Before the Independent Hearing Panel

In the Matter	of the Resource Management Act 1991 (**RMA**)
And	
In the Matter	of an application to the Central Otago District Council and Otago Regional Council for resource consent to establish and operate a gold mining activity at 1346 – 1536 Teviot Road, Millers Flat
Reference	RC230325 (Central Otago District Council) RM23.819 (Otago Regional Council)

Evidence of Colin Macdiarmid on behalf Hawkeswood Mining Limited

(Geotech and Temporary Batter Slope Stability)

Dated 29 April 2024

Jeremy Brabant

Barrister

Foundry Chambers

Level 4, Vulcan Buildings

PO Box 1502, Shortland St

Auckland City

021 494 506

Email: jeremy@brabant.co.nz

Introduction

1. My full name is Colin Macdiarmid. I am a Principal Geotechnical Engineer at GeoSolve Limited, a specialist geotechnical consultancy based in Otago.

2. I am a Chartered Professional Engineer and hold the following qualification and memberships.

    a. MEng Civil Engineering with Geology, University of Glasgow (1st);

    b. Chartered Member of the Institute of Professional Engineers New Zealand (CMEngNZ);

    c. Member Institution of Civil Engineers UK (MICE);

    d. Chartered Professional Engineer UK and New Zealand (CPEng).

3. I have over 25 years' experience as a geotechnical engineer, working in New Zealand, Australia, the United Kingdom and various other countries worldwide.

4. I have worked on a number of similar projects including geotechnical assessment of the proposed alluvial gold mine at Winding Creek in Southland as well as the geotechnical assessment of a number of existing sand and gravel quarries in Central Otago in similar ground conditions.

5. I was instructed by Hawkeswood Civil Limited in February 2024 to undertake a slope stability analysis of temporary mine batters parallel to Teviot Road for the proposed gold mining activity. I am familiar with the area to which the application for resource consent relates.

6. I have prepared a letter report titled *"Slope Stability Analysis – Temporary Mine Batters, Millers Flat Goldmine, 1346-1536 Teviot Road"* dated 29 April 2024, which is appended to this evidence.

7. Although this is not a hearing before the Environment Court, I record that I have read and agree to and abide by the Environment Court's Code of Conduct for Expert Witnesses as specified in the Environment Court's

Practice Note 2023. This evidence is within my area of expertise, except where I state that I rely upon the evidence of other expert witnesses as presented to this hearing. I have not omitted to consider any material facts known to me that might alter or detract from the opinions expressed.

Scope of Evidence

8. The appended report provides full details of the assessment carried out and should be read in conjunction with this evidence.

9. My evidence will address the following:

    a. The ground conditions at the site;

    b. Comments on precedent performance of existing batters at the site;

    c. Slope stability analysis with respect to Teviot Road; and

    d. Suitable slope angle for temporary batter cuts formed parallel to Teviot Road reserve;

Ground Conditions

10. Site observations by myself and other Geosolve staff of the existing trial excavation and borehole data supplied by the applicant were used to assess the ground conditions at the site.

11. The stratigraphy of the site is very simple:

    a. Tightly packed outwash gravels comprising sandy GRAVEL with cobbles and boulders. These deposits are between 12 and 20 m thick and contain the gold bearing horizons which the mine is targeting.

    b. Schist bedrock underlies the gravel and extends to significant depth.

12. Groundwater sits around 5 m above the schist level, and this will be temporarily drawn down to 3 m above rock during mining activities.

Existing Batters at the Site

13. The test pit at the site provides a working example of batter cuts which can be achieved within the onsite outwash deposits. The existing batters have an overall slope inclination of between 60-70˚. These batters have been left open for around 6 months and exhibited no signs of instability apart from minor superficial erosion and fretting.

Slope Stability Modelling

14. I completed slope stability analysis using the cross-section ground models contained with the report to determine suitable temporary batters adjacent Teviot Road within the outwash deposits.

15. The key data inputs used in my analysis (soil parameters, seismic loading, surcharges etc.) are provided in the appended report. The target factors of safety with respect to Teviot Road are also provided in the report.

