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## MEMORANDUM

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**Document Number:** J-NZ0455-001-M-Rev3

**Document Title:** Net Percolation Assessment for the Proposed Bendigo-Ophir Gold Project Mine Waste Storage Facilities

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Mine Waste Management Limited (MWM) has been engaged by Matakanui Gold Limited (MGL) to assess the net percolation (NP) (or water ingress) rates into mine waste storage facilities (MWSFs) at the Bendigo-Ophir Gold Project (BOGP). The estimated water ingress rates will be used to support an assessment of environmental effects for the BOGP and support the resource consent application under the Fast Track Act Application.

### **EXECUTIVE SUMMARY**

Higher NP is typically associated with increased Acid and Metalliferous Drainage (AMD) load and will therefore be a key influence on AMD water collection and treatment requirements to meet closure objectives at the BOGP. The Water and Load Balance Model (WLBM) developed for the BOGP will use NP estimates provided in this assessment to understand the project risks associated with downstream water quality and treatment needs.

### **Objectives of this Study**

- Estimate a range of potential water ingress rates into the proposed MWSFs to support an assessment of environmental effects for the BOGP.
- Make recommendations for forward works to advance cover system designs and increase confidence in expected performance.

### **Findings**

- During operations, the uncovered ELF, with relatively coarse texture and higher permeability material will result in high NP, estimated to be in the region of 60 to 80 % of annual precipitation.
- The proposed cover system can be categorised as a water store-and-release cover system. The main driving factors are the climate and texture of the proposed cover materials. Landform and vegetation aspects are not expected to significantly influence NP.
- NP for the covered ELF and TSF is estimated to range between 30% and 50% of annual precipitation.

- Data from Macraes (MWM, 2024) suggest lower NP may be possible, in the region of 10 to 20% of annual rainfall, but further work is required to demonstrate this is achievable at the BOGP.
- Cover system design elements such as thicker layers and/or lower permeability layers at the base of the cover system could be considered to achieve NP towards the lower range (e.g., NP of 20% of annual rainfall).
- Modelling to understand potential effects of the BOGP uses 20% NP. Further work is required to validate this assumption and comprehensive cover trials are required in the first few years of operations.

### **Recommended Forward Works**

Following development of the BOGP, it is recommended that cover system field trials, dedicated cover monitoring, and focused material characterisation be initiated following approvals to improve confidence in post-closure cover system performance.

Ultimately, the understanding gained from these studies will improve estimates of closure costs, (especially post-closure water collection and treatment requirements and longevity) and convey to external stakeholders a level of understanding of the site that demonstrates a commitment to successful closure.

### **ASSESSMENT SCOPE**

The scope of this assessment was to develop a range of NP estimates for the following MWSFs and BOGP phases:

- Mine rock Engineered Landform (ELF) during operations.
- ELF post-closure with a cover system constructed over the surface.
- Tailings Storage Facility (TSF) post-closure with a cover system constructed over the surface.

The current BOGP mine plan includes three ELF, Shepherds ELF, Western ELF and Srex (SRX) ELF. For the purposes of this assessment, it is assumed that they share similar characteristics that would influence NP, and thus it is proposed that a single range of estimated NP values is applicable for all ELFs. The TSF during operations was excluded from the scope as the water balance will largely be influenced by active tailings deposition / process water and water management practices.

The typical process followed in cover design is shown as a flow chart in Figure 1. The scope outlined in this assessment falls into the first two steps: (i) Site and Materials Characterisation and (ii) Conceptual Design, noting that the scope of this assessment is based on a cover system design provided by others (i.e., this document does not design the cover system, only assess potential performance of said design). The WLBM that will be used the estimates of NP made in this assessment will allow for Impact Analysis to identify any noncompliance and/or unacceptable risk that may necessitate changes in the current cover system design.

