

From: Matt Dumont
To: Cheryl Low
CC:
Date: 06/10/2026
Subject: Response to Dr. Alexander McAlpine's Response

1 Introduction

This memo is a response to concerns raised by Dr. Alexander McAlpine regarding the groundwater modelling based assessment of the potential for lost seepage from the proposed Bendigo Ophir Gold Project (BOGP) (McAlpine, 2026). Dr. McAlpine's primary concern is that the groundwater model does not adequately include the geological defects described in PSM (2024). In particular, Dr. McAlpine is concerned that the model does not allow vertical anisotropy greater than 1 (e.g., vertical hydraulic conductivity greater than horizontal hydraulic conductivity). Based on this concern, Dr. McAlpine concludes "From personal experience, and by rough approximation, I consider these modelling choices have resulted in the current modelling to have underpredicted the potential seepage into the schists, possibly by one or two of orders of magnitude."

2 Response

I have reviewed the concerns raised by Dr. McAlpine and disagree with their conclusions. First, it is unclear how Dr. McAlpine arrived at the one to two orders of magnitude underprediction. This figure is not supported by any calculations or analysis, but from "personal experience and by rough approximation". Therefore, I will respond to the general concern that the model may underpredict seepage into the deep schist rather than the specific figure.

There are four important sources of anisotropy that affect seepage in the BOGP area:

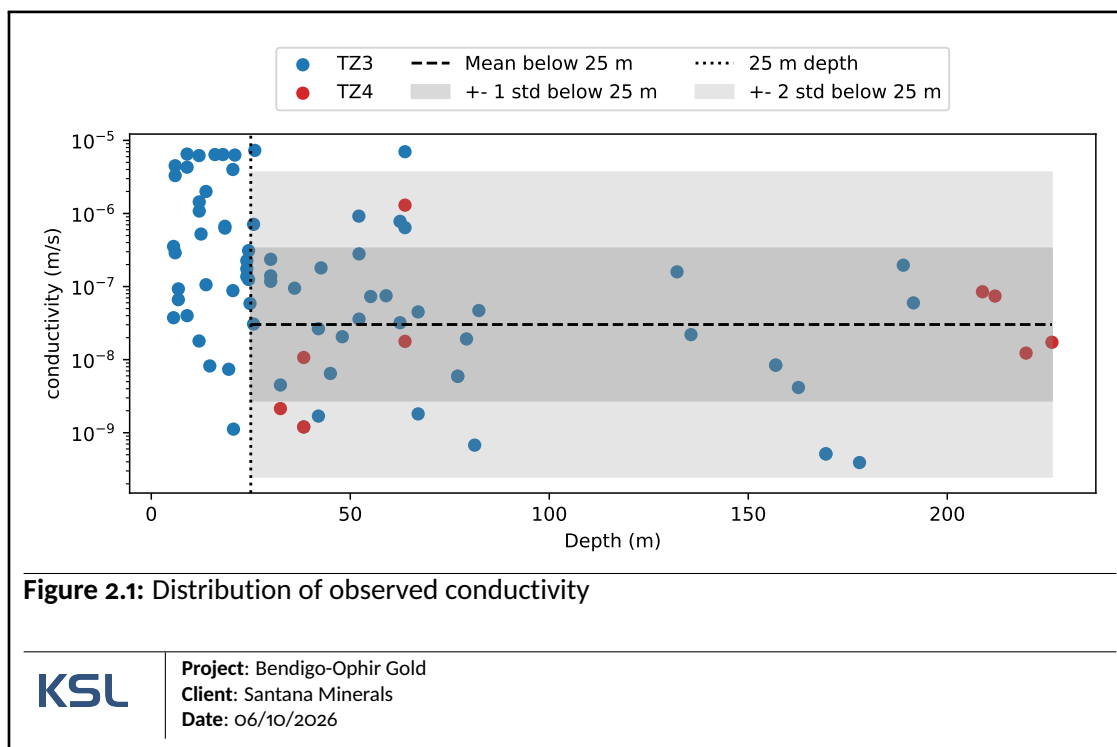
1. The relative hydraulic conductivity between the mine features (e.g., the tailings storage facility and Shepherds ELF), quaternary sediments, weathered schist, and unweathered schist.
2. The anisotropy of hydraulic conductivity between the TZ3, Thompsons Gorge Fault zone, and TZ4 unweathered schist.
3. The large scale anisotropy of hydraulic conductivity in the unweathered schist. This occurs on the scale of hundreds of meters to kilometers and is greater than the scale of the model cells.
4. The anisotropy of hydraulic conductivity in the unweathered schist at the sub-model cell scale. This scale is < 100 m horizontally and vertically:
 - < 10 m vertically for 0–100 m depth
 - < 25 m for 100–350 m depth
 - < 50 m for depths > 350 m

The deep model parametrisation explicitly allows for the first three sources of anisotropy. In particular, the pilot point parametrisation of the unweathered schist is based on 3D interpolation of pilot points. This means that, should the model require a preferential vertical or sub-vertical conductive pathway to match the observed data, the model optimisation process will implement this. Because the vertical cell discretisation is quite fine (e.g., 10 m in the upper 100 m of the model), the model can more easily induce preferential vertical flow through the unweathered schist via the pilot point parametrisation.