Recommended Temporary Batter Angles Adjacent to Teviot Road

16. The batter angles for the proposed cut were adjusted within the model until the target factors of safety were achieved for all loading scenarios.

17. The analysis indicates that:

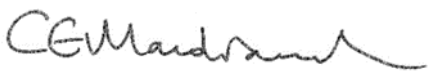
    a. At the overall batter slope of 45˚ parallel to Teviot Road safety factors at the edge of the road reserve meet the above targets using the proposed 7.5 m offset to the crest of the batters.

18. The mine path will need to advance through Stages 1 & 2 long before batter cuts are opened alongside Teviot Road. This will afford the Applicant ample opportunity to experience firsthand the performance of temporary outwash batters. Geotechnical review of batter performance will enable the above analysis and recommended slope angles to be refined.

Conclusions

19. Overall batter angles of 45 degrees are suitable for the temporary batter slopes adjacent to Teviot Road for the proposed 7.5 m offset from the crest of the batters to the road reserve.

20. It will be possible to review these recommendations as the mine is developed and the performance of batter slopes can be reviewed. Additionally, if the proposed offset were to change the recommendations could be updated.



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Colin Macdiarmid

Dated 29 April 2024

Attachment: Geosolve Letter Report

GeoSolve Ref: 230526.01
29 April 2024

Hawkeswood Civil Limited
399 Whitford Park Road,
Auckland 2576

Attention: Simon Johnstone

Slope Stability Analysis - Temporary Mine Batters
Millers Flat Goldmine, 1346-1536 Teviot Road

1. Introduction

This report presents the results of a slope stability analysis completed by GeoSolve Limited for an alluvial goldmine on 1346-1536 Teviot Road, Millers Flat. The purpose of the analysis is to provide recommendations on the formation of temporary batters adjacent Teviot Road based on the supplied setback distances. This report is intended to inform mine planning alongside Teviot Road and to support an application for resource consent.

Photo 1. Panoramic view of the existing test pit at 1346-1536 Teviot Road (17/02/2024).

This report has been commissioned by Hawkeswood Civil Limited in accordance with GeoSolve Ltd.'s proposal (ref no. 230526.01) dated 14th of December 2023, which outlines the scope of work and conditions of engagement.

2. Proposed Activity

We have reviewed the Applicants supplied mining methodology which describes the proposed activity. An opencast pit, comprising two separate stages (Stages 2 & 3), will form temporary batters parallel with Teviot Road, a Council administered asset. The vertical height of the adjacent batters will vary but generally range between 15 and 19 m.

Mining will commence within the test pitting (Stage 1), as shown in Photo 1, before advancing towards Stage 2. Stripping of overburden soils, mining of wash gravel and backfilling of the open pit will occur contiguously so that only short sections of batter remain open during the mining process, rather than their full length.

The mine layout and staging plan, as applied for consent, is attached as Figure 2, with relevant features annotated. The existing ground surface through Teviot Road, relative to projected batter cuts, is shown on the geological cross-sections presented on Figures 2a-2c attached.

3. Topography

Existing topography along Teviot Road and the surrounding area of influence is sub-horizontal. The excavation depth or floor of the mine pit will follow the basement bedrock contact between 15 and 19 m below ground level. Upon the completion of mining, batters adjacent Teviot Road will be backfilled, and the site topography returned similar to existing.

4. Subsurface Stratigraphy

4.1 Ground Conditions

GeoSolve visited the mine site on 17/02/2024 to gain an understanding of the prevailing geotechnical conditions to inform the analysis. The existing test pit was of particular focus. The Applicant also supplied existing exploration borehole data for review to confirm the deep ground model adjacent the road reserve.

Subsurface soils observed within the test pit area comprise medium dense (tightly packed) outwash gravel to the full depth of the existing pit, as shown below in Photo 2. A general log of the outwash soils was made during our inspection and comprises the following:

- Sandy GRAVEL to sandy cobbly GRAVEL with rare boulders.