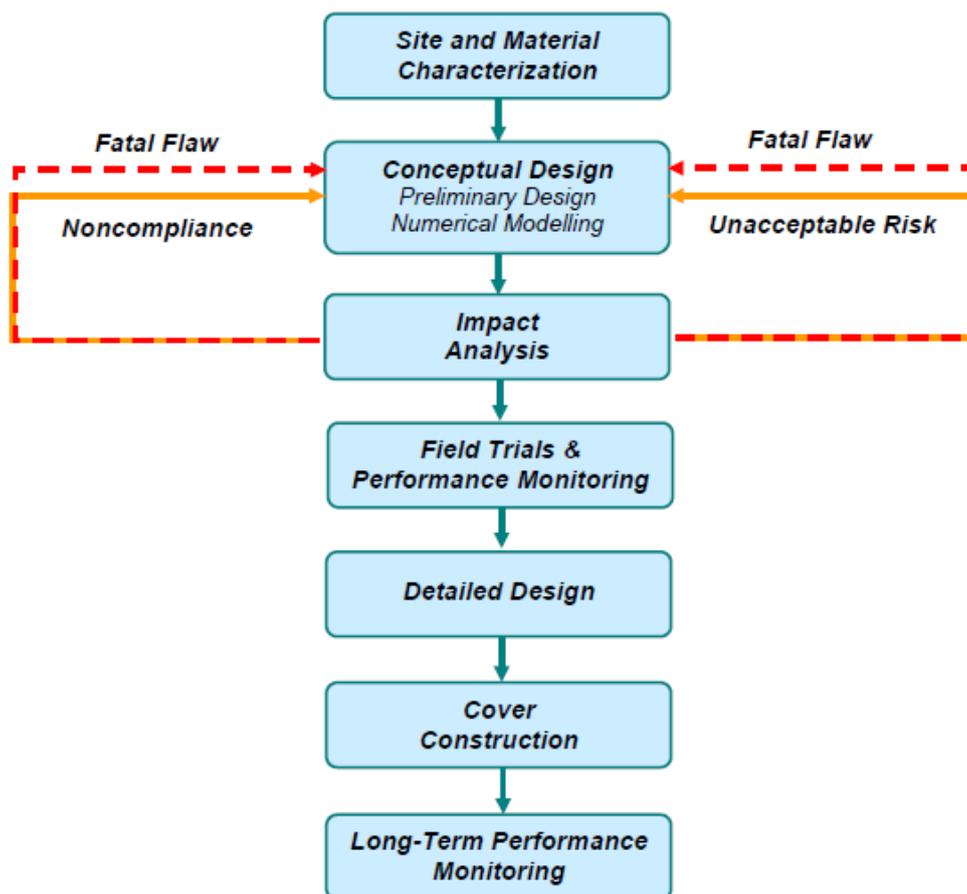


Figure 1: Typical cover design flow chart.

Source: MEND (2004).

**CONCEPTUAL MODEL**

This section describes key BOGP ELF material properties and aspects of the upper and lower boundary conditions used to estimate NP. ELF aspects are based on the Project Description (PD)<sup>1</sup> and discussions during a meeting<sup>2</sup> held with MGL and other subject matter experts.

For the purposes of this assessment, the term NP means infiltration of water that will migrate below the ‘active zone’ into the underlying mine waste material (see Figure 2). Within the near surface active zone, water can be subject to storage, transport, evaporation, or transpiration processes. Once NP has reached the mine waste, it could either be stored as moisture, report to groundwater, or emerge at the toe of the facility.

<sup>1</sup> Bendigo-Ophir Gold Project Description, Version 2. Dated 30 July 2024.

<sup>2</sup> In person meeting held 19 September 2024.

