated soil materials shall be held on Site pending inspection by the Engineer. The Engineer will provide instruction regarding disposal of contaminated excavation materials.

2 Earth Fill Placement

2.1 Contractor Requirements

The Engineer requires that a site supervisor is designated to take responsibility for all fill quality and forward to us this sign off that (i) whether the Engineer has been involved from the outset or not, the subgrade has been properly stripped, no rubbish, organic or toxic material has been incorporated and all fill is densely compacted and (ii) where the Engineer have been involved from the outset that all fill quality and agreed compaction methodology has been followed at all times including when an Engineer representative is not present and that further fill has not been placed upon a layer that has not complied fully with the compaction criterion.

Designated Site Supervisor (compaction) …………………………... (Print name)

Project ……………..................................Signed………….……................. Date Completed…………..

2.2 Definition of Terms

Borrow

Is excavation authorised by the Engineer from locations outside the designated site.

Cut

Is excavation from within the construction batter limits shown on the drawings and above the final subgrade surface and includes cut to waste and cut to fill.

Cut to Fill Material

Is all material available from excavations which in the opinion of the Engineer is suitable for use as fill in the lower regions of the new foundation and may include material excavated from existing road shoulders, existing road pavements, cut batters, benching and any other area to be excavated in terms of this specification or nominated by the Engineer.

The fill for the geogrid reinforcement area is currently proposed to be sourced from the existing debris bulb. If this fill is unable to be transported to form the lower bund then an alternative approved site won fill material will be required. GeoSolve should regularly review the material used for filling operations.

Cut to Waste Material

Is excavated material which in the opinion of the Engineer is unsuitable for use as fill and may include materials from existing road shoulders, water channels, cut batters, existing fill batters to be stripped, benching and any other area to be excavated in terms of this specification or nominated by the Engineer.

Fill

Is all material placed as fill from the ground surface after stripping and/or cutting and undercutting up to the final subgrade surface.

Fill Subgrade

Is defined as the surface onto which any fill is to be placed.

Granular Fill Material

Is material which has been placed in the fill and which contains less than 35 per cent passing a 75 micrometre sieve and has a sand equivalent greater than 20. **The maximum particle size shall be 125 mm.**

Imported fill

Is defined as fill imported to site from other sites in the region and incorporated into the *Fill*

Overbreak

Is the excavated material removed by the Contractor's operations from outside the construction batter limits shown on the drawings, but not authorised as borrow.

Site Clearance

Is the clearance of all organic material including previously stockpiled debris, trees and any other vegetation from the area identified within the site boundary on the plans unless otherwise specified.

Subgrade

Is defined as that layer of material in the top 1.0 metre of the construction measured down from the final subgrade surface. This may be fill or undisturbed material.

Undercut

Is excavation from below the construction limits shown on the drawings and may be an extension in depth of a cut area or removal of unsuitable foundation material in addition to topsoil in an area of fill.

Construction

Earthworks shall be in accordance with NZS 4431 - Code of Practice for Earthfill for Residential Development, 1989.

2.3 General Requirements

2.3.1 Drainage and Erosion Control

All earthworks shall be carried out in fully drained conditions with no free water on the working surfaces. Where it is impracticable to maintain excavations of unsuitable material deposits in a fully drained condition, the Engineer will have discretion to relax this requirement to the degree that is necessary. Cut areas shall be sloped and graded adequately so that they do not pond water or allow water to infiltrate, and drains shall be installed or pumping carried out as necessary on a regular basis to remove water from the areas of operations, or to drain water as soon as it is seen to develop. Any filling which has been allowed to become too wet or soft shall be removed and dried, or replaced. All fill surfaces shall be rolled off at the end of each day's work to prevent erosion and deterioration. Prior to commencement of the filling operations the following day, the smooth surface shall be scarified by approved plant to prevent layering of the fill.

Earthworks shall be undertaken in accordance with Enviroscope's environmental management plan.

2.3.2 Dust control

Dust control shall be undertaken in accordance with Enviroscope's environmental management plan.

2.3.3 Silt Control

Silt control shall be undertaken in accordance with Enviroscope's environmental management plan.

2.3.4 Sequence of operation

In the event that a particular sequence of operation is required by the Principal or the Engineer, or because of the nature of the Works, then the Contractor shall submit with his original programme a Methodology Statement which will include his preferred sequence of carrying out the Works. Any such statement shall be subject to the approval of the Engineer and shall comply with any internal completion dates or order of carrying out the Works set

out in the tender. The Methodology Statement shall be updated from time to time as required by the Engineer, and in any case no less frequently than once a month.

2.3.5 Removal of Vegetation

The Contractor shall remove all vegetation from the site of earthworks, and shall clear all obstructions from the Site of the Works. Clearing shall mean the removal of all growth (other than grass and weeds), extraction of stumps and other items remaining above the surface of the ground, and the complete disposal of all items. Extraction of stumps (if any) shall remove all roots greater than 25 mm in diameter. The removal of grass and weeds shall be provided for under topsoil stripping.

2.4 Excavation

2.4.1 Removal of Topsoil and Uncontrolled Fill

All turf, organic topsoil and uncontrolled fill shall be stripped from the areas subject to earthworks before other operations commence in these areas. All topsoil shall be stockpiled for future reuse in the locations shown on the Drawings, or areas otherwise approved on Site by the Engineer. The stockpiles shall have slopes not steeper than 1 vertical to 2 horizontal and have all changes of grade rounded to conform generally with the surrounding landscape.

The depth of topsoil stripping shall be sufficient to remove all organic material, turf and significant plant roots. Except where limited by boundaries, existing works or other limiting features, stripping shall extend 2 metres beyond the limits of areas subject to earthworks or construction. The Contractor shall co-operate with the Engineer ahead of and during stripping operations to determine the stripping depth and shall avoid unnecessary over excavation.

2.4.2 Over Excavation

The Contractor shall direct his operations to avoid excavating beyond designated profiles. Any excavation beyond these profiles carried out without express instruction by the Engineer shall be made good to the direction of the Engineer with compacted fill or equal quality to that designated to cover the excavated profile. This reinstatement work shall be at no cost to the Principal.

2.4.3 Cut to Waste

If instructed by the Engineer, cut material other than topsoil and that required for fill or backfill shall be carted to the Principal's nominated dump or removed from site and disposed of. The dumped material shall be track rolled and levelled to the level of the surrounding ground, or as directed.

2.4.4 Excavate to Fill

Prior to compaction, all fill material shall be broken into fragments of less than 75 mm. The material shall be spread uniformly in layers of less than 225 mm thickness, and conditioned to an appropriate average water content.

New fill shall not be spread over surfaces that have deteriorated from their specified condition. Where necessary, the old surface shall be scarified and conditioned and re-compacted before placing new fill.

The Contractor shall exclude all rubbish and organic matter including topsoil from fills. Where excessive separation is required, the Engineer may approve up to 2% of organic silt to be included in non-critical bulk fills.

2.5 Fill Placement

2.5.1 General

Prior to fill placement each area of the stripped fill subgrade is to be inspected by the Engineer or his representative and approved. The fill material shall be spread uniformly in layers of less than 225 mm thickness, and conditioned to appropriate average water content. If any boulders are encountered should be removed prior to fill placement. Should the contractor demonstrate adequate compaction to satisfy the requirements of the standard, the Engineer may approve an increase the layer thickness at his discretion with a written instruction. Prior to compaction, all fill material shall be broken into fragments of less than 75 mm.

New fill shall not be spread over surfaces that have deteriorated from their specified condition (e.g. frozen ground). Where necessary, the old surface shall be scarified and conditioned and recompacted before placing new fill.

The Contractor shall exclude all organic matter and refuse from fills.

No imported fill shall be used unless the Engineer or his representative has approved its suitability for use on site. There shall be no organic matter included in this imported fill. Any material which has deteriorated from the original approved condition, or is not Engineer approved shall be removed from site at the Contractor’s expense.

2.5.2 Equipment

The Contractor shall employ sufficient compaction equipment to achieve the specified compaction. The number and type of plant necessary shall be confirmed by trials to obtain the necessary compaction factor. No subsequent changes shall be introduced without the prior approval of the Engineer. When compacting in close proximity to a wall, the structural Engineer must be advised of the type of equipment.

Plate compactors are only recommended for small areas of shallow fill and methodology is to be established by compaction trails. Layer thickness for plate or other hand compactors or pedestrian rollers must not exceed 100 mm without written approval.

2.5.3 Control of Water Content (Soil Conditioning)

Precautions shall be taken when stripping and placing to ensure water content of any subgrade where trafficking is proposed, does not exceed optimum and to ensure that no trafficking of any form, takes place on any such area that may be susceptible to weaving. No soil placement shall continue if substantial weaving develops, and the Engineer shall be notified immediately. When soil is to be dried the Contractor shall scarify or disc the soil and allow it to dry uniformly to its full depth.

When the soil is to be wetted, this shall be done using sprinkling equipment ensuring uniform and controlled distribution of water in conjunction with blading and discing. Any costs of drying, wetting or time to allow uniform distribution and equalisation of water content will be deemed to be included in the fill rate or other scheduled items. No extra payments will be made for soil conditioning.

2.5.4 Compaction Requirements

Cohesionless material such as hardfill or gravels shall be placed in uniform condition in layers not greater than 225 mm loose thickness (unless shown in trials that thicker layers can be routinely compacted to this standard).

The specific compaction methodology using the proposed plant is recommended to be established using a trial at the start of construction.

2.5.5 Compaction Trials

Before filling is started the Contractor shall demonstrate to the Engineer the adequacy of the equipment to be used by spreading and compacting a minimum of two individual superimposed layers of soil (225 mm maximum thickness before compaction) in which tests of the standard of compaction shall be conducted.