Some thin layers of outwash sand are also present within the pit walls, albeit discontinuous. The outwash gravels exhibit a relatively high degree of apparent soil cohesion enabling batter cuts to be over-steepened beyond the natural repose angle (refer Photo 2 below). The outwash deposits are underlain by regionally extensive schist bedrock which will form the termination depth of the mine pit. Bedding within the outwash terrace is generally expected to be sub-horizontal.

Photo 2. Outwash gravel exposed in a bench cut within the test pit. This particular face is 4 m high and cut sub-vertically. Geological hammer for scale in the centre of image.

4.2 Groundwater

The groundwater model beneath Teviot Road and how that relates to batter slope stability is relatively straightforward. Observations of the test pit pond and exploration borehole logs indicate the static groundwater table is relatively flat lying and coincides with Clutha River level. Cut slopes exposed within the test pit were in a dry condition. Perched groundwater flows or seepages from batter cuts alongside Teviot Road and above the static groundwater table are unlikely in this terrain.

The mining method requires a temporary draw-down of the static groundwater table to around 3 m above the bedrock contact to facilitate processing of the wash gravel layer. This is indicated on the geological cross-sections attached.

5. Existing Batter Precedent

The test pit on site, provides a working example of batter cuts which can be achieved within the onsite outwash deposits. The batters within the test pit were created by forming a series of stepped sub-vertical benches with an overall slope inclination of between 60-70˚. The pumped groundwater table below coincides with the wash gravel layer targeted for processing via the floating recovery plant.

The batter cuts within the test pit were left open for around 6 months without any slope instability before being re-buttressed with backfill. Existing slopes within the test pit on the northwestern edge of the pond have also remained open since at least November of 2022, close to 18 months prior to our inspection on 17/02/2024. Despite this, there are no signs of significant instability other than superficial erosion and fretting of the free face.

6. Slope Stability Analysis

Slope stability analysis was completed using the cross-section ground models and the computer software programme Slide2 to determine suitable temporary batters adjacent Teviot Road within the outwash deposits. Soil and rock parameters used in the analysis, have been assigned from site observations and back analysis of precedent batters using Slide2. The soil parameters presented below in Table 1 are consistent with our previous experience in similar outwash soils exposed elsewhere alongside the Clutha catchment.

Table 1 – Geotechnical Soil and Rock Parameters used in the Slope Stability Analysis.

Geological Unit	Bulk Density γ (kN/m^3)	Effective Cohesion c' (kPa)	Effective Friction ϕ' (deg)
Q2a Outwash Gravel	20	10	38
Schist Bedrock	26	100	30

Back analysis of those slopes within the test pit established a credible limit for the outwash gravel parameters of 18 kPa cohesion and a 38˚ friction angle for a 70˚ slope prior to failure under static conditions. However, we consider these parameters to be an upper bound for what can be expected of this soil type, we have therefore adopted a more conservative cohesion for the analysis.

The geological cross-section models reviewed as part of the assessment are attached, although only cross-section B (Figure 2c) was analysed as this cross-section represents the worst-case scenario in terms of depth to bedrock and overall batter height.

The following slope stability scenarios have been analysed:

- **Static Case** – No seismic loading;
- **Importance Level 1 (IL1)** – Earthquake equivalent to a 1/25-year annual probability of exceedance (AEP); and,
- **Importance Level 2 (IL2)** – Earthquake equivalent to a 1/100-year AEP.

Design events for the analysis have been developed from Module 1 of the NZGS/MBIE guidelines for Earthquake Geotechnical Engineering Practice (Nov. 2021) and Table 3.3 of NZS 1170.0:2002 Structural Design Actions. The previous procedure from the NZTA Bridge Manual was also used to rationalise peak horizontal ground accelerations for Millers Flat. The importance level cases listed above include both serviceability and ultimate limit states and assume temporary batters adjacent Teviot Road will be exposed for less than 6 months.

We have modelled the surcharge from Teviot Road and a soil bund at the batter crest based on the bund profile and setbacks supplied by the Applicant, as shown on Figures 2a-2c. We understand the bund is required for visual screening of the mine site; however, the bund applies loading to the crest of the slope and decreases stability. The provided setback between Teviot Road and the batter crest is around 7.5 m.

The following target factors of safety have been adopted.