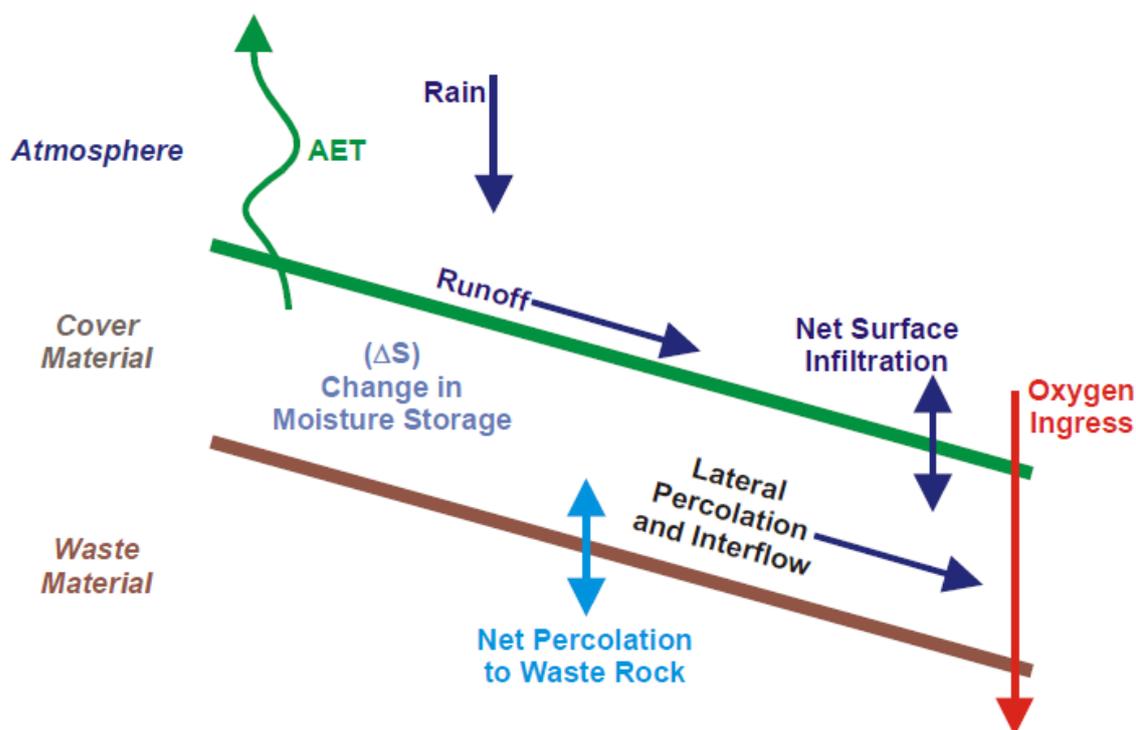


Figure 2: Net percolation conceptual illustration.

Source: MEND (2004).

### Proposed Cover System

During operations, mine rock will be exposed during active placement. According to the PD, the ELF's will be built bottom up in small lifts that are end tipped with a dozer push to reduce segregation.

At closure both the ELF and TSF will have the following proposed cover system, from the top down, installed over the respective mine waste material (EGL, 2025).

- 0.2 m of topsoil/subsoil.
- 0.3 m of moderately weathered mine rock (commonly known as 'Brown Rock').

Given the upper boundary climate condition with a potential evaporation (PE) to precipitation ratio of 0.75, the cover system will reduce NP through the process of water store-and-release, where a proportion of precipitation is stored within the cover profile and then subsequently released back to the atmosphere through evapotranspiration.

### Climate

At the BOGP, three meteorological stations have been installed across the project area at varying elevations. Data has been collected since November 2022. The SRX meteorological station data was used to characterise the climate for this assessment since it is at an elevation closest to where the ELF's will be positioned on the landscape. Other stations are positioned at lower elevations so are likely to be less representative, particularly for precipitation. In addition, these lower elevation stations experienced measurement malfunctions for solar radiation over a number of months in 2023.

Precipitation and PE are presented on a monthly basis in Figure 3. Precipitation was based on a synthetic rainfall record (Chater, 2024) developed for the Lake Clearview station (2006 to 2023, 17 years) and scaled to the SRX station elevation. Snowfall occurs anecdotally over winter (site meteorological stations do not measure snowfall or snowpack depth), but with mean monthly winter temperatures ranging between 2 to 5 °C, active ablation of the snowpack occurs. Overall, precipitation may be underestimated slightly, but unlikely enough to change the interpretation of climatic conditions relevant to this assessment.

PE was calculated with the Penman (1948) method, using site specific air temperature, relative humidity, wind speed, and solar radiation for the period available at the time of reporting (November 2022 through July 2025).

Calculating water surplus (Rainfall-PE)<sup>3</sup> at different temporal scales provides an approximate indication of the climate's ability to remove water from a cover system through evapotranspiration processes (assuming negligible surface ponding or runoff). The cover systems with greater ability to store water would tend towards weekly to monthly scales and vice versa. Calculations for data between 22/11/2022 and 29/07/2025, were as follows:

- Monthly scale, 322 mm of water available for net percolation, or ~25% of rainfall that fell over this period (1,370 mm). 75% is returned to the atmosphere.
- Weekly scale, 582 mm of available for net percolation, or ~40% of rainfall. 60% is returned to the atmosphere.
- Daily scale, 1095 mm of available for net percolation, or 80% of rainfall. 20% is returned to the atmosphere.

The following observations are made based on the available climatic data:

- Based on the Köppen-Geiger classification, the climate can be characterised as temperate, without a dry season, and as having a warm summer (Cfb). Mean annual air temperature is 8 °C. Without a dry season, the process of water store-and-release will be muted over the winter where there is an observed decrease in PE.
- On an annual basis, precipitation (P) is approximately 510 mm while PE is approximately 815 mm. On average, the annual PE:P ratio is 1.6, and typically ranges between 1.3 and 2.0 over the 17-year rainfall record (PE was assumed constant given the lack of data).
- The climate is relatively dry, with a strong energy surplus (PE>P) present between September through March, and an energy deficit (PE<P) over the remainder of the year, most notably over winter.
- For cover systems that have a favourable ability to store water, 60 to 75% of infiltrating water could be removed through evapotranspiration (assuming negligible surface ponding or runoff). Conversely, cover systems that have a poorer water ability to store water (i.e., thin covers), 20 to 60% of soil water could be removed.

