APPENDIX F BPCP AMD HAZARD CLASSIFICATION SUMMARY

MINE WASTE MANAGEMENT
GREENROAD GROUP

[redacted]

T. [redacted]

MEMORANDUM

Recipient:	[redacted] – Bathurst Resources Limited
From:	[redacted] – Mine Waste Management Limited
Date:	20 July 2026
Cc:	[redacted] – MWM; [redacted] – BRL
Document Number:	J-NZ0453-003-M-FINAL
Document Title:	BPCP AMD Hazard Classification Summary

Bathurst Resources Limited (BRL) is seeking to obtain authorisation through the Fast-track Approvals Act (FTAA) to progress development and mining of the coal resources across the wider Buller Plateaux. This project is referred to as the Buller Plateaux Continuation Project (BPCP or Project).

INTRODUCTION

The purpose of the BPCP is to reconsent the existing infrastructure and mining operations associated with the existing Stockton Mine and provide access to additional coal mining areas across the Buller Plateaux, as the coal resource in the current Stockton Mine is close to depletion, and further coal resources for blending are required. There are five key project sub-areas:

- Stockton mining area (Stockton)
- Mount Frederick South (MFS)
- Escarpment Extended (ESE)
- Upper Waimangaroa Haul Road (UWHR)
- Cypress mining area (Cypress)

Mine Waste Management Limited (MWM) was engaged by BRL to provide an overview of geoenvironmental hazard classification systems for the BPCP. This memorandum presents details of the classification systems developed for MFS, ESE, and UWHR sub-areas, which will be used to support the assessment of environmental effects (AEE) for the FTAA application.

OBJECTIVES AND SCOPE

Understanding the environmental geochemistry of materials that require management will be an important aspect of the Project. The objective of this memo is to:

- Provide an outline of the acid and metalliferous drainage (AMD) classification systems for the BPCP to support the development of the waste rock geochemical block models and the AEE; and
- Explain why multiple classifications are being used across the Project.

INTRODUCTION TO AMD

AMD refers to water contamination caused by mining activities, containing toxic metals, salts, and acidity. AMD is typically generated by the excavation of rocks that contain sulfide minerals, such as pyrite. When these minerals are exposed to oxygen and water, they undergo weathering processes and oxidise, generating acidity and releasing toxic metals. Microorganisms accelerate this process.

Classification of materials is important to understand the quantities of AMD-generating materials that require management. Classification is typically based on either (or both) the AMIRA (2002) or Price (2009) classification schemes until site-specific classification systems are developed.

CLASSIFICATION SYSTEMS

The AMIRA Classification system uses net acid producing potential (NAPP) and net acidity generation (NAG) pH to classify samples as Potentially Acid Forming (PAF), Non-Acid Forming (NAF) or Uncertain (UC) (Figure 1). NAG testing of carbonaceous materials associated with coal mines can often be compromised by the generation of organic acidity creating low NAG pH and high acidities, resulting in UC classification (AMIRA, 2002).