During the compaction trials the Contractor may develop, in conjunction with the Engineer, ad hoc tests, which the Contractor may use himself as an approximate guide to the standard of compaction being achieved at any time.

Should differing kinds of soil be uncovered during the course of subsequent works, further trials shall be conducted at the direction of the Engineer.

The final number of passes of compaction equipment shall be determined by the trials.

3 Reinforced Slope Construction

3.1 General

Geogrids shall be geo-synthetics specifically manufactured for soil reinforcement. The following geogrid products have been specified by the Engineer:

Geogrid reinforcement: Miragrid GX 100/30

Refer to Drawings to see where the products are applicable.

The Engineer may approve alternative geogrids should they meet the following requirements:

- No deviations in mechanical properties of more than 5%;
- A creep limited strength for design life of 50 years with an in-soil temperature of 20 degrees and allowing for both environmental and site damage factors for <125 mm aggregate fill equivalent to the specified products;
- The long term design strength for fill size <125 mm and an environment of ph between 4 and 10 equivalent to the specified products.

The Contractor shall submit a manufacturer's certification backed by independent laboratory testing and certification that the geogrid proposed for construction meets the above criteria.

3.2 Foundation/Subgrade Preparation

Foundation soils shall be excavated as required to the depth as shown on the drawings and as directed onsite by the Engineer.

Foundation soil shall be inspected by the Engineer to confirm that the actual foundation soil conditions meet or exceed any assumed design conditions.

Unsuitable soils shall be removed and replaced with acceptable material approved by the Engineer.

Over excavated areas shall be backfilled with approved compacted backfill material in accordance with this specification.

3.3 Base Levelling

The subgrade shall be compacted to provide a dense, level surface. Compaction shall be in accordance with this specification.

3.4 Reinforced Soil Block Construction

3.4.1 Fill Material

It is understood site won fill sourced from the debris bulb will be used for the reinforced soil block and downslope bund construction.

3.4.2 Geogrid Installation

All Geogrid shall be installed in accordance with the manufacturers recommendations. Geogrid shall be laid at the proper elevations, lengths and orientation as required in the Drawings.

Note: The proposed reinforcing geogrid are maximum strength in one direction only. The Contractor shall verify that the geogrid has been placed on the correct direction of maximum strength before backfilling.

The maximum particle size for fill around the geogrid is 125 mm.

The geogrid shall then be tensioned by pulling the geogrid perpendicular to the slope alignment (i.e. in the direction of maximum strength) using a tensioning bar or method as prescribed by the geogrid manufacturer.

The back edge of the geogrid should be secured by staking prior to and during backfilling and compaction.

The manufacturer's guidelines relating to overlap requirements of the geogrid shall be followed with **a minimum requirement of 200 mm**.

Fill placement should begin near the reinforced soil slope face and move progressively towards the cut or rear of the embankment to ensure that the geogrid remains under tension. When backfill is in position tensioning stakes may be removed.

3.4.3 Construction Considerations

Backfill shall be placed, spread and compacted in such a manner that minimises the development of slack or loss of pretension in the geogrid.

Compaction trials should be carried out at the commencement of fill placement to establish the most suitable compaction equipment. Selection of appropriate compaction equipment is at the discretion of the Engineer. See section 2.5.2 for details.

Tracked construction equipment shall not be operated directly on the geogrid. A minimum backfill thickness of 150 mm is required prior to operation of tracked vehicles over the geogrid. Turning of tracked vehicles should be kept to a minimum to prevent tracks from displacing the fill and damaging the geogrid.

Rubber tyred equipment may pass over the geogrid reinforcement at slow speeds, (less than 15 km/h.). Avoid sudden braking and sharp turning.

Any geogrid which is delivered damaged or is damaged onsite prior to construction may be rejected for use by the Engineer. Replacement if required will be at no cost to the principal.

3.5 Site Control

The Contractor shall get approval for the use of site machinery and plant adjacent to the wall face so that an appropriate setback may be provided.

Boffa Miskell

Reavers Catchment Debris Removal

Landscape and Natural Character Effects Assessment
Prepared for Queenstown Lakes District Council
21 August 2024

Boffa Miskell is proudly a
Toitū net carbonzero certified consultancy

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Cover photograph: View from the upper slip looking towards Gorge Road and Queenstown Hill. Boffa Miskell Limited, 2024.

CONTENTS

Graphic Supplement (bound separately)

1.0 Introduction

1.1 Scope of the report

Boffa Miskell Limited (BML) has been engaged by Queenstown Lakes District Council in January 2024 to undertake a Landscape Effects Assessment (LEA) for proposed debris removal works (refer to Image 1 below) within the Reavers Creek catchment (otherwise referred to as The Site in this report). The Site is zoned Informal Recreation within the proposed Queenstown Lakes District Plan.

Image 1: Approximate extent of the slip (grey dash) and debris flow (orange line) within the Reavers Creek catchment.

The following Landscape Effects Assessment addresses the effects of the proposed debris removal works on the immediate and surrounding environment.

1.2 Assessment Process

This assessment follows the concepts and principles outlined in *Te Tangi a te Manu: Aotearoa New Zealand Landscape Assessment Guidelines*[1]. A full method is outlined in **Appendix 1** of this report. In summary, the effects ratings are based upon a seven-point scale which ranges from very low to very high.

A Site visit was undertaken on Monday 29th January 2024 by Hannah Wilson (landscape architect). The purpose of the Site visit was to appraise the Site and to understand its wider context. Weather on the day was fine, with light winds and good visibility.

[1] *'Te Tangi a te Manu: Aotearoa New Zealand Landscape Assessment Guidelines', Tuia Pito Ora New Zealand Institute of Landscape Architects, July 2022.*

2.0 Existing Environment

2.1 Landscape Context

The broader landscape context of the Site forms the interface between the urban environment of Queenstown, and the mountain ranges above (refer to **Figure 1** of the Graphic Supplement). The wider landscape is characterised by the steep mountain ranges, glacially carved roche moutonnee features, and a patchwork of exotic forest, remnant beech forest, tussockland, and residential development.

The west of the Site is characterised by the steep and forested slopes of Ben Lomond. The area is largely clad in mature Douglas fir forest, with areas of exposed rock and slips disbursed between. Beyond the areas of forestry, the upper slopes of Ben Lomond transition into tussock grassland with some beech forest in gullies. These areas can be accessed via the Ben Lomond track.

To the east of the Site is the residential area around Gorge Road which forms the conduit between the northern extent of Queenstown and Arthurs Point. The road is centrally located within the valley which separates Ben Lomond and Queenstown Hill. It is a main road containing pastoral land closer to Arthurs Point, as well as industrial development and the residential edge of Queenstown.

Queenstown Hill, a prominent feature forms the eastern backdrop to Queenstown township. Clad in exotic forest on its lower slopes, the upper reaches contain open areas of tussock grassland. The low profile of these species allows for optimum views of the Whakatipu Basin and beyond from the Queenstown Hill track, a popular track for walkers and runners.

To the south is Lake Whakatipu, a deep, glacially carved lake forming the broader context to Queenstown township. The lake is characterised by three distinctive arms, extending from Glenorchy and the Dart River in the north-west, Frankton in the east and Kingston in the south. The lake is largely surrounded by high country stations and conservation land, although the township of Queenstown is located on the northern shores of the lake.

The Site is located on the interface between Queenstown township and the slopes Bob's Peak, a prominent local feature on the edge of Queenstown township. Queenstown is a rapidly growing and developing township on the shores of Lake Whakatipu and is highly popular tourist destination for both international and domestic visitors. The centre of Queenstown is characterised by several retail, commercial, and hospitality businesses as well as extensive visitors' accommodation.

Skyline gondola, one of Queenstown's most popular tourist attractions is located in proximity of the Site and overlooks the township below. The recreational hub offers opportunities for walking, mountain biking, luging and sightseeing, with expansive and spectacular views of Lake Whakatipu available from the upper terminal at Bob's Peak and tracks above. Skyline gondola is currently undergoing extensive re-development of both its upper and lower terminal, and upgrades to its gondola and luge attractions. In addition, since the September 2023 rain event which caused several slips and damage to the slopes of Bob's Peak, Skyline is undergoing significant construction works and storm remediation works in conjunction with the upgrades to the amenities on Site.

2.2 Site Description

The Site is located on the lower slopes of Bob's Peak and within the Reavers Creek catchment. The creek catchment extends from Reavers Lane at the base of the hill, to Bob's Peak above the Skyline upper terminal and faces towards the north-east (Gorge Road). A description of the Site is outlined below (refer to **Figure 2** for photograph locations).

The northern extent of the Site can be broadly split into three components, the slip and upper debris flow, the middle of the debris flow, and lower extent of the debris flow. The upper extent is characterised by an open clearing to the north of the Skyline luge. As shown in **Site Appraisal Photograph A**, the slip falls steeply at a 45-degree angle towards a rocky cliff on the edge of the forest. This area of the Site is largely barren and is surrounded by Douglas fir forest on the lower slopes, and the Skyline development adjacent to the upper slope. This steep section of the Site can only be accessed from the top of the slope and is not accessible to the public.

Access to the mid slope is via an existing forestry track which was heavily damaged during the September 2023 rain event. The tracks within the forest are accessed from a mid-point on Bob's Peak, which passes underneath the existing Skyline Gondola. As shown in **Site Appraisal Photographs B to D**, the tracks have once accommodated vehicle access, and traversed the steep slopes of Bob's Peak through dense Douglas fir forest.

Access to the mid extent of the slip is through the forest, as demonstrated in **Site Appraisal Photograph E**. The slip is located below a rock cliff face which falls steeply towards a second ravine below. Unlike the upper slope, this area of the Site is enclosed by Douglas fir forest and contains loose gravels and fallen trees as demonstrated in **Site Appraisal Photographs F and G**. Views towards Queenstown, Gorge Road, and the upper terminal of Skyline are completely curtailed by the intervening forest surrounding the Site.