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<sup>3</sup> Where PE>Rainfall, water surplus is set to zero.

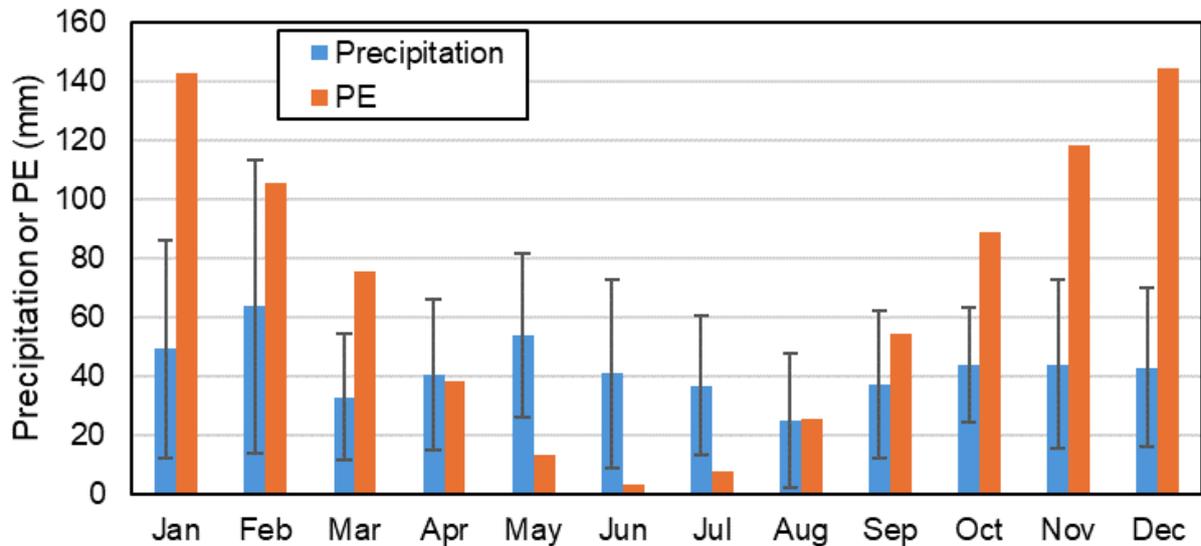


Figure 3: Monthly precipitation and PE summary.

PE=Potential Evaporation. Bars show monthly averages while error bars show rainfall standard deviation over period of record.

### Material Properties

Site-specific reclamation and waste material physical material properties are not available. Based on the nearby Macraes Mine, which has a similar climate (mean annual rainfall of approximately 600 mm) and similar geological setting, mine rock is expected to be relatively coarse textured, with a high surface infiltration rate and hence reduced potential for runoff generation.

In the absence of site-specific data, the following is assumed:

- Topsoil: When stripped, it is likely to be a mixture of topsoil and upper weathered bedrock horizon. Site visit observations suggest in-situ soil is well graded and loamy (Figure 4). For the purposes of this assessment the topsoil layer is assumed to be representative of a loamy sand material, with 20% fines and relatively moderate saturated permeability ( $k=10^{-5}$  m/s).
- Brown Rock: Mine rock overburden with a moderate degree of weathering, will be relatively coarse, well graded, with limited clay and silt sized particles (fines) (potentially less than 10%<sup>4</sup>) with and estimated saturated hydraulic conductivity of  $1 \times 10^{-4}$  m/s.

<sup>4</sup> Provided by E. Torvelainen of Engineering Geology Limited via email 11 November 2024.



Figure 4: Topsoil (in-situ) example.

## Landform

The project layout and ELF's are shown Figure 5. The following landform relevant details are highlighted:

- The ELF's and TSF will be positioned in the valley bottoms of incised valleys.
- Post-closure, the ELF's are expected to have a relatively flat top surface with minor slope to direct any runoff generated to manage water. The batter slopes of the ELF landforms will be 3(H):1(V). All ELF's will have a mixture of north, south, east and west aspects.
- Post-closure, the TSF will be relatively flat, with minor slopes to direct any runoff generated to the north side to the clean water diversion drain which is ultimately conveyed past the Shepherds ELF back to the valley bottom downstream of the ELF toe.
- Post-closure, the ELF's will be sloped to convey any runoff that is generated off the landforms. The TSF drainage condition post-closure will be drained.