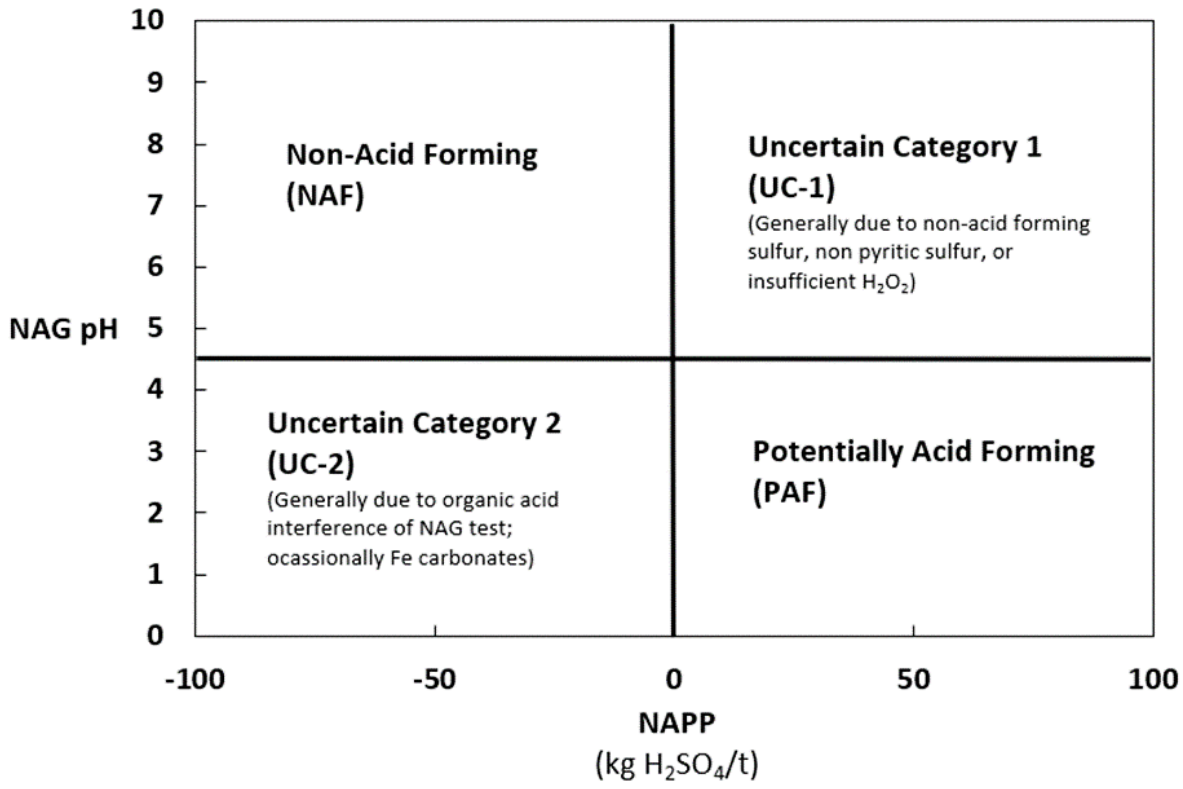


Figure 1: AMIRA (2002) AMD classification scheme for rock samples.

Source: Olds et al. (2015).

The Price (2009) classification system (Figure 2) uses the ratio between acid neutralising capacity (ANC) and maximum potential acidity (MPA) to classify samples as PAF, NAF or UC, where the neutralisation potential ratio (NPR) = ANC/MPA (Price, 2009).

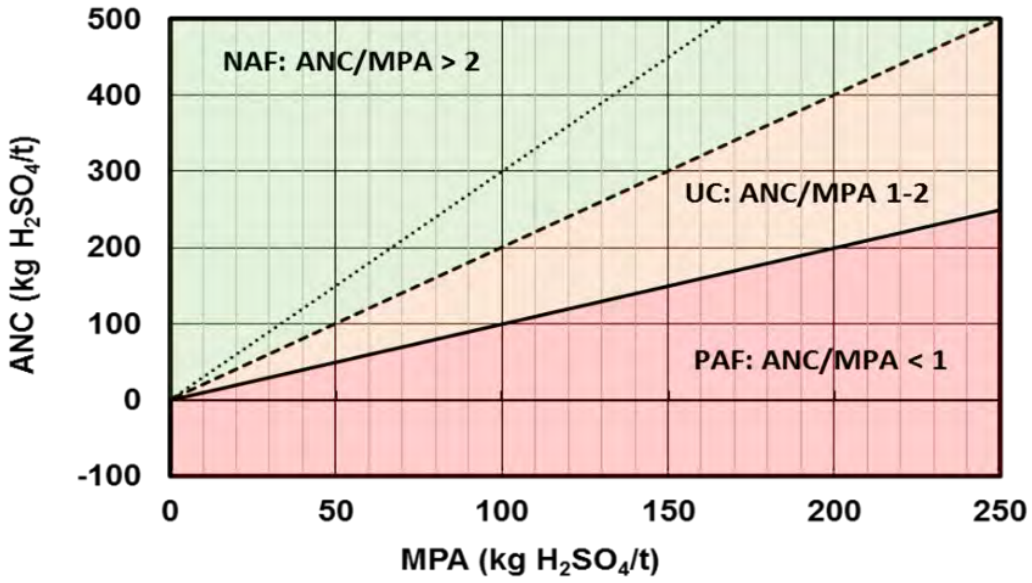


Figure 2: Price (2009) acid base accounting classification scheme for rock samples.