Table 2 – Target Factors of Safety.

Scenario	Slip Circles Affecting Teviot Road Reserve
Static Loading (temporary case)	>1.4
25-year AEP (0.07 g)	>1.1
100-year AEP (0.13 g)	>1.0

The analysis indicates that:

- An improvement of safety factors, albeit marginally, is achieved via temporary draw-down of the static groundwater table within the mine pond adjacent the free face;
- At the overall batter slope of 45˚ parallel to Teviot Road, as drawn on the cross-sections, safety factors at the edge of the road reserve meet the above targets.

Bedding structure within the outwash gravel is not conducive to facilitating mass slope failure nor is any failure expected to initiate within the underlying schist bedrock. The mine path will need to advance through Stages 1 & 2 long before batter cuts are opened alongside Teviot Road. This will afford the Applicant ample opportunity to experience firsthand the precedent performance of temporary outwash batters and how that relates to their mining method. Geotechnical review of batter performance will enable the above analysis and recommended slope angles to be refined.

The effects of seiching (wave erosion) along the toe of the batter within the mine pond should be noted through the course of mining within Stages 1 & 2. If a significant failure of temporary batters were to occur, prior to reaching Teviot Road, it is important that GeoSolve inspect this failure to inform and re-assess our existing analysis, if required.

7. Discussion

Criteria adopted for the slope analysis assumes batter cuts will be exposed for a period of less than 6 months alongside Teviot Road. Indeed, the Applicants intention is to minimise the length of time batters are kept open by preferentially backfilling the active pit below the road. The progressive re-buttressing of batters along the toe, by even a few meters, will gradually increase slope safety factors.

If a sudden slope failure were to occur in batters cut to 45˚ or less, it is likely to be triggered by a key event such as prolonged heavy rainfall or a significant earthquake. Saturation causes a reduction of shear strength as the wetting front descends through the soil profile whereas seismic events increase the destabilising load on the soil mass. The cohesive nature of the outwash deposits and bedding structure is not conducive to facilitating mass failure of cut slopes without some prior notable destabilising event.

8. Geotechnical Considerations and Recommendations

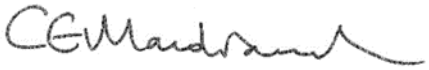
- It is recommended that GeoSolve review precedent batter performance during mining operations within Stages 1 & 2 to allow the above advice to be refined.
- The length of time batter cuts are kept open below Teviot Road should be minimised to reduce the chance of a slope failure. This is readily achievable for the Applicant by preferentially backfilling against these batters within the active pit. This should be made a priority in the mine plan.
- GeoSolve should be notified if a continuous layer of outwash sand were to become exposed during formation of batters below the road as these soils will behave considerably different to outwash gravel, although this is considered unlikely.
- Mine staff should routinely check temporary batters and slope crests parallel with the road reserve for any signs of cracking or instability particularly following notable events such as prolonged heavy rainfall or an earthquake.
- Increasing the distance between the batter crest and visual soil bund beyond 1 m will reduce additional loading on the crest.
- In all instances site runoff should be considered, ensuring that it is directed away from the free face. In general, this can be achieved via positive grading of the surface beyond the batter crest and formation of shallow swale drains if necessary.
- GeoSolve should be contacted if subsoil or groundwater conditions vary from those currently described within this report as recommendations may need to be updated. Manuherikia Group Sediments are known to overly schist bedrock downstream of Millers Flat, although none appear to have been encountered in exploration drilling.

9. Applicability

This report has been prepared for the benefit of our client, Hawkeswood Civil 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 written agreement.

It is important that GeoSolve be contacted if there is any variation in subsoil or ground conditions from those described within this report.