The lower extent of the Site is located below another rock cliff face. As demonstrated in **Site Appraisal Photograph H**, the slip continues to extend below, containing a mixture of loose gravels and fallen trees. This area of the slope is more enclosed than the mid slope, with limited breaks in the forest canopy.

2.3 Landscape Category and Values

Values Identification Framework for Priority Areas for Outstanding Natural Features and Outstanding Natural Landscapes

3.3.43 In applying the Strategic Objectives and Strategic Policies for Outstanding Natural Features, Outstanding Natural Landscapes and Rural Character Landscapes, including the values identification frameworks in SP 3.3.37, 3.3.38, 3.3.40 and 3.3.41 and the landscape assessment methodology in SP 3.3.45, have regard to the following attributes:

- *a. Physical attributes:*
  - *i. geology, geomorphology and topography;*
  - *ii. ecology;*
  - *iii. vegetation cover (exotic and indigenous);*
  - *iv. the presence of waterbodies including lakes, rivers, streams, wetlands, and their hydrology;*

v. *land use (including settlements, buildings and structures; and*

b. *Sensory (or experiential) attributes:*

i. *legibility or expressiveness – how obviously the feature or landscape demonstrates its formative processes;*

ii. *ii. aesthetic values including memorability and naturalness;*

iii. *iii. wild or scenic values;*

iv. *iv. transient values including values at certain times of the day or year;*

v. *v. experiential attributes, including the sounds and smells associated with the landscape; and*

c. *Associative attributes:*

i. *whether the attributes identified in (a) and (b) are shared and recognised;*

ii. *cultural and spiritual values for Tangata Whenua;*

iii. *historical and heritage associations; and*

iv. *recreational values.*

(relevant to SO 3.2.1, 3.2.1.7, 3.2.1.8, 3.2.2, 3.2.2.1, 3.2.5, 3.2.5.1 – 3.2.5.7)

The proposal is located within the Western Whakatipu Basin ONL which encompasses the south-eastern mountain slopes of Te Taumata o Hakitekura (Ben Lomond), southern and eastern slopes of Bowen Peak, and the roche moutonnée landforms associated with Queenstown Hill and Sugar Loaf. The following attributes have been derived from on-site observations, desktop research, and the Western Whakatipu Basin ONL Priority Area Schedule (as they apply).

Physical attributes and values

The broader landscape context is characterised by the steep slopes of Te Taumata o Hakitekura (Ben Lomond 1,748m), Bowen Peak (1,631m) and Queenstown Hill (907m), all of which are distinctive peaks within the Queenstown context. These glacially carved landforms form the backdrop to the northern extent of Queenstown township and contain several elevated ridgeline spurs including Bob's Peak (812m). The southern slopes of these peaks have a smooth 'up glacier' slope when descends towards Lake Whakatipu, while the northern slopes are steeper in topography.

The landscape context includes Lake Whakatipu, a large glacial lake to the south of the township. The lake extends from Glenorchy in the north-west to Kingston in the south-east. While not included within the Western Whakatipu Priority Area, the lake forms an integral part of the landscape character of the wider context. Other hydrological features include the steep creeks and incised tributaries of Lake Whakatipu and the Shotover River catchment within the wider context.

Much of the lower slopes of the Western Whakatipu ONL are characterised by extensive areas of plantation Douglas fir forests which extend from Fernhill in the south-west to just north of Horn Creek. Fragmented areas of forest are intermixed with grey shrubland, sycamore, broom gorse, and crack willow. Above the tree line however, there are extensive areas of important ecological features and vegetation types. Broadleaved forest can be found at the western extent of the priority area, with pockets of mountain beech within the gullies. At higher altitudes there are extensive areas of subalpine shrubland, and snow tussock.

Modifications within the landscape are largely associated with the urban settlement of Queenstown and associated infrastructure. Skyline is a prominent feature within the ONL itself, with the presence of the upper and lower terminal, a gondola and chairlift, one of which traverses the slopes of Bob's Peak, luge tracks, forestry tracks, and various walking and mountain biking trails. Wilding conifers are also a significant modification within the landscape, and are prominent on the lower slopes of Ben Lomond, Bowen Peak, and Queenstown Hill. Within the Gorge Road valley north of Queenstown there is a general absence of rural living and rural buildings, however the valley is characterised by extensive areas of pasture.

Perceptual attributes and values

The landscapes of the Western Whakatipu ONL and broader context are highly expressive of their glacial formative processes and highly memorable. Expansive panoramic views are available from Bob's Peak, Ben Lomond saddle and summit, and Queenstown Hill. This includes views across Lake Whakatipu, the Remarkables, Ben Lomond, Queenstown Hill, and the broader mountainous context of Queenstown. The dominance of natural elements, patterns, and process is evident within this landscape, with built form being a secondary element to this landscape.

The seemingly undeveloped character of the Western Whakatipu Basin ONL in comparison to its urban context creates a higher sense of perceived naturalness, albeit with forestry, and pastoral landcover present.

Transient characteristics within the Western Whakatipu Basin ONL and broader context include the seasonal snowfall, and colour changes. Transient characteristics also include the drastic weather changes and patterning of light within the landscape.

Associative attributes and values

The Western Whakatipu ONL and broader context have whakapapa connections for Kāi Tahu who uphold the mauri of the landscape. The ONL and Whakatipu basin are associated with Hakitekura, who was the first person to swim across Lake Whakatipu. After observing two women attempting to outswim each other, Hakitekura, a Kati Mamoe woman, swam across the lake in darkness and lit a fire on the opposite side of the lake. The mountains she used for guidance became known as Te Taumata a Hakitekura (The Resting Place of Hakitekura).

The Whakatipu basin was also once part of an extensive network of mahika kai and traditional travel routes, including connections to the Mackenzie Basin, West Coast, and Southland.

Upon arrival of early European settlement, the interactions with the landscape included farming and gold mining, which this area is still known for. Today the landscape is predominantly associated with several recreational opportunities including walking, mountain biking, paragliding, and bungee jumping. Skyline forms a key feature within the Western Whakatipu ONL, offering gondola rides, luging and other popular recreational opportunities.

2.4 Visual Catchment

The extent and degree to which the Site is visible from the surrounding landscape was considered as part of the Site visit. Based on the methodology applied to this assessment, the following categories of extent of visibility/ views have been determined:

- No view: views of the Site are completely curtailed.
- Truncated/Glimpsed Views: a view towards the Site that is mostly or almost entirely curtailed by a visual barrier.

- Partial Views: a view of part of the Site between trees or structures, or a filtered view of the Site/ proposed building.
- Open Views: a clear view of a significant proportion of the Site and/ or proposed building within the wider landscape.

A series of Site Photographs have been taken to illustrate the Site's existing characteristics and visibility from the broader landscape. Their locations are shown in **Figure 3: Visual Appraisal Plan.** The Site can be broadly split into two areas, the slip and debris flow within the Reavers Creek catchment on the forested north-eastern face of Bob's Peak, and the footprint of the existing access track on the exposed south-eastern face of Bob's Peak.

The debris flow and slip are located above Reavers Lane. Reavers Lane consists of residential properties which adjoin the slopes of Ben Lomond. As demonstrated within **Site Context Photograph 1**, views of the debris flow and slip are curtailed by the intervening Douglas fir forest which is present on the hillside. The underlying landform of Reavers Creek is evident from this viewpoint, extending to the upper reaches of Bob's Peak, in addition to the crane associated with the Skyline development at the upper terminal.

Further east, and away from the toe of the slope, Warren Park has open views of the residential development at the end of the Reavers Creek catchment, the slopes of the Ben Lomond and Bob's Peak above. Views of debris flow and slip from Warren Park are equally curtailed by intervening forestry. As shown in **Site Context Photograph 2**, views of the Skyline development and existing vegetation clearance near the summit of Bob's Peak are partially visible from this viewpoint.

To the south-east of Warren Park in proximity of Hallenstein Steet is a large residential area forming the north-eastern extent of Queenstown township on the lower slopes of Queenstown Hill. There are open views of the existing access track which traverses the hill slope underneath the Skyline Gondola, and glimpsed views of the upper and lower terminal. This also includes views of the extensive Skyline development and construction works, and exposed south-eastern face of Bob's Peak. Views of the debris flow and slip, are entirely curtailed by intervening forest on the hill side, as demonstrated in **Site Context Photograph 3**.

From Queenstown township, views are contained to the exposed existing access tracks extending perpendicular to the Skyline Gondola, including the extensive Skyline development and construction works. As shown **Site Context Photograph 4**, open views of the existing access track are available, viewed in the context of the existing Skyline development and commercial edge to Queenstown township.

To the south of the Site, is a small residential area on the western outskirts of Queenstown township and at the southern extent of Bob's Peak. As demonstrated in **Site Context Photograph 5,** open to partial views of the exposed south-eastern face of Bob's Peak are available, including the Skyline gondola, upper and lower terminal, and existing access tracks on the face of the slope.

Further afield, views of the entire Site from the north become almost entirely curtailed by the intervening Douglas fir forest on the slopes of Bob's Peak. The existing access tracks and Skyline Gondola are screened from view from public viewpoints to the north, as shown in **Site Context Photograph 6**, however views of the crane associated with the Skyline redevelopment at the upper terminal, are visible. When travelling on Gorge Road on the outskirts of Queenstown long distance, partial views of the upper extent of the slip become available. **Site Context Photograph 7** demonstrates this viewpoint from Queenstown Harvest Community Gardens. Views of the existing Skyline Luge Gondola, and upper terminal also available from this viewpoint.