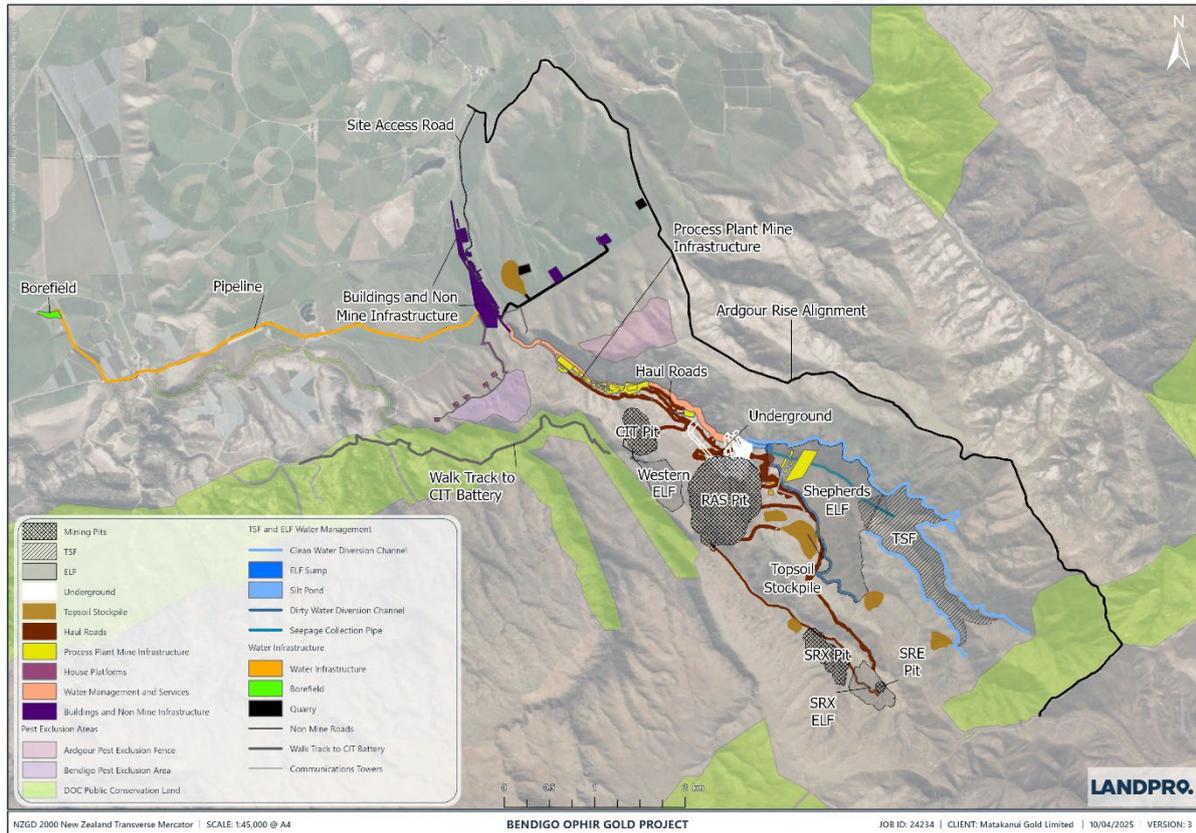


Figure 5: BOGP layout showing the TSF, Shepherds ELF, Western ELF, and SRX ELF.

Source: MGL Project Description.

**Vegetation**

Post-closure vegetation established over the cover systems is anticipated to be similar to the existing vegetation, notably a mixture of pasture and tussock. An example of this vegetation is shown in Figure 6.