Report prepared by:



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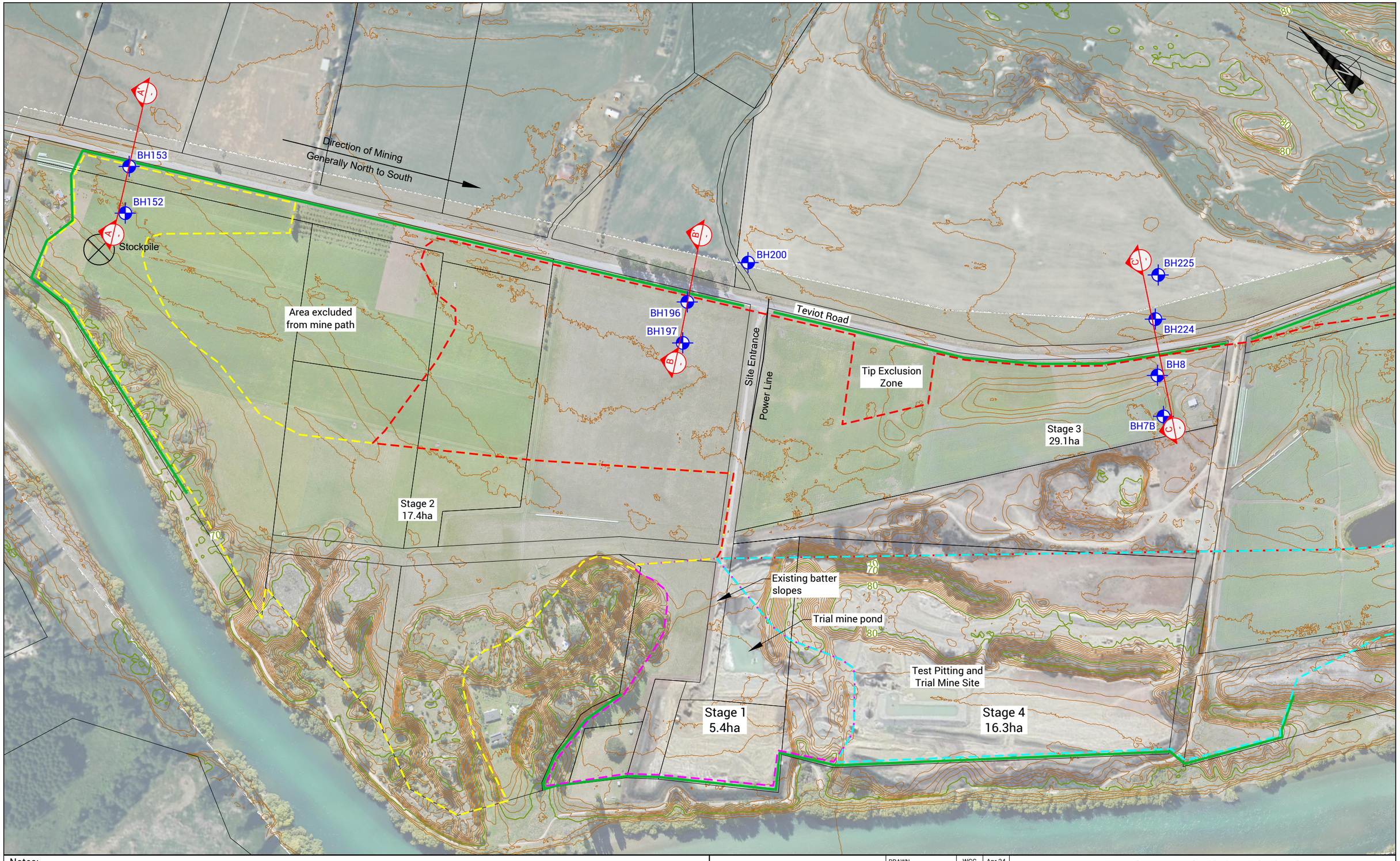
Colin Macdiarmid
Senior Geotechnical Engineer, CPEng

Attachments:

- Mine Layout and Staging Plan (Figure 1); and,
- Geological Cross-Sections (Figures 2a-2c).



Notes:

1. These drawings have been prepared for the benefit of Hawkeswood Mining 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.