To the east of the Site is Queenstown Hill and the Queenstown Hill walking track. As shown in **Site Context Photographs 8 and 9,** views of the south-eastern face of Bob's Peak become more open when following the track due to the higher elevation. Views from the start of the track shown in **Site Context Photograph 8**, include open views of the existing access tracks, exposed south-eastern slope of Bob's Peak, construction works, and partial views of the upper Skyline Terminal, including the gondola. The slip and debris flow are entirely concealed from this viewpoint by the intervening forestry on the slopes of Bob's Peak. At a higher elevation (above the tree line where views out are possible) partial views of the upper extent of the slip become available as demonstrated in **Site Context Photograph 9**. The upper terminal, gondola, existing access tracks, and luge infrastructure associated with the Skyline development are also visible from this viewpoint.

To the south-east, long distance views of the debris flow and slip are entirely curtailed from Queenstown Gardens from the northern walkway. As shown in **Site Context Photograph 10**, long distance views of the south-eastern face of the Site are available including the Skyline gondola, upper and lower terminal, and existing access tracks on the face of the slope. The slope forms the backdrop to the western extent of Queenstown township, with the north-eastern face curtailed from view by intervening topography and dense Douglas fir forest.

3.0 Proposal Description

The proposal is to remove approximately 2,500m^3 of loose material deposited on the upper slope of Reavers Catchment, near the northern extent of Skyline's upper terminal development. The slip is the result of the September 2023 rain event which saw several slips throughout the Skyline development on the slopes of Bob's Peak and is proposed to be removed by truck and helicopter. The proposal broadly comprises two components. Works within the Douglas fir forest within the Reavers Creek catchment and works on the exposed hill slope on the south-eastern face of Bob's Peak. The majority of works will be undertaken within the forest, including the establishment of a temporary access track, a debris flow barrier, and earthworks to remove the slip and excess debris. **Figure 2** shows the aspects of the proposal, including the existing, permanent, and temporary access tracks. The proposed permanent access track realignment (shown in **Figure 2** in red) will replace the overlapping existing track (shown in blue). The proposed temporary track (shown in pink) will be removed and remediated on completion in addition to the debris flow and slip. Details of these aspects of the proposal are outlined below.

South-eastern face of Bob's Peak

On the exposed south-eastern face of Bob's Peak there are several existing access tracks, two of which connect to the existing tracks within the forest to the north. Works on the exposed face of Bob's Peak include the realignment of one of the existing access tracks (shown in **Figure 2** of the graphic supplement). This will largely follow the footprint of the existing track, and no vegetation removal is proposed.

Reavers Catchment

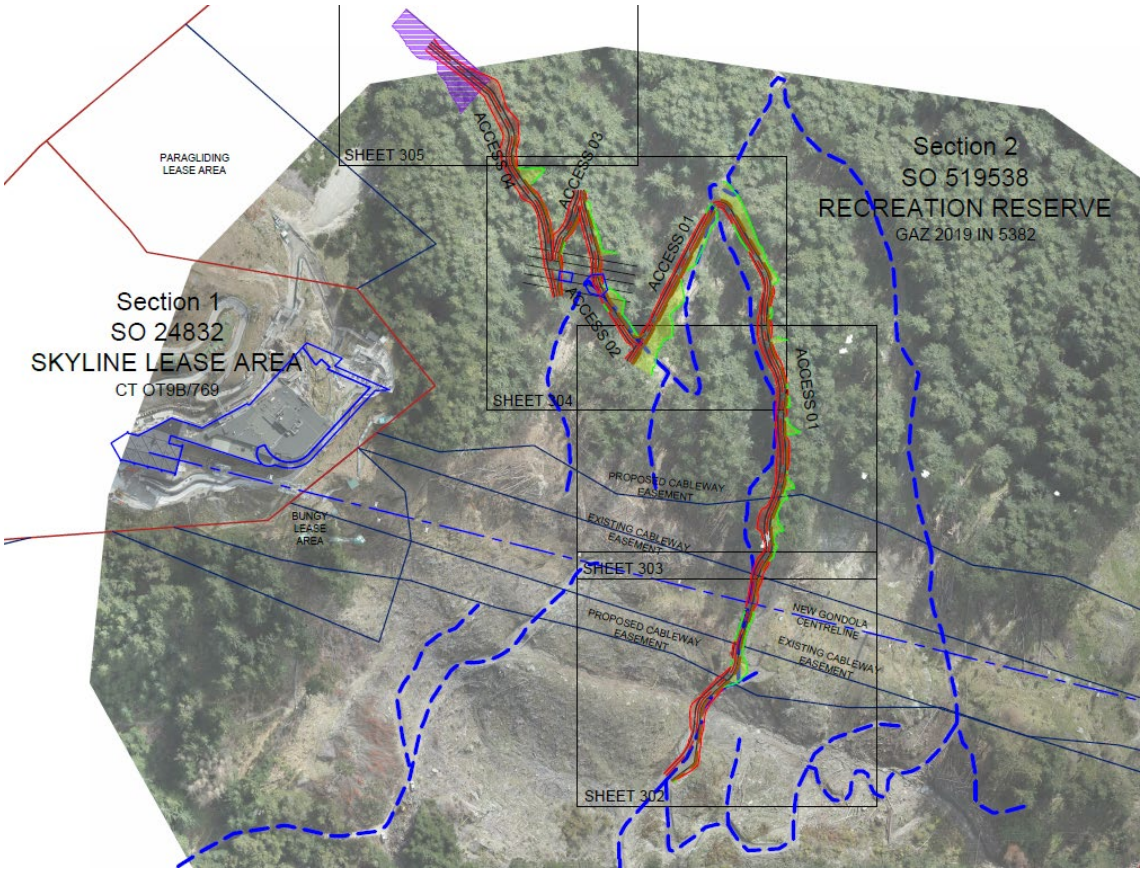


Image 2: Cut (red) and fill (green) required to form the proposed tracks within the Site. Existing access tracks are shown in blue dash. Plan provided by Patersons Land Professionals.

Most of the works associated with this proposal will be undertaken within the Reavers catchment on the north-eastern slopes of Bob's Peak within Douglas fir forest. Two new tracks will be established on the north-eastern slopes of Bob's Peak within the forest. The first will broadly follow the alignment of an existing access track within the forest and will remain on the completion of the remediation works (red dash on **Figure 2** of the graphic supplement). The second will extend beyond the footprint of the existing access track towards the debris flow and will be temporary (pink dash on **Figure 2** of the graphic supplement). The temporary access track will be rehabilitated on the completion of the proposed excavation works, including recontouring the track to reflect the broader topography of Bob's Peak.

Both the proposed permanent and temporary tracks will be constructed at a gradient of 1:6. The construction of the tracks will include earthworks to establish and level the roads, forming new fill batters between 1:0.5 to 1:1.5 and cut batters of 1:0.25 to 1:0.5 (refer to **Image 2** above). These earthworks will broadly follow the contours of the north-eastern slope of Bob's Peak and any excess fill will be used to repair the existing tracks damaged by the September 2023 storm. Much of the earthworks and vegetation clearance proposed will be contained to the footprint of the tracks, which are approximately 5-10 metres in width (including the cut and fill each side of the track). Larger areas of fill are proposed to the north of the Site and are associated with the switch backs on the proposed permanent track realignment. These new batters will be contoured to broadly follow the landform of Bob's Peak and will include vegetation removal to form the battered slopes.

Photograph 1: Example of an existing debris flow barrier in the lower Reavers Creek catchment.

Once tracks have been constructed to access the debris flow, the proposal involves the installation of a debris flow barrier (DFB) (refer to **Photograph 1**) at the mid slope of the debris flow within the Site. This will be 70 metres wide and 6 metres in height and will extend perpendicular to the debris flow. To construct the barrier, a series of anchors will need to be drilled and cemented into the rock prior to the installation of the barrier itself which will remain for the duration of the debris removal.

Upon installation of the DFB, a spider excavator will be used to push the material from the slip near the Skyline luge, down towards the DFB. An excavator will then be used to load the material on trucks and taken off-site via the temporary and permanent access tracks. Debris on the lower slope will also be removed by trucks via the proposed access track.

On completion of the debris removal, the DFB barrier will be removed from the Site, and the surface in the vicinity will be restored and re-contoured. The proposed temporary access tracks used to haul the material out will be recontoured to follow the existing form of the hill side. The permanent access track realignment will remain to provide access to the forest on either side of the Skyline gondola. Overall, the duration of the debris removal is expected to take approximately 6 months to a year.

4.0 Visual Effects

Visual amenity effects are influenced by a number of factors including the nature of the proposal, the landscape absorption capability and the character of the site and the surrounding area. Visual amenity effects are also dependent on distance between the viewer and the proposal, the complexity of the intervening landscape and the nature of the view.

4.1.1 Effects from public vantage points

The visual catchment can be split into three components, views of the Reavers Creek catchment, views from Queenstown Central, and views from Queenstown Hill.

Views of Reavers Creek catchment

Views to the east of the Site from Gorge Road and adjoining roads will be limited. Views of the vegetation removal within the footprint of the proposed tracks and battered slopes will be evident but will not disrupt the contiguous appearance of the Douglas fir forest on the slopes above. Consequently, works associated with the slip and debris flow will remain screened by intervening Douglas fir forest. Visual effects for users of the southern extent of Gorge Road and the Warren Park area are considered **very low adverse**.

Further north within the Gorge Road valley views of the debris removal will be more evident when travelling in a southerly direction towards Queenstown. Open to partial views of the upper slip will be available from the road, including the temporary spider excavation works proposed which will involve pushing the debris down the slope to the DFB below. While open views of the upper slip will be available, these will be viewed in the context of the existing Skyline development and will be temporary in nature with the tracks and debris flow barrier concealed by the intervening Douglas fir forest. Visual effects for users of the northern extent of Gorge Road are therefore considered **very low adverse**.