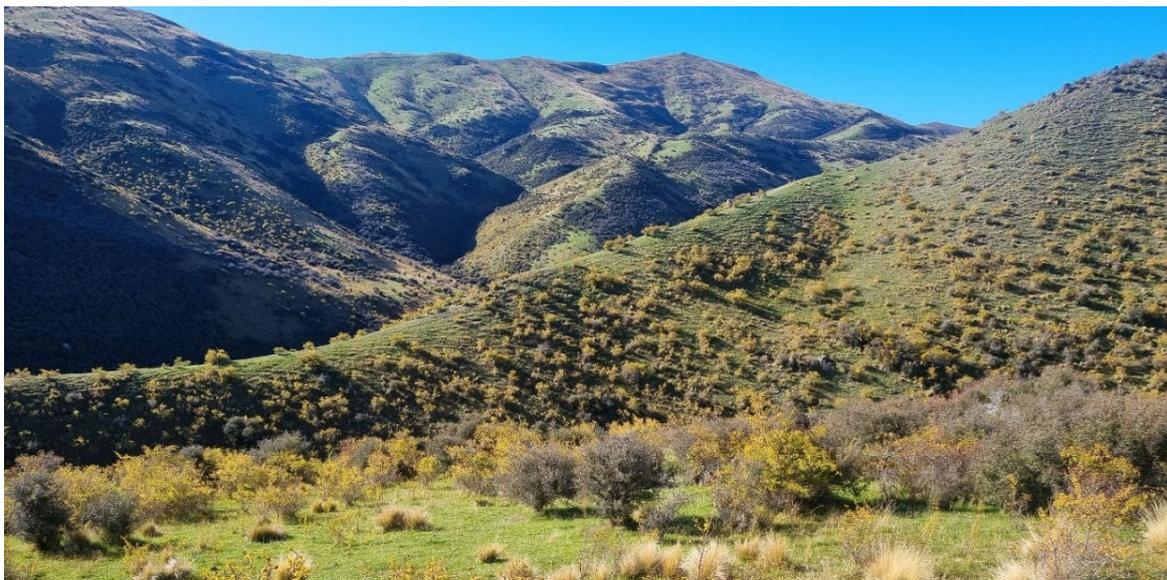


Figure 6: Existing vegetation examples for the region.

Looking approximately east.

## **ASSESSMENT FINDINGS**

### **Exposed ELF (Operations)**

Although the BOGP climatic setting suggests that there is potential for PE to lower NP into exposed (or uncovered) ELFs, the likely coarse texture, inferred high permeability and limited water retention capacity of the mine rock, coupled with the upper climate boundary condition, suggests a relatively high expected NP. Williams (2008) collated and reviewed worldwide data on NP into waste rock dumps and found it ranges between 50 and >85% of annual rainfall.

The bottom-up ELF construction would produce running surfaces on each lift, but the permeability needed to start appreciably diverting runoff and reducing NP, would be challenging to achieve in a consistent manner given the anticipated physical properties of the mine rock.

On balance, NP for the exposed ELFs is expected to range between 60% to 80% of annual precipitation.

### **Rehabilitation Cover System for ELF and TSF (Post-Closure)**

Industry guidance is useful to place the climatic setting into the context of expected performance for different types of cover systems. For a temperate climate and a water store-and-release cover system, INAP (2017) suggest NP performance can be expected to range between 15% to 50% of mean annual precipitation. An enhanced water store-and-release or barrier type system would likely be required to reduce NP below this range given the Köppen-Geiger Cfb climate classification.

The GARD Guide (INAP, 2014) define cover system type suitability based on climatic setting, as shown in Figure 7. Based on a PE:P ratio of 1.7, ranging between 1.3 and 2 (shown in red on Figure 7), the GARD Guide (INAP, 2014) suggests that water store-and-release cover systems are targeted for climates with a PE:P of greater than 2 and as such a cover system that includes some form of infiltration control (e.g., enhanced store and release, low permeability barrier, etc.) would improve performance (i.e., lower NP).

Williams (2008) also compiled and reviewed worldwide data on NP performance for cover systems. For water store-and-release covers, the reported NP performance was approximately 15% or less. However, these types of systems were used in more arid sites in Australia and USA, and the cover systems were much thicker (2 m or more) than proposed for the BOGP, allowing for more water store-and-release prior to NP. For example, NP for a 2 m thick store-and-release system at the Mt. Whaleback Mine in Western Australia (with a stronger PE:P ratio of roughly 8) was reported to achieve a NP of 5% to 15 % of annual rainfall. Note the influence of material texture is not factored into this comparison given the lack of data. For example, thinner covers with finer texture material can perform better than thicker and coarser material. On balance, the lower BOGP PE:P ratio suggests higher rates of NP as compared to performance observed at more arid sites as reported by Williams (2008).

MWM (2024) estimated NP into the Frasers West Waste Rock Stack at Macraes Mine to be about 12% of annual rainfall.

Factors from the conceptual model influencing potential NP ranges are summarised in Table 1. Overall, based on currently available data, it is expected the proposed cover system, a relatively thin water store-and-release cover system with relatively permeable material, will achieve a NP performance in the range of 30 to 50 % of annual precipitation. Data from Macraes (i.e., MWM, 2024) suggest lower NP in the range of 10 to 20% of annual rainfall may be possible, but further work is required to

demonstrate this is achievable (see the Recommendations section for further details). Cover system design elements such as thicker layers and/or lower permeability layers at the base of the cover system could be considered to achieve NP towards the lower range (e.g., NP of 20% of annual rainfall).

