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APPENDIX C

Pit Geotechnical Letter

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Our Ref: PSM71-245L

5 March 2020

Mine Planning Engineer
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Attention: Louie Herrero

Dear Louie

RE: DEEPDELL STAGE III - ADDITIONAL INFORMATION

1. Introduction

This letter presents the additional information requested by the Otago Regional Council (ORC) as summarised in your recent emails [(1)]. The two questions which were raised by the ORC from its review of our Deepdell Stage 3 report [(2)], are:

9. The Mohr-Coulomb strength parameters for intact schist are significantly different from those used for assessing the stability of the waste rock stack and Deepdell South backfill. Provide further discussion on the development of the adopted parameters and/or demonstrate that the stability objectives can be achieved with lower strength parameters.
10. (This question is in two parts)
    a. Comment on whether the potential for block failure (such as planar sliding, wedge failure, and toppling) under seismic conditions (has) been considered.
    b. Provide further information if this has been assessed, or justification if this assessment is not warranted.

Responses are provided in the following sections.

2. Strength Parameters

Firstly, intact rock is much stronger than waste rock and backfill.

The waste rock / backfill comprises broken rock that is transported by truck and dumped. It rills at slope angles of between 34 to 38°, slightly lower for oxidised schist, but overall typically 37°. Figure 1 shows a few typical examples. Conversely, intact rock mass is stable at much steeper angles. The poorest rock masses at Macraes can form stable 60° slopes, the better rock masses can be cut vertically, i.e. 90°. Figure 2 shows typical examples.

[(1)] Emails from Louie Herrero to Robert Bertuzzi dated 27th February and 2nd March 2020

[(2)] PSM, Geotechnical review of updated Deepdell Stage 3 pit, PSM71-238L, 12 June 2019

Figure 1: **Examples of waste rock and backfill.**

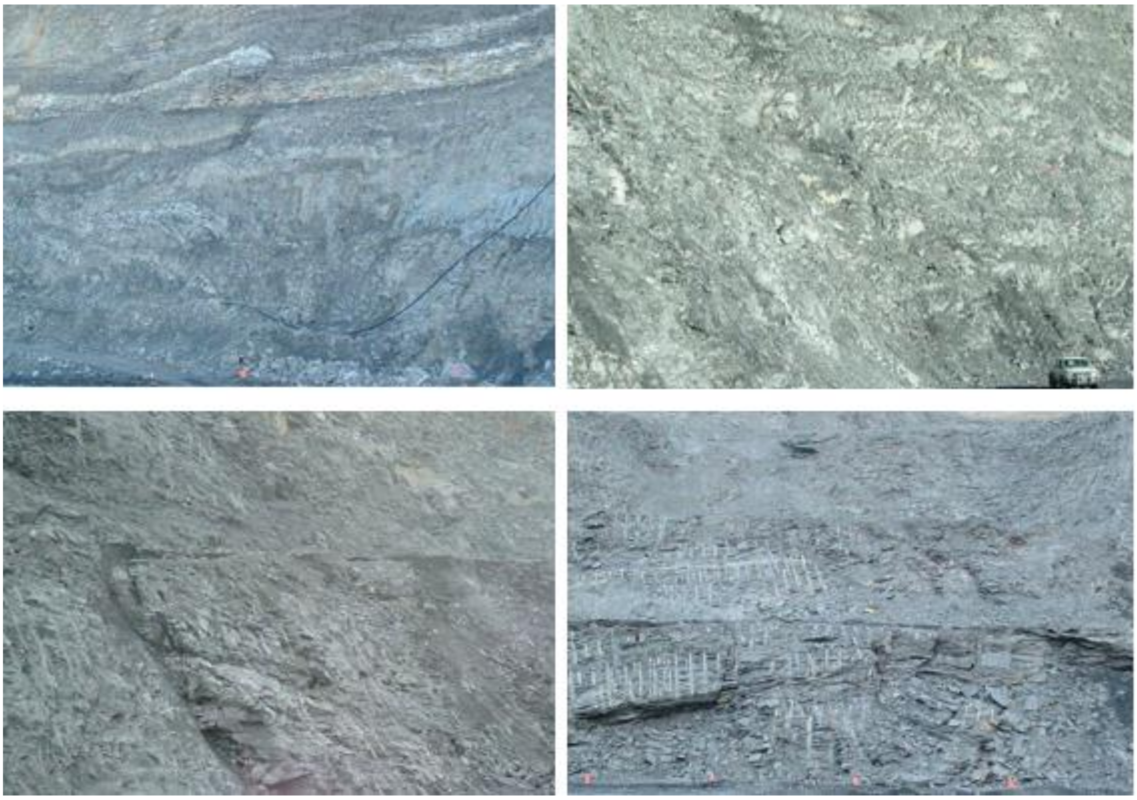

Figure 2: **Examples of intact rock slopes ranging from the better rock mass in the top left to the poorer rock mass in the bottom right.**

The strength parameters adopted for stability assessments comprised those shown in Table 1 [(2)].