Legend:

- Site contours, 10m Major interval, 1m Minor interval
- Visual Bunding
- Stage 1
- Stage 2
- Stage 3
- Stage 4
- Exploration Borehole Locations

SCALE 1:4000

0 40 80 120 160 200 (m)

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DRAWN	WCG	Apr.24
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APPROVED	CEM	Apr.24
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SCALES (AT A3 SIZE): 1:4000		
PROJECT No: 230526.01		

Hawkeswood Mining Limited

1346-1536 Teviot Road, Millers Flat

Slope Stability Analysis

Site Plan

FIG No: Appendix A, Figure 1

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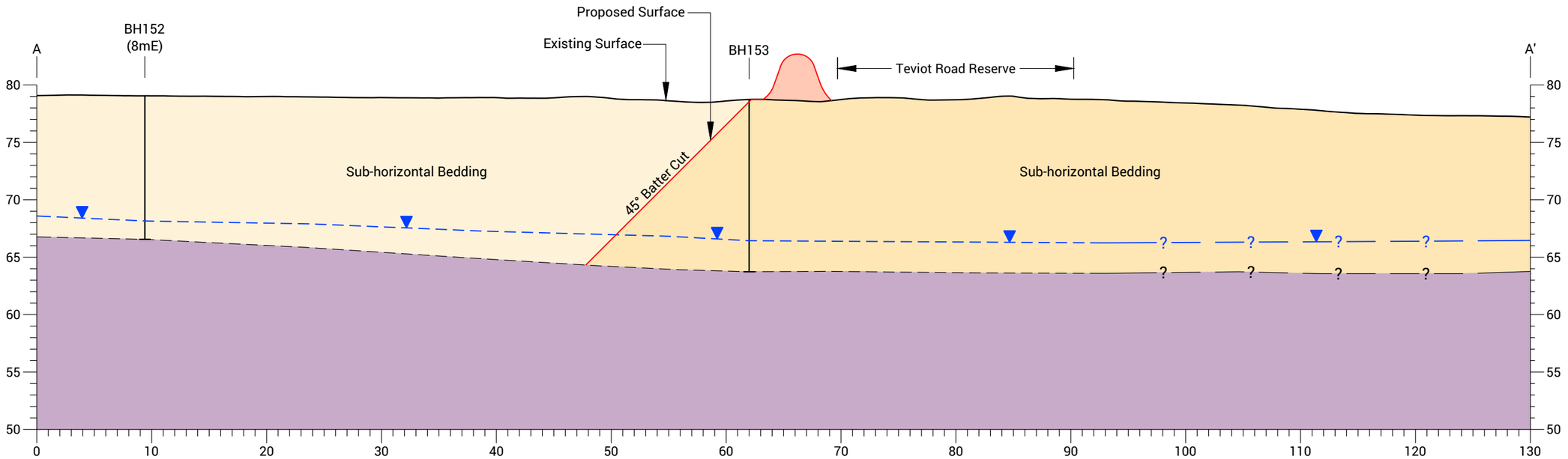

SCALE 1:400

0 4 8 12 16 20 (m)

Notes:

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Legend:

- Soil Bund
- Q2a Outwash Gravel
- Schist Bedrock
- Static Groundwater Table

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FIG No: Appendix A, Figure 2a

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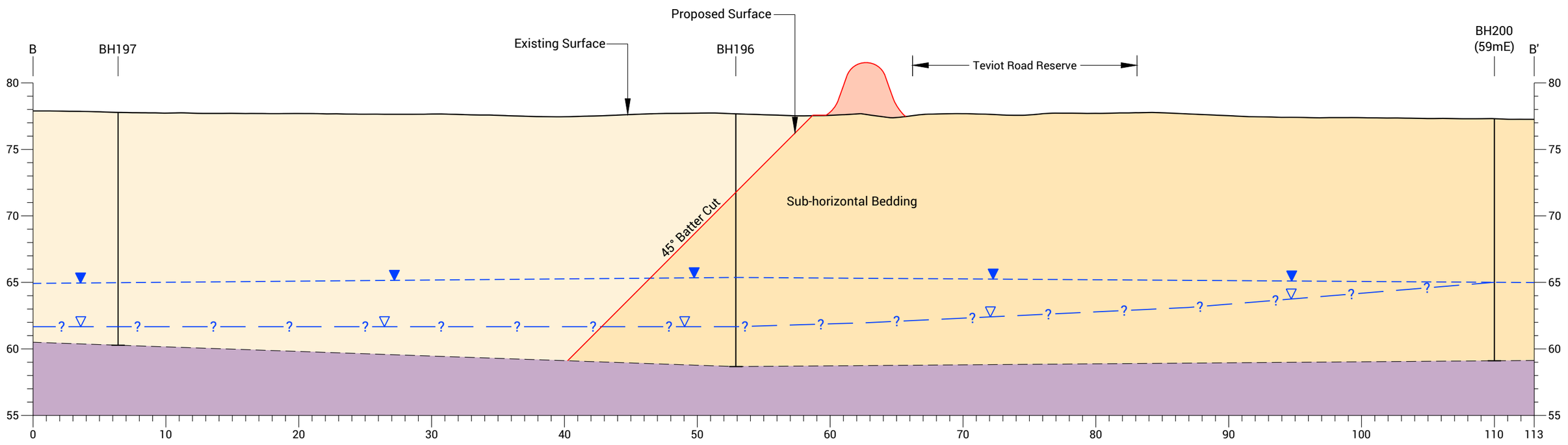
1346-1536 Teviot Road, Millers Flat