The sub-cell scale anisotropy is parameterised using a vertical anisotropy factor, which can range from 1 – 100, e.g., vertical hydraulic conductivity can be equal to horizontal hydraulic conductivity or up to 100 times less than horizontal hydraulic conductivity. I agree that I did not implement sub-cell scale vertical hydraulic conductivity to be greater than horizontal hydraulic conductivity. I do not believe that this is a significant limitation of the model for several reasons. First, the model optimisation provides a mechanism to assess the importance of the sub-cell scale vertical anisotropy in matching observed water level data. In general the model optimisation preferred more isotropic unweathered schist, but the posterior parameter distribution still shows significant

uncertainty in the vertical anisotropy factor. That means that the model can replicate the observed data with vertical hydraulic conductivity as low as 1/50 of horizontal hydraulic conductivity. A spearman rank correlation analysis between the vertical anisotropy factors and the objective function (e.g., the goodness of fit to observed data) shows negative correlations of -0.51, -0.75, and -0.75 for the Thompsons Gorge Fault zone, TZ3, and TZ4 respectively. This means that as the anisotropy increase (e.g. vertical hydraulic conductivity decreases relative to horizontal conductivity), the model fit to observed data improves (the objective function decreases).

This behaviour makes sense because enhanced downward hydraulic conductivity in the unweathered schist does not necessarily yield increased flow through the unweathered schist. While downward flow potential may increase, the flow still needs to propagate horizontally over great distances to reach the potential discharge points. For example, water lost to the deep schist in the tailings storage facility would need to travel approximately 2.5 km to reach lower elevations in Dry Creek, and approximately 4 km to reach the range front. Note that the available piezometric data does not support a flow path towards Dry Creek, so only the range front is a potential discharge point. This would require a very deep flow pathway over long distances through the unweathered schist. Across all hydraulic conductivity testing there is a strong relationship between hydraulic conductivity and depth (Figure 2.1). Therefore, even if seepage into the unweathered schist reaches deep depths, it will then encounter very low hydraulic conductivity and hence flow rates towards the range front would be extremely low. This flow path is not supported by the modelling, and I suggest that it is very unlikely to occur from first principles. Discharge to the shallow groundwater system is much more likely, and is the conclusion of the modelling.



The model optimisation does show a strong preference for isotropic weathered schist and has a positive spearman rank correlation of 0.43 between the vertical anisotropy factor and the objective function. While this does support the importance of vertical anisotropy in the weathered schist, it is unlikely to significantly impact the prediction of lost seepage. The weathered schist is removed and grouted at the confining features (e.g., at the TSF dam), so the weathered schist cannot provide a preferential pathway for seepage to bypass the confining features. Water is more likely to flow horizontally through the weathered schist and then upwards and out at the confining features due to the much higher hydraulic conductivity (up to $10^{-4.5}$ m/s) of the weathered schist relative to the unweathered schist (typically 10^{-7} m/s).

Finally, in their response, Dr. McAlpine states "Open natural fractures are a general feature of the Otago Schist which in parts of Otago have sufficient water-conductivity to form designated aquifers and be utilised as water supplies, albeit low-yielding". They reference two works to justify this statement: [Wilson and Rekker \(2012\)](#)

and Yeo (2023). I have reviewed these works and find that they do not support this statement in the context of the unweathered schist at the BOGP site.

Wilson and Rekker (2012) primarily focuses on the Tertiary sediments derived from the weathering of Otago Schist. There were two exploratory bores drilled into the bedrock schist, and the authors concluded that: "The rock was highly fractured, but wireline packer testing showed that the permeability of the schist is low. The upper 20-30m of the schist is likely to provide up to 5 l/min/m, which is sufficient for domestic or stock water supply. The high metamorphic grade of the schist renders it an unlikely source for significant volumes of water." Wilson and Rekker (2012). Note that where a fault zone was intercepted, Wilson and Rekker (2012) found that "This zone had very low permeability, due to the abundance of puggy saturated plastic grey clay". Additionally, the Cresslea site was actively hydraulically fractured to try and increase bore yield. Wilson and Rekker (2012) concludes "A packer test was carried out after the [hydraulically fracturing] to determine the change in well yield. The test showed an actual decrease in yield by a third (Table 2). So, although the rock had been hydraulically fractured, there was negligible interconnected porosity around the bore to sustain any improvement in yield." In the other site, Wilson and Rekker (2012) found that the most highly fractured zone encountered in the drilling showed the poorest hydraulic response. From our assessment of Wilson and Rekker (2012), I conclude that the Otago Schist is unlikely to host significant flow. Additionally and contrary to Dr. McAlpine's statement, highly fractured zones may actually decrease the hydraulic conductivity due to mechanical and chemical weathering of micas to clay minerals.

Yeo (2023) primarily focuses on the potential policy options to manage fractured rock groundwater in Otago rather than a technical assessment of the flow potential of the Otago Schist. However, Yeo (2023) does identify that there are approximately 27 production bores in the Otago Schist throughout all of Otago, with most bores operating at very low yields and with large drawdowns (> 20 m). This does not support Dr. McAlpine's implication that the Otago Schist hosts significant groundwater flow regionally.

References

McAlpine, A. (2026). STATEMENT OF EVIDENCE OF DR ALEXANDER MCALPINE ON BEHALF OF SUSTAINABLE TARRAS INC. [1](#)

PSM (2024). Bendigo-Ophir Gold Project Pre-Feasibility Geotechnical Assessment. Technical Report PSM5131-003R DRAFT. [1](#)

Wilson, S. and Rekker, J. (2012). *Groundwater Exploration in the Ida Valley*. Otago Regional Council, Dunedin [N.Z.]. [2](#)

Yeo, S. (2023). Options for management of fractured rock aquifers. Technical report. [2](#)