Views from Queenstown Central

Within Queenstown central, views of the Reavers Creek catchment are entirely curtailed by intervening forest and the natural topography of the landform. The aspects of the Site visible from the Queenstown catchment include the proposed permanent access track realignment (shown in red on **Figure 2**) on the south-eastern face of Bob's Peak.

Visual effects will include localised cut and fill associated with the construction of the proposed permanent track realignment. These changes will be evident but viewed in the context of the extensive construction and storm recovery works, existing forestry access tracks, and development at Skyline. In addition, views of selective vegetation removal within the footprint of the track realignment (approximately 5-10 metres) will be evident. These views will be contained to the south-east of the Reavers catchment and will not disrupt the coherent cover of Douglas fir forest. Visual effects from Queenstown Central are therefore considered no greater than **low adverse (less than minor),** reducing to **very low adverse** on completion.

To the south-east of the Site is Queenstown Gardens, which offers mid to long distance views. Long distance views of the proposed permanent access track realignment and vegetation removal within Reavers catchment will be available. These will be viewed in the context of the overall development at Skyline, existing forestry tracks, storm recovery, and forestry activity on the hillside. Visual effects from Queenstown gardens are considered no greater than **low adverse (less than minor),** reducing to **very low adverse** on completion**.**

Views from Queenstown Hill

The upper extent of the Queenstown Hill track above the tree line provides views of the slip and upper debris flow and the south-eastern face of Bob's Peak. Long distance views of the proposed permanent track realignment on the exposed face of Bob's Peak and temporary works on the upper face of the debris flow will be evident. Works will be seen in the context of the wider Skyline development and upper terminal which is clearly visible from the walkway. The installation of the DFB will be concealed entirely by the existing forest on the hill slope; however, the construction of the permanent and temporary tracks will be evident through selective

vegetation removal within the footprint of the track alignment, and battered slopes. Vegetation removal while evident from this viewpoint will be limited, with the coherent stand of Douglas fir forest remaining throughout the duration of the proposal. Visual effects for users of the Queenstown Hill Track are considered no greater than **low adverse (less than minor)** reducing to **very low adverse** on completion.

4.1.2 Visual Effects from private vantage points

The private viewing audience includes residential properties within Queenstown Central, including the lower slopes of Queenstown Hill, Man Street and Isle Street, and residential areas surrounding Warren Park. Effects from private vantage points have been grouped into three viewing catchments. This includes the Gorge Road valley on the fringes of Queenstown's town centre and immediately east of the Reavers Creek catchment; properties accessed from Man Street and Isle Street, and the lower slopes of Queenstown Hill.

Views from residential areas within the proximity of Gorge Road, Reavers Lane, and Warren Park are of the north-eastern face of Bob's Peak (Reavers Creek catchment) which will include the debris flow and slip works, and establishment of the permanent and temporary tracks. Views of the debris flow barrier, and debris removal works including construction of the proposed tracks will be curtailed by the intervening forest. Some vegetation clearance associated with the construction of the temporary and permanent tracks will be visible, but small in the context of the wider forest. Visual effects from properties within the Gorge Road, Reavers Lane, and Warren Park area are considered **very low adverse**.

To the south of the Site is a narrow extent of residential properties which are accessed from Man Street and Isle Street and are largely orientated towards Lake Whakatipu. Glimpsed to partial views of the proposed permanent track realignment on the exposed face of Bob's Peak will be available from these properties. Views of the tree removal associated with the permanent tracks within Reavers catchment will also be available but will be limited to the footprint of the track. Visual effects from properties within the Man Street and Isle Street area are considered no greater than **low adverse (less than minor),** reducing to **very low adverse** on completion. Works will largely be contained to an existing access track and will not appear out of character in the context of the Skyline development.

To the east of the Site above Queenstown township is a residential area on the lower slopes of Queenstown Hill. These properties are accessed from local roads including Hallenstein Street, Edinburgh Drive, and Belfast Terrace and are orientated to the south towards Lake Whakatipu. The elevated nature of these properties provides for views of the entire face of Bob's Peak; however, the majority of works will be entirely curtailed by the intervening forest. The proposed permanent access track realignment on the south-eastern face of Bob's Peak will be evident from properties within this area due to the exposed cliff face. These works will however be viewed in the context of the extensive construction and development currently ongoing at Skyline. Views of the vegetation removal associated with the construction of the permanent and temporary tracks will also be available, however the tracks themselves will remain curtailed by intervening forest. Visual effects on properties on the lower slopes of Queenstown Hill are considered no greater than **low adverse (less than minor).**

5.0 Assessment of Landscape Effects

5.1 Proposed District Plan

The following statutory assessment responds to the relevant objectives, policies, and assessment matters outlined within the Proposed Queenstown Lakes District Plan. Specific chapters of relevance to the proposal include Chapter 3 Strategic Direction and Chapter 38 Open Space and Recreation Zones.

5.1.1 Chapter 3 Strategic Direction

3.2.4 The distinctive natural environments and ecosystems of the District are protected. (addresses Issue 4)

3.2.4.3 The natural character of the beds and margins of the District's lakes, rivers and wetlands is preserved, or enhanced where possible, and protected from inappropriate subdivision, use and development.

In terms of natural character, the highest degree of naturalness occurs where there is the least amount of human induced modification. Structures, earthworks, and other modifications can adversely change and alter the natural character of an area and the significance of this effect is dictated by the size, location, and sensitivity of the receiving environment.

The slip and debris flow works are located within the context of Reavers Creek. The stream extends into the upper reaches of Bob's Peak on the north-eastern face and has a narrow active bed which is not visible from outside viewpoints due to the surrounding Douglas fir forest. The margins are clad in a narrow strip of sycamore trees and fernland, while the broader context is characterised by Douglas fir forest.

The proposal includes earthworks within the context of Reavers Creek, approximately 120 metres above the creek on the upper slopes of Bob's Peak. This includes the installation of the debris flow barrier, spider excavation of the upper slip and removal of debris via trucks and helicopter. The works will be undertaken away from the active bed and margins of Reavers Creek and confined to the upper slopes of Bob's Peak within the debris flow. Effects on the natural character of Reavers Creek are therefore considered **neutral**.

3.2.5 The retention of the District's distinctive landscapes

3.2.5.1 The District's Outstanding Natural Features and Outstanding Natural Landscapes and their landscape values and related landscape capacity are identified.

An identification of the landscape character and visual amenity values for the Site and the wider area, according to SP 3.3.43 are outlined in Section 2.3 above.

3.2.5.3 In locations other than in the Rural Zone, the landscape values of Outstanding Natural Features and Outstanding Natural Landscapes are protected from inappropriate subdivision, use and development.

The proposal is located within the Western Whakatipu ONL in the proposed district plan. The values of the ONL are addressed below in accordance with 3.3.45.

It was recently recommended that the Priority Area Schedules be adopted within the PDP as Schedules 21.22 and 21.23[2]. These were prepared and notified by QLDC outlining the values and landscape absorption capacity of each area. The proposal is located within the Western Whakatipu Priority Area ONL.

Existing modifications within and in proximity of the Site have been identified within the Priority Area Schedule under shared and recognised attributes, and land use patterns, including the Skyline gondola, luge, and mountain bike tracks, and their proximity to Queenstown township. The schedule also refers to the confinement of built form to Bob's Peak and near Arthurs Point, with little to no development present elsewhere within the ONL.

The proposed debris flow works, and track construction are located within the Reavers catchment, and the footprint of Skyline's existing construction and forestry works. Earthworks and water control measures will be required to construct the permanent access track realignment; however this will be viewed in the context of the modified cableway associated with the Skyline gondola, existing forestry tracks, and existing earthworks associated with the Skyline development. These works are not considered out of character within the context of Site.

Within the forest, the permanent access track realignment and temporary tracks will broadly follow the topography of Bob's Peak, before extending to the north-west towards the debris flow barrier. The construction of the tracks, debris flow barrier, and debris removal works will be largely curtailed by the Douglas fir forest on the north-eastern slopes of Bob's Peak, with some limited vegetation removal required within the footprint of the tracks, and battered slopes. On completion of the debris flow removal, the landform will be recontoured to reflect the underlying topography, and the proposed temporary tracks will be removed.

The overall effects of the proposal on the values of the ONL are considered no greater than **low adverse (less than minor)** reducing to **very low adverse** on completion.

Outstanding Natural Features and Landscape and Rural Character Landscape

3.3.30 Protect the landscape values of Outstanding Natural Features and Outstanding Natural Landscapes. (relevant to SO 3.2.1, 3.2.1.7, 3.2.1.8, 3.2.5, 3.2.5.2, 3.2.5.3, 3.2.5.4 and 3.2.5.6)

This has been addressed above within section 3.2.5.3.

Values Identification Framework for Priority Areas for Outstanding Natural Features and Outstanding Natural Landscapes

3.3.43 In applying the Strategic Objectives and Strategic Policies for Outstanding Natural Features, Outstanding Natural Landscapes and Rural Character Landscapes, including the values identification frameworks in SP 3.3.37, 3.3.38, 3.3.40 and 3.3.41 and the landscape assessment methodology in SP 3.3.45, have regard to the following attributes:

d. Physical attributes:

vi. geology, geomorphology and topography;

vii. ecology;

[2] Variation to Chapter 21 (Rural Zone) of the Proposed Queenstown Lakes District Plan - Introduction of Priority Area Landscape Schedules: 21.22 (Outstanding Natural Features and Landscapes) and 21.23 (Rural Character Landscapes) Priority Area (PA) Schedules, 09 May 2024.

viii. vegetation cover (exotic and indigenous);

ix. the presence of waterbodies including lakes, rivers, streams, wetlands, and their hydrology;

x. land use (including settlements, buildings and structures; and

e. Sensory (or experiential) attributes:

vi. legibility or expressiveness – how obviously the feature or landscape demonstrates its formative processes;

vii. ii. aesthetic values including memorability and naturalness;

viii. iii. wild or scenic values;

ix. iv. transient values including values at certain times of the day or year;

x. v. experiential attributes, including the sounds and smells associated with the landscape; and

f. Associative attributes:

v. whether the attributes identified in (a) and (b) are shared and recognised;

vi. cultural and spiritual values for Tangata Whenua;

vii. historical and heritage associations; and

viii. recreational values.