Slope Stability Analysis

Cross Section A



SCALE 1:300

0 3 6 9 12 15 (m)

Notes:

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Legend:

- Soil Bund
- Q2a Outwash Gravel
- Schist Bedrock
- Static Groundwater Table
- Pumped Groundwater Table

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Slope Stability Analysis

Cross Section B

FIG No: Appendix A, Figure 2b

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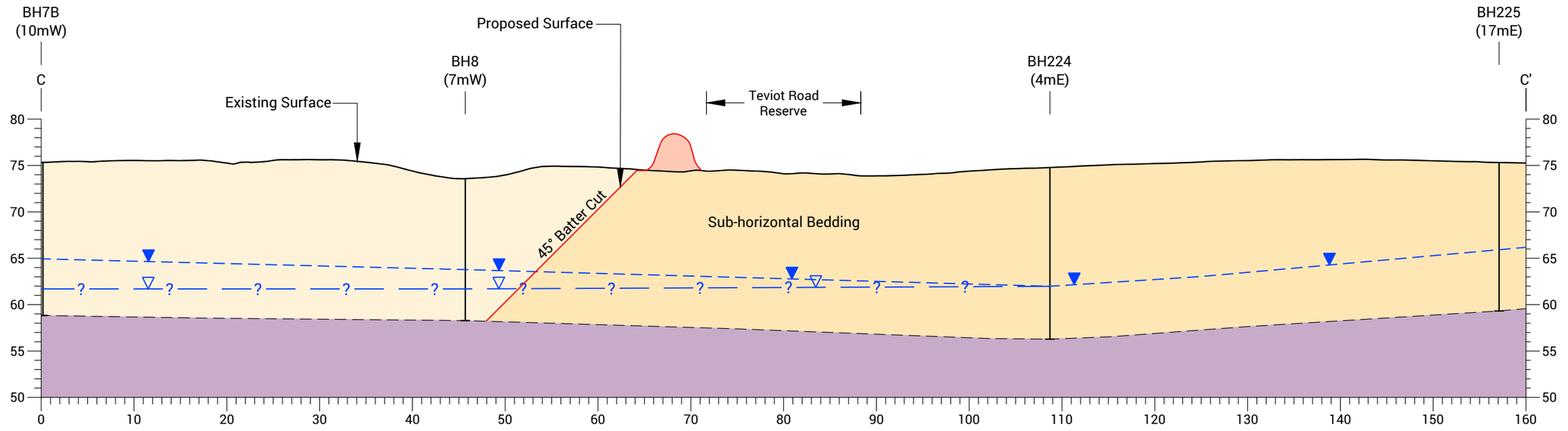

SCALE 1:500

0 5 10 15 20 25 (m)

Notes:

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Legend:

- Soil Bund
- Q2a Outwash Gravel
- Schist Bedrock
- Static Groundwater Table
- Pumped Groundwater Table

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Slope Stability Analysis

Cross Section C

FIG No: Appendix A, Figure 2c

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