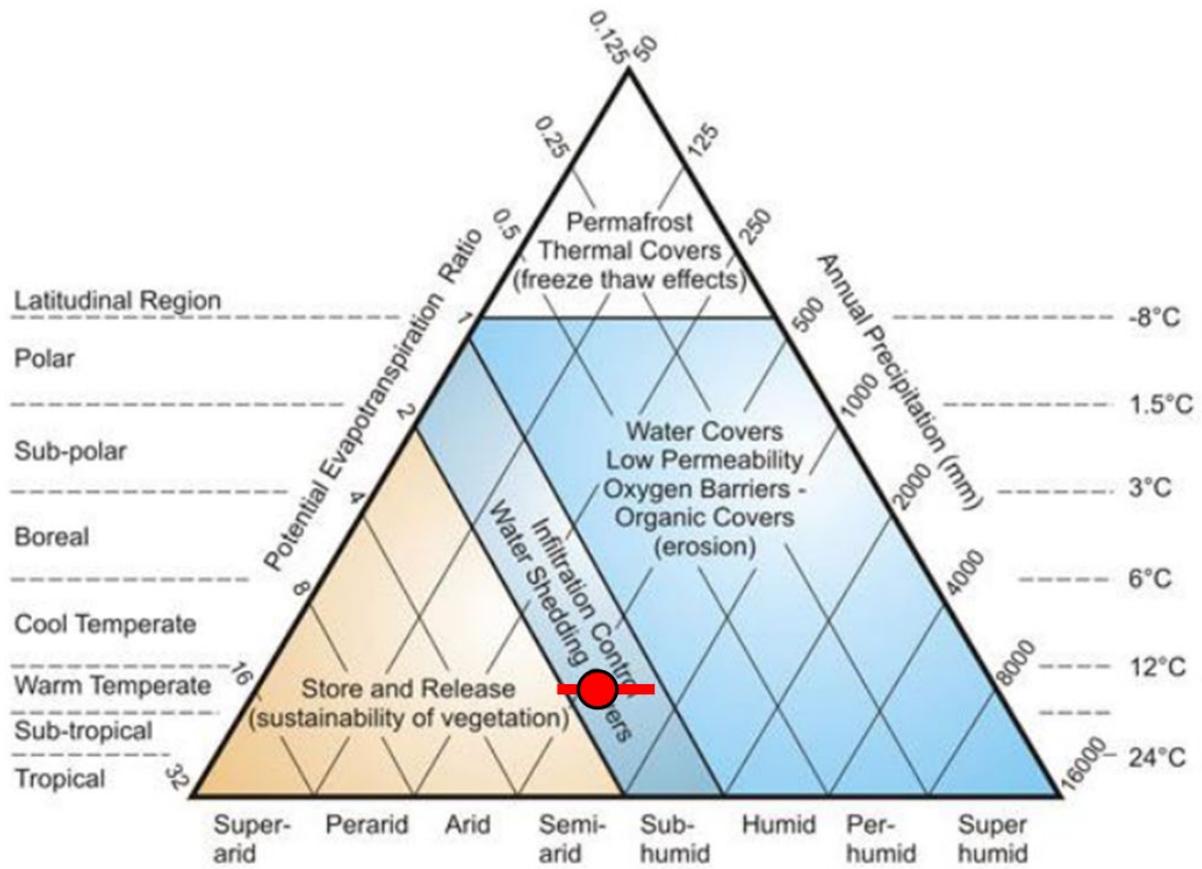


Figure 7: Climatic conditions to support water store-and-release cover systems.

Note: the red circle represents the long term annual average climatic conditions, while the bar show the typical annual variability.

Source: INAP (2014).

Table 1: Estimated performance of a water store-and-release cover system.

PARAMETER	REMARK	NET PERCOLATION
Climate	<ul style="list-style-type: none"> <li>Temperate, without dry season, warm summer (Cfb).</li> <li>Gard Guide recommends barrier type cover system.</li> <li>The estimated performance based on INAP (2017) seems reasonable.</li> </ul>	20% to 50%
Materials	<ul style="list-style-type: none"> <li>Cover material to be moderately weathered coarse mine rock and topsoil with modest fines content, possible less than 20%, with limited clay minerals.</li> <li>Nominally thin cover profile with reduced water storage.</li> <li>This would support a NP towards the higher end of the range from climate alone.</li> </ul>	Lower NP estimate scaled upward based on materials to 30% to 50%
Landform	<ul style="list-style-type: none"> <li>Landform unlikely to have high degree of influence on NP due to anticipated relatively high surface permeability. Range unchanged from materials.</li> <li>Both the ELF and the TSF are largely flat or north facing, so likely have similar PE.</li> <li>ELF has steeper slopes while TSF is much flatter so runoff likely higher for ELF.</li> <li>Overall, ELF NP could be lower than that of the TSF but may not be substantially different if surface permeability is relatively high.</li> <li>Long-term lower boundary condition within the TSF not considered assessment.</li> </ul>	Landform not considered to change estimated NP range 30% to 50%
Vegetation	<ul style="list-style-type: none"> <li>Mixture of grassland and evergreen species.</li> <li>Vegetation will promote evapotranspiration during the growing season however this may be limited due to the relatively coarse textured cover material and low winter PE.</li> <li>Overall, vegetation is unlikely to greatly influence NP compared to other parameters.</li> </ul>	Vegetation considered to be healthy and not increase NP range 30% to 50%