(relevant to SO 3.2.1, 3.2.1.7, 3.2.1.8, 3.2.2, 3.2.2.1, 3.2.5, 3.2.5.1 – 3.2.5.7)

Landscape values assessment in accordance with 3.3.43. Refer to Section 2.3 above.

3.3.45 Landscape assessments shall:

a. for Outstanding Natural Features and Outstanding Natural Landscapes:
i. identify landscape attributes and values; and
ii. assess effects on those values and on related landscape capacity;

The values outlined within 3.3.43 above are largely associated with the prominence of the landform forming the backdrop to the wider Queenstown Context, the legibility of the glacial landform, and views outward towards the broad Whakatipu basin including the Remarkables, Lake Whakatipu, and Queenstown Hill. While the extensive Douglas fir forest commonly occurs in this landscape, it is a weed species and not a valuable ecological feature or vegetation type.

The Site is located within the context of the Skyline development on the edge of Queenstown's town centre. Development includes the presence of the Skyline's upper and lower terminals, the Skyline gondola, luge infrastructure, mountain bike and walking trails, and existing forestry trails on the lower slopes. Since the September 2023 flooding, the south-eastern face of Bob's Peak has become exposed, and these tracks are more evident from viewpoints throughout the wider Queenstown township.

The proposal includes the construction of permanent and temporary access tracks, and a temporary DFB. These works will also include the transient presence of trucks, and helicopters, as well as on Site machinery including a spider excavator.

The works within the Douglas fir forest on the north-eastern slopes of Bob's Peak will be largely concealed from view although vegetation removal within the footprint of the tracks and battered slopes will be detectable within the forest cover. Modification to the existing landform within the Reavers catchment will be undertaken through the establishment of the permanent and temporary access tracks and earthworks required to resurface the slip and final landform on completion of the debris removal works. Works on the south-eastern slopes of Bob's Peak will include earthworks to form the permanent access track realignment and will be viewed in the context of the existing forestry tracks.

The capacity to absorb the change proposed, including the temporary works is high given the extensive modification in proximity of the Site, existing forestry tracks, and dense Douglas fir forest on the slopes of Bob's Peak. Overall effects on landscape character and values are considered no greater than **low adverse (less than minor)**, reducing to **very low adverse** on completion. The proposal is largely a temporary activity which will be undertaken within a year, and rehabilitation will include resurfacing the slip and recontouring the landform to follow the existing underlying topography of the landform. Most of the proposal is located within dense Douglas fir forest to be retained and will not compromise the naturalness and legibility of the landform identified within the Western Whakatipu ONL. The remaining realignment of the permanent access track on the south-eastern face of Bob's Peak will be viewed in the context of the Skyline development identified as a modification within the Priority Area Schedule.

5.1.2 Chapter 38 Open Space and Recreation

38.4.2 Objective – Use and development of the Ben Lomond Sub-Zone provides a high-quality destination for residents, and domestic and international tourists, while maintaining the landscape values and amenity values of the surrounding Outstanding Natural Landscape.

38.4.2.1 Control the visual impact of buildings, passenger lift systems, earthworks and infrastructure associated with commercial and commercial recreation activities.

38.4.2.4 Ensure the removal of exotic conifer trees in areas other than the Gondola Corridor mitigates the post-harvest adverse effects on landscape and visual amenity through landscape rehabilitation.

The Ben Lomond Sub-Zone encompasses the lower slopes of Bob's Peak, and Bowen Peak including the Skyline upper and lower terminal bases, and gondola. The entire proposal is located within the Ben Lomond Sub-Zone (**Figure 4**).

The proposal includes a series of temporary and permanent tracks that will be constructed within the Reavers catchment and on the exposed slopes of Bob's Peak. The proposal also includes the installation of a temporary DFB which will be required to remove the debris flow. As addressed within Section 4 above, views of the permanent access track realignment on the south-eastern face of Bob's Peak will be contained to public and private viewpoints to the south and east of the Site including Queenstown Hill, Queenstown township, and Queenstown Gardens. The realignment of the track will be viewed in the context of the existing earthworks and forestry trails on the slopes of Bob's Peak, and the modifications associated with the Skyline development. Views of the works within Reavers catchment will be limited, with temporary long-distance views of the upper debris flow visible from Gorge Road, and limited tree removal associated with the construction of the tracks. The remainder of the proposal will be curtailed by intervening forest.

Limited removal of exotic conifer trees is proposed within the Ben Lomond Sub Zone. This is largely due to the slip which occurred in September 2023 which cleared the south-eastern face

of Bob's Peak. Tree removal within the Reavers catchment will be limited to the footprint and battered slopes associated within the permanent and temporary access tracks. Tree removal within the forest will not detract from the coherent land cover currently present.

38.15.1 Outstanding Natural Features and Outstanding Natural Landscapes (ONF and ONL).

Under the Proposed Queenstown Lakes District Plan the proposed activity is considered a non-complying activity. Nevertheless, Landscape Assessment Matters for Discretionary Activities in the Open Space and Recreation Zones is still considered relevant to this assessment and has been assessed below.

38.15.1.1 Effects on landscape quality and character

In considering whether the proposed development will maintain or enhance the quality and character of Outstanding Natural Features and Landscapes, the Council shall be satisfied of the extent to which the proposed development will affect landscape quality and character, taking into account the following elements:

a. Physical attributes:
- *Geological, topographical, geographic elements in the context of whether these formative processes have a profound influence on landscape character;*
- *Vegetation (exotic and indigenous);*
- *The presence of waterbodies including lakes, rivers, streams, wetlands.*

b. Visual attributes:
- *Legibility or expressiveness – how obviously the feature or landscape demonstrates its formative processes;*
- *Aesthetic values including memorability and naturalness;*
- *Transient values including values at certain times of the day or year;*
- *Human influence and management – settlements, land management patterns, buildings, roads.*

c. Appreciation and cultural attributes:
- *Whether the elements identified in (a) and (b) are shared and recognised;*
- *Cultural and spiritual values for Tangata whenua;*
- *Historical and heritage associations.*

The Council acknowledges that Tangata Whenua beliefs and values for a specific location may not be known without input from iwi.

d. In the context of (a) to (c) above, the degree to which the proposed activity or development will affect the existing landscape quality and character, including whether the proposed activity or development accords with or degrades landscape quality and character, and to what degree.

This has been addressed within 3.3.45 above.

38.15.1.2 Effects on Visual Amenity

In considering whether the potential visibility of the proposed activity or development will maintain and enhance visual amenity, values the Council shall be satisfied that:

a. *The extent to which the proposed activity or development detracts from visual amenity values as viewed from public roads and other public places;*

b. *The proposed development will not be visually prominent such that it detracts from public or private views of and within Outstanding Natural Features and Landscapes;*

c. *The proposal will be appropriately integrated, screened or hidden from view by elements that are in keeping with the character of the landscape;*

d. *The proposed activity or development will not reduce the visual amenity values of the wider landscape (not just the immediate landscape);*

e. *Structures will not be located where they will break the line and form of any ridges, hills and slopes;*

f. *Any carparking, access, lighting, earthworks and landscaping will not reduce the visual amenity of the landscape.*

The proposal will include the introduction of permanent and temporary tracks within the Douglas fir forest on the north-eastern slopes of the hill and exposed south-eastern face of Bob's Peak. In addition, temporary structures and modifications will include the installation of the debris flow barrier, and use of a spider excavator, excavator, trucks, and helicopters to remove the debris from the hill side.

As addressed in Section 4.0 above, views of the Site are largely curtailed by intervening forestry on the north-eastern slopes of Bob's Peak for properties and public viewpoints on the northern fringes of Queenstown township. Long distance views of the upper slip are able to be obtained from Gorge Road and Queenstown Hill, while views of the south-eastern face of Bob's Peak can be obtained from Queenstown township, the lower slopes of Queenstown Hill, and Queenstown Gardens.

The proposed development and temporary works associated with the debris removal will not detract from the visual amenity values, and landscape values associated with the Western Whakatipu ONL. Views to the permanent and temporary tracks, and debris flow barrier will be largely curtailed by intervening vegetation on the north-eastern slopes of Bob's Peak, while temporary works on the upper slope will be visible at a long distance. The tracks will broadly follow the topography of the landform, with cut and fill material contoured to integrate the tracks into the existing landform. Works associated with the south-eastern face of Bob's Peak, while visible from public and private viewpoints along the sections outside the forest will not break the line of any ridges, hills or slopes. The works will also be viewed in the context of the wider Skyline development and existing forestry tracks.

38.15.3 Other factors and positive effects, applicable in all the landscape categories

38.15.3.1 The extent to which the proposed activity or development detracts from or enhances the amenity of the Open Space Zone and wider natural or rural environment with particular regard to the experience of remoteness or wildness.

The realignment of the permanent access track on the south-eastern face of Bob's Peak will have limited effects on the amenity of the Open Space Zone (Informal Recreation) and wider natural environment. Much of the proposal is curtailed from views within the Douglas fir forest on the north-eastern slopes of Bob's Peak, while the proposed works on the south-eastern face are located within the context of existing forestry tracks, and Skyline gondola corridor.

Effects on amenity and landscape character are considered no greater than **low adverse** (less than minor)**,** reducing to **very low adverse** on completion. The proposed modifications are not considered out of character within the context of the Skyline development and are largely temporary. The forested slopes will also be retained throughout the duration of the debris removal.

38.15.3.2 The extent to which cumulative effects of activities will adversely affect landscape quality, character or visual amenity values.