Table 1 – Adopted rock mass strength properties

Material	Unit Weight (kN/m^3) mean ± sd, range	Cohesion (kPa) mean ± sd, range	Friction Angle (°) mean ± sd, range
Waste rock	20	1	35
Weathered schist	25	120	35
Inter-shear pelite	25 -3 +2, 22 - 27	180 -15 +25, 170 – 205	43 -5 +2, 38 – 45

The rock mass strengths are based on the following sources.

- A comprehensive undertaking of laboratory testing on intact rock and defect shear strength was undertaken for mine design studies carried out in 1997 [(3)]. This comprised:
  - Point load strength
  - Unconfined compressive strength
  - Direct shear
  - Ring shear
  - Comparison with data from Clyde and Maniototo projects.

  That database indicated that the intact schist at Macraes is of high strength (UCS > 25 MPa).

- The widely accepted GSI [(4)] / Hoek-Brown classification method.

  This method uses a classification rating to factor the intact rock strength down to a rock mass strength. Our report [(2)] showed that the rock mass strengths predicted by this method are higher than those adopted in the analyses (Figure 3). For example, the GSI / Hoek-Brown method gives strength parameters of c′ = 275 kPa & φ′ = 40° to c′ = 570 kPa & φ′ = 49° for the schist within the inter-shear zone. The adopted strength parameters are c′ = 180 kPa & φ′ = 43°.

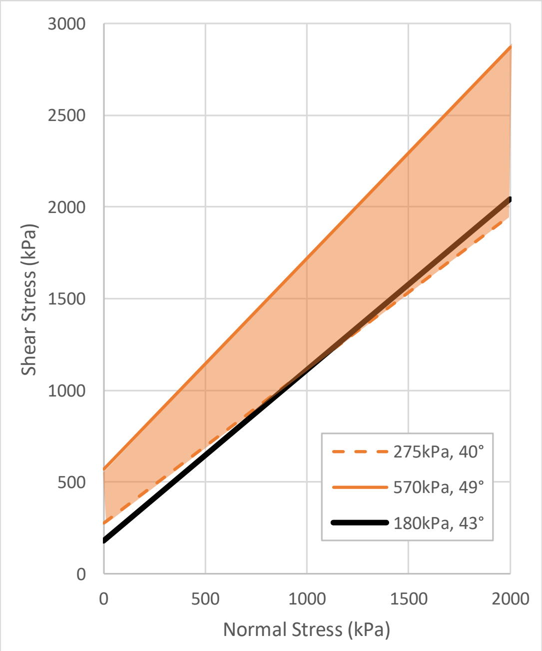

Figure 3: Comparison of adopted strengths to those predicted using the GSI / Hoek-brown method.

[(3)] PSM, Mine geotechnical design studies, PSM71.R8, 20 November 1997

[(4)] Geological Strength Index

- Back-analyses of the pit slope performance at Macraes over the past 30 years, which includes slope failures

In addition, variability is introduced by way of normal distributions based on the mean ± standard deviation to cater for uncertainty in the rock mass strength.

As stated in our report for Deepdell Stage III (2), a conservative shear strength for the waste rock was adopted as it does not impact on the stability analysis because the waste rock stack is physically only a minor part of the slopes.

It would not be appropriate to adopt the waste rock strength parameters for the intact rock mass.

3. Block Failure

Block failures (planar sliding, wedge failure and toppling) that occur while the Deepdell Stage III pit is in operation will be dealt with during mining.

Block failures that could occur post pit closure are implicitly included in the seismic analysis of the overall slope that is presented in our previous report (2). Further, our recent letter (5) describes the results of the risk study of Deepdell Creek (6), which considered the Maximum Design Earthquake initiates a 15,000 m^3 rock fall, a volume of rock that represents a 60 m high slope failing over a 30 m length, i.e. a large block failure.

The wave generated by this block failure was given a probability of 50% of overtopping a 2.5 m freeboard in that risk study. By extension, there is negligible, effectively zero, probability that this wave would overtop the 35 m freeboard which exists with the proposed Deepdell Stage III pit.

We trust this letter is in keeping with your requirements and addresses the ORC's questions. Should you have any further queries please do not hesitate to contact us.

For and on behalf of
PELLS SULLIVAN MEYNINK

ROBERT BERTUZZI
PRINCIPAL

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(5) PSM, Deepdell Stage III - Risk of flooding from the pit, PSM71-244L, 12 February 2020

(6) URS, Deepdell Creek – Population at risk, 42092492, 23 July 2012.