## **CONCLUSIONS**

Findings from the NP assessment for the uncovered and covered MWSFs are as follows:

- During operations, the uncovered ELF, with relatively coarse texture and higher permeability material will result in high NP, estimated to be in the region of 60 to 80 % of annual precipitation.
- The proposed cover system can be categorised as a water store-and-release cover system. Industry guidance (INAP, 2014, 2017) suggest it will not perform as well as infiltration control type systems due to the reduced atmospheric demand for water over the winter period.
- Post-closure, NP for the covered ELF and TSF is estimated to range between 30% and 50% of annual precipitation. The main driving factors are the climate and texture of the proposed cover materials. Landform and vegetation aspects are not expected to significantly influence NP.
- Data from Macraes (MWM, 2024) suggest lower NP may be possible, in the region of 10 to 20% of annual rainfall, but further work is required to demonstrate this is achievable at the BOGP. Cover system design elements such as thicker layers and/or lower permeability layers at the base of the cover system could be considered to achieve NP towards the lower range (e.g., NP of 20% of annual rainfall).

- Given the ELF's have greater proportions of north facing slopes that will increase PE, and have steeper slope angles that would increase runoff, NP for the ELF could be lower than the TSF (valley bottom position and flat slopes). However, if surface permeabilities are relatively high as anticipated, the difference in NP may not be substantial.

## **RECOMMENDATIONS**

If further studies indicate improved cover system performance is required, in terms of treatment requirements or downstream water quality, the following recommendations can be considered:

- Material textural properties are based on anecdotal evidence and could be finer texture than currently assumed. In general, finer textured materials would tend to improve NP performance (i.e., reduce estimated NP toward the lower end of ranges provided). As such, incorporation of site-specific particle size distribution data would refine the assessment.
- Numerical simulations are completed to better assess sensitivity to the upper and lower boundary condition and material properties on simulated performance. Modelling may be able to demonstrate more favourable performance (i.e., expected performance is closer to 30% of annual precipitation than 50%).
- Alternate cover system designs could be considered. For example, thicker cover layers, enhanced water store-and-release systems, or low permeability barrier type systems would improve expected performance.

Following development of BOGP it is recommended that cover system field trials, dedicated monitoring, and focused material characterisation be initiated following approvals to improve confidence in post-closure cover system performance and allow for detailed design (i.e., as shown in Figure 1 ).

Ultimately, the understanding gained from these studies will improve estimates of closure costs, (especially post-closure water collection and treatment requirements and longevity) and convey to external stakeholders a level of understanding of the site that demonstrates a commitment to successful closure.

## **CLOSING REMARKS**

Please do not hesitate to contact Paul Weber at +64 3 242 0221 or paul.weber@minewaste.com.au should you wish to discuss this memorandum in greater detail.

## **REFERENCES**

- Chater, M, 2024. Extension of synthetic rainfall time series, Bendigo Project. Dated August 2024.
- Engineering Geology Limited (EGL), 2025. Bendigo-Ophir Gold Project Shepherds Tailings Storage Facility Technical Report. Prepared for Matakanui Gold Limited. Dated 15 July 2025.
- International Network for Acid Prevention (INAP), 2014. Global Acid Rock Drainage (GARD) Guide. Dated October 2014. [https://www.gardguide.com/index.php?title=Chapter\\_6](https://www.gardguide.com/index.php?title=Chapter_6). Accessed October 2024.
- International Network for Acid Prevention (INAP), 2017. Global Cover System Design - Technical Guidance Document. Dated November 2017.
- MEND, 2004. Design, Construction and Performance Monitoring of Cover Systems for Waste Rock and Tailings. Volume 1. Dated July 2004.
- Mine Waste Management (MWM), 2024. BWWRS Geochem Model. MWM Report J-NZ0229-M-009-Rev0 for OceanaGold. Available: <https://www.orc.govt.nz/media/vfpbccka/annexure-02-brwrs-geochemical-model-mwm.pdf>
- Penman, H., 1948. Natural evaporation from open water, bare soil, and grass. Proceedings of the Royal Society of London, Series A: Mathematical and Physical Sciences, 193: 120-145.
- Williams, 2008. The Influence of Climate on Seepage from Mine Waste Storages During Deposition and Post-Closure. Mine Closure 2008 proceedings.