The proposed development will include the construction of permanent and temporary access tracks, and temporary installation and use of a debris flow barrier. This also includes the associated machinery and vehicles which will be required to remove the debris from the hill side and earthworks required to form the access tracks, including recontouring the battered slopes into the landform.

The proposal includes a series of temporary modifications which will then be removed or remediated on completion of the debris removal. The realignment of the permanent access tracks, and temporary track construction within the Reavers catchment and south-eastern face of Bob's Peak will increase the amount of tracking within the area. Nevertheless, the tracks proposed are not out of character within the broader context of the Site and largely curtailed by intervening forest.

Overall, cumulative effects of this proposal are considered no greater than **low adverse (less than minor)** reducing to **very low adverse** on completion.

6.0 Recommendations

As described throughout this assessment, there is no mitigation required to reduce the landscape effects of the proposed debris removal, largely due to the dense Douglas fir forest which curtails views of much of the Site including the debris flow works, and proposed tracks. Nevertheless, as identified within the above assessment the proposal will include earthworks on an exposed face of Bob's Peak (within the gondola corridor), including the cut and recontouring of the landform to accommodate proposed permanent access tracks.

To soften the earthworks associated with the construction of the permanent access tracks within Reavers catchment, it is recommended that where feasible on the battered slopes, earthworks will be scarified and hydroseeded with grass as soon as practicable after construction. This will reduce visibility of the ground disturbance and provide some immediate surface and soil stability.

7.0 Conclusion

This assessment addresses the landscape effects of the proposed debris removal, and track construction on the north-eastern and south-eastern face of Bob's Peak, Queenstown.

The proposal is located within and in proximity of an area of existing modification associated with the Skyline Queenstown development, including the gondola, upper and lower terminals, luge, mountain bike, and walking tracks. It is located within the Western Whakatipu Outstanding Natural Landscape which encompasses the steep south-eastern mountain slopes of Te Taumata o Hakitekura (Ben Lomond), the steep south and eastern mountain slopes of Bowen Peak and the two elevated roche moutonnée landforms of Te Tapunui (Queenstown Hill and including Sugar Loaf).

The majority of works associated with this proposal are located within the Reavers Creek catchment on the north-eastern face of Bob's Peak. Views of the Reavers Creek catchment are largely curtailed by the mature Douglas fir forest, and intervening topography. Earthworks are also proposed on the exposed south-eastern face of Bob's Peak and entail the realignment of one existing access track. While views of the clear-felled south-eastern face are available, they will occur in the context of the Skyline gondola cableway, ongoing construction work associated with Skyline's redevelopment, and existing forestry tracks. Visual effects from both public and private viewpoints are no greater than **low adverse (less than minor)** and reduce to **very low adverse** on completion of the proposal. This is due to the temporary nature of the works, coupled with the majority of the proposal being screened throughout the duration of the debris flow removal.

Effects on landscape character are no greater than **low adverse (less than minor),** reducing to **very low adverse** on completion. The proposal is largely contained to an existing area of development and modification associated with the Skyline gondola corridor and terminals, as recognised with in the Western Whakatipu Priority Area Schedule. Temporary earthworks associated with the debris removal will be remediated on completion, while the permanent access track realignment will not appear out of character in the context of the wider Skyline development, existing forestry tracks, and exposed slopes of Bob's Peak.

Finally, it is noted that while natural character effects have been assessed, these are considered **neutral**. The proposal will be undertaken on the upper slopes of Bob's Peak and within the existing debris flow, away from the active bed and margins of Reavers Creek.

8.0 Appendix 1: Method Statement

22 November 2023

This assessment method statement is consistent with the methodology (high-level system of concepts, principles, and approaches) of 'Te Tangi a te Manu: Aotearoa New Zealand Landscape Assessment Guidelines', Tuia Pito Ora New Zealand Institute of Landscape Architects, July 2022. The assessment provides separate chapters to discuss landscape, visual and natural character effects where relevant, but is referred to throughout as a Landscape Effects Assessment in accordance with these Guidelines. Specifically, the assessment of effects has examined the following:

- *The existing landscape;*
- *The nature of effect;*
- *The level of effect; and*
- *The significance of effect.*

The Existing Landscape

The first step of assessment entails examining the existing landscape in which potential effects may occur. This aspect of the assessment describes and interprets the specific landscape character and values which may be impacted by the proposal alongside its natural character where relevant as set out further below. The existing landscape is assessed at a scale(s) commensurate with the potential nature of effects. It includes an understanding of the visual catchment and viewing audience relating to the proposal including key representative public views. This aspect of the assessment entails both desk-top review (including drawing upon area-based landscape assessments where available) and field work/site surveys to examine and describe the specific factors and interplay of relevant attributes or dimensions, as follows:

Physical –relevant natural and human features and processes;

Perceptual –direct human sensory experience and its broader interpretation; and

Associative – intangible meanings and associations that influence how places are perceived.

Engagement with tāngata whenua

As part of the analysis of the existing landscape, the assessment should seek to identify relevant mana whenua (where possible) and describe the nature and extent of engagement, together with any relevant sources informing an understanding of the existing landscape from a Te Ao Māori perspective.

Statutory and Non-Statutory Provisions

The relevant provisions facilitating change also influence the consequent nature and level of effects. Relevant provisions encompass objectives and policies drawn from a broader analysis of the statutory context and which may anticipate change and certain outcomes for identified landscape values.

The Nature of Effect

The nature of effect assesses the outcome of the proposal within the landscape. The nature of effect is considered in terms of whether effects are positive (beneficial) or negative (adverse) in the context within which they occur. Neutral effects may also occur where landscape or visual change is benign.

It should be emphasised that a change in a landscape (or view of a landscape) does not, of itself, necessarily constitute an adverse landscape effect. Landscapes are dynamic and are constantly changing in both subtle and more dramatic transformational ways; these changes are both natural and human induced. What is important when assessing and managing landscape change is that adverse effects are avoided or sufficiently mitigated to ameliorate adverse effects. The aim is to maintain or enhance the environment through appropriate design outcomes, recognising that both the nature and level of effects may change over time.

The Level of Effect

Where the nature of effect is assessed as **'adverse'**, the assessment quantifies the level (degree or magnitude) of adverse effect. The level of effect has not been quantified where the nature of effect is neutral or beneficial. Assessing the level of effect entails professional judgement based on expertise and experience provided with explanations and reasons. The identified level of adverse natural character, landscape and visual effects adopts a universal seven-point scale from **very low** to **very high** consistent with Te Tangi a te Manu Guidelines and reproduced below.

Landscape Effects

A landscape effect relates to the change on a landscape's character and its inherent values and in the context of what change can be anticipated in that landscape in relation to relevant zoning and policy. The level of effect is influenced by the size or spatial scale, geographical extent, duration and reversibility of landscape change on the characteristics and values within the specific context in which they occur.

Visual Effects

Visual effects are a subset of landscape effects. They are consequence of changes to landscape values as experienced in views. To assess where visual effects of the proposal may occur requires an identification of the area from where the proposal may be visible from, and the specific viewing audience(s) affected. Visual effects are assessed with respect to landscape character and values. This can be influenced by several factors such as distance, orientation of the view, duration, extent of view occupied, screening and backdrop, as well as the potential change that could be anticipated in the view as a result of zone / policy provisions of relevant statutory plans.

Natural Character Effects

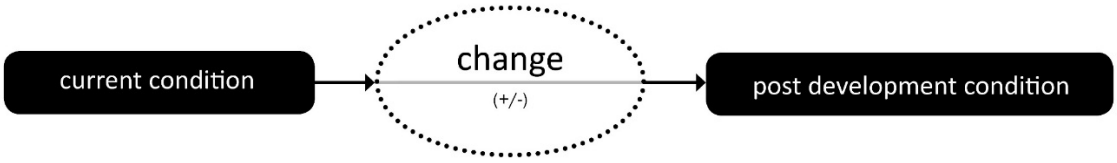
Natural Character, under the RMA, specifically relates to *'the preservation of the natural character of the coastal environment (including the coastal marine area), wetlands, and lakes and rivers and their margins, and the protection of them from inappropriate subdivision, use, and development'*. Therefore, the assessment of natural character effects only involves examining the proposed changes to natural elements, patterns and process which may occur in relevant landscape / seascape contexts.

As with assessing landscape effects, the first step when assessing natural character effects involves identifying the relevant physical and experiential characteristics and qualities which

occur and may be affected by a proposal at a commensurate scale. This can be supported through the input of technical disciplines such as geomorphology, hydrology, marine, freshwater, and terrestrial ecology as well as input from tāngata whenua. An understanding of natural character considers the level of naturalness and essentially reflects the current condition of the environment assessed in relation to the seven-point scale. A higher level of natural character means the waterbody and/or margin is less modified and vice versa.

A natural character effect is a change to the current condition of parts of the environment where natural character occurs. Change can be negative or positive. The resultant natural character effect is influenced by the existing level of naturalness within which change is proposed; a greater level of effect will generally occur when the proposal reduces the naturalness of a less modified environment. In short, the process of assessing natural character effects can be summarised as follows:

- Identify the characteristics and qualities which contribute to natural character within a relevant context and defined spatial scale(s), including the existing level of naturalness;
- Describe the changes to identified characteristics and qualities and the consequent level of natural character anticipated (post proposal); and
- Determine the overall level of effect based on the consequence of change.



The Significance of Effects

Decision makers assessing resource consent applications must evaluate if the effect on individuals or the environment is less than minor[3] or if an adverse effect on the environment is no more than minor[4]. For non-complying activities, consent can only be granted if the s104D 'gateway test' is satisfied, ensuring adverse effects are minor or align with planning objectives. In these situations, the assessment may be required to translate the level of effect in terms of RMA terminology.

This assessment has adopted the following scale applied to relevant RMA circumstances[5] (refer to diagram below), acknowledging low and very low adverse effects generally equate to 'less than minor' and high / very high effects generally equate to significant[6].

[3] RMA, Section 95E

[4] RMA, Section 95E

[5] Seven-point level of effect scale. Source: Te tangi a te Manu, Pg. 15

[6] The term 'significant adverse effects' applies to specific RMA situations, including the consideration of alternatives for Notices of Requirement and AEEs, as well as assessing natural character effects under the NZ Coastal Policy Statement.

Together. Shaping Better Places.

Boffa Miskell is a leading New Zealand environmental consultancy with nine offices throughout Aotearoa. We work with a wide range of local, international private and public sector clients in the areas of planning, urban design, landscape architecture, landscape planning, ecology, biosecurity, Te Hīhiri (cultural advisory), engagement, transport advisory, climate change, graphics, and mapping. Over the past five decades we have built a reputation for creativity, professionalism, innovation, and excellence by understanding each project's interconnections with the wider environmental, social, cultural, and economic context.

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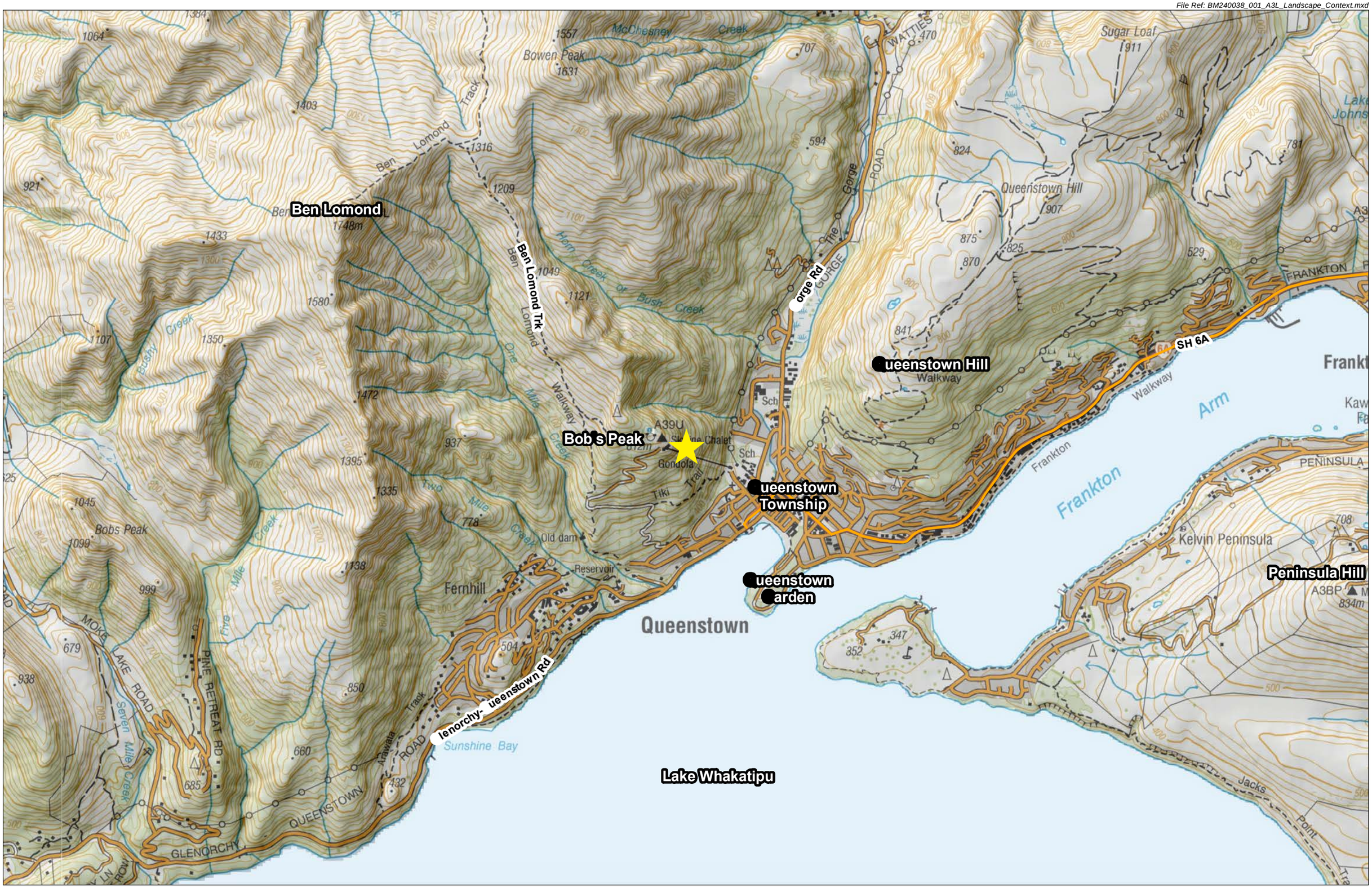
REAVERS CATCHMENT DEBRIS REMOVAL

GRAPHIC SUPPLEMENT

21 AUGUST 2024

CONTENTS



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Data Sources:
LINZ Data Service.

Projection: NZGD 2000 New Zealand Transverse Mercator

LE END

The Site

State Highway 6A

Reavers Catchment Debris Removal

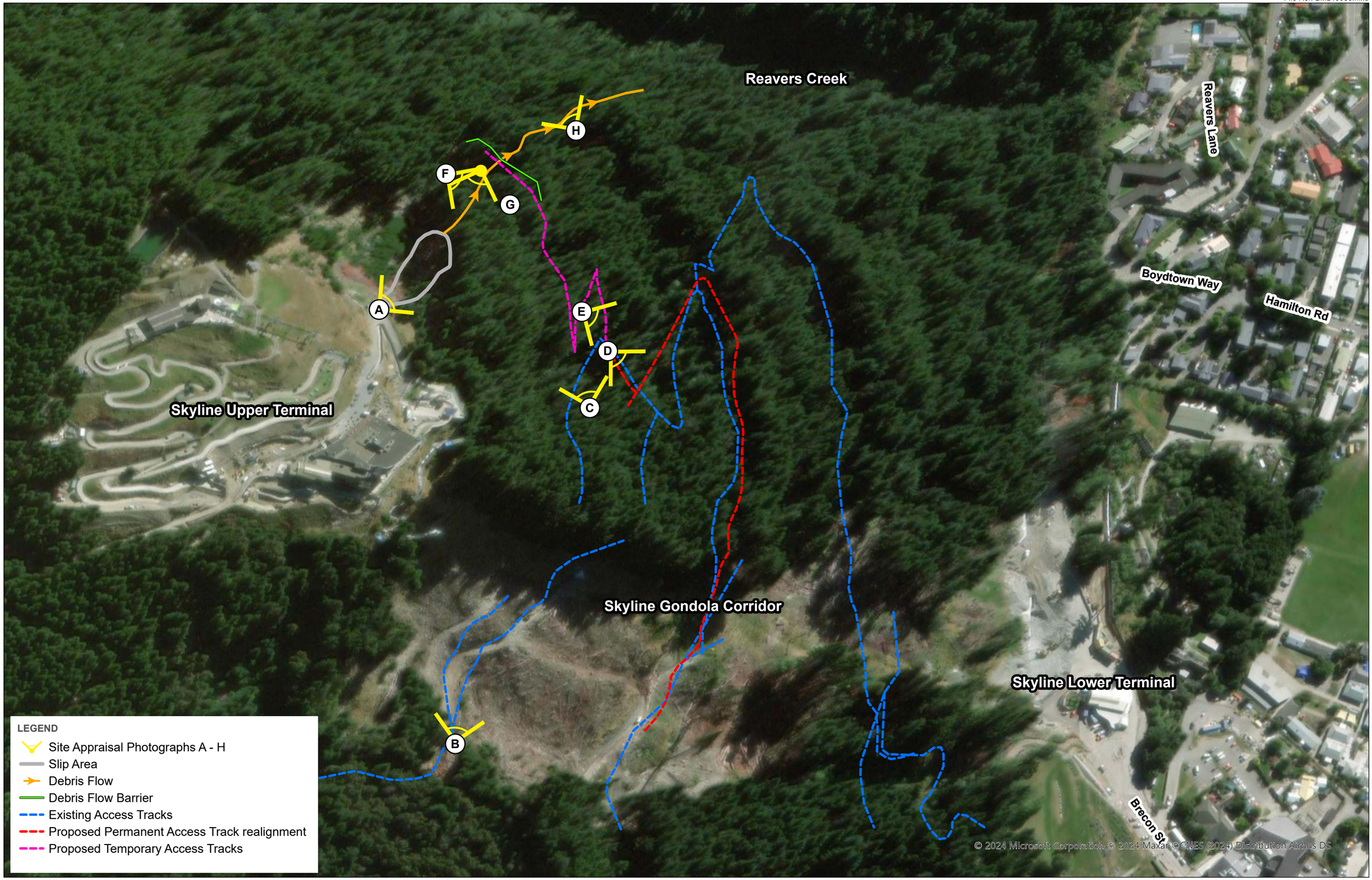
Landscape Context

Date: 01 February 2024 | Revision: 0

Plan prepared for Queenstown Lakes District Council by Boffa Miskell Limited

Project Manager: Hannah.Wilson@boffamiskell.co.nz | Drawn: SCh | Checked: HWi

Figure 1



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Data Sources:
Bing Map, and LINZ Data Service.

Projection: NZGD 2000 New Zealand Transverse Mercator

Reavers Catchment Debris Removal

Site Appraisal

Date: 20 August 2024 | Revision: 2

Plan prepared for Queenstown Lakes District Council by Boffa Miskell Limited

Project Manager: Hannah,Wilson@boffamiskell.co.nz | Drawn: SCh | Checked: HWi

Figure 2