Source: Olds et al. (2015).

These criteria for the AMIRA (2002) and Price (2009) classification schemes can be presented in tabular form as shown in Table 1 and Table 2. Generally, both criteria are used to provide guidance on AMD risks for material types.

Table 1. AMIRA (2002) acid base accounting classification system.

CLASSIFICATION	CRITERIA	COMMENTS
Potentially Acid Forming (PAF)	NAPP ≥ 0 NAG pH ≤ 4.5	Sample always has a significant sulfur content, the acid generating potential of which exceeds the inherent acid neutralising capacity of the material.
Non-Acid Forming (NAF)	NAPP < 0 NAG pH >4.5	Sample may, or may not, have a significant sulfur content but the ANC availability is more than adequate to neutralise the acid that theoretically could be produced.
Uncertain (UC)	NAPP ≥ 0; NAG pH >4.5 NAPP < 0; NAG pH ≤ 4.5	An uncertain classification is used when there is an apparent conflict between the NAPP and NAG results.

Table 2. Price, 2009 acid base accounting classification system.

CLASSIFICATION	CRITERIA	COMMENTS
Potentially Acid Forming (PAF)	ANC/MPA ≤ 1	Potentially acid generating material, unless sulfide minerals are non-reactive, or ANC is preferentially exposed on surfaces.
Non-Acid Forming (NAF)	ANC/MPA > 2	Non-potentially acid generation material, unless ANC is insufficiently reactive, extremely reactive sulfides are present, or preferential exposure of sulfides is found in the material.
Uncertain (UC)	1 < ANC/MPA ≤ 2	Possibly PAF if ANC is insufficiently reactive or is depleted at a faster rate than sulfides.

Understanding the geochemical characteristics of overburden material within the project area and assessment of materials against both the AMIRA (2002) and Price (2009) classification schemes allows the development of site-specific classification systems. Such site-specific classification systems should utilise additional testing (e.g., column leach tests, shake-flask tests, etc) to validate the classification system.

VARIABILITY OF AMD RISK

Regional variability for AMD source hazards across the Project areas (i.e., Stockton, MFS, ESE, UHWR) is heavily influenced by paleo-depositional environment of the Brunner Coal Measures (BCM) and Kaiata Mudstone. The BCM form the foundational layer of a transgressive sequence, which are a succession of estuarine high sulfur sedimentary rocks consisting of clastic rocks and coal seams. The sequence is 70 to 130 m thick and was deposited in a fluvioparalic environment consisting of braided and meandering streams within a deltaic, barrier, tidal environment. The BCM are conformably overlain by, and laterally interfingered with, the Eocene marine Kaiata Mudstone formation, which has increasing carbonate content upwards away from the BCM contact (Flores and Sykes, 1996).

As noted in literature (e.g., Pope et al., 2010), fluvial systems tend to be lower in pyrite compared to marine-influenced systems. At the ESE and MFS project areas the AMD risks are expected to be lower than at the adjacent Stockton Coal Mine (Stockton) as the BCM have a lower sulfur content compared to overburden materials at Stockton, although the Mount Frederick area of the Stockon Coal mine is lower sulfur (BRL, 2024). This lower risk at ESE and MFS is due to the depositional environment being strongly influenced by fresh water fluvial sediments (low sulfur) south of Stockton with occasional periodic marine incursions (high sulfur), whereas the depositional environment at Stockton was predominantly a marine-influenced environment with higher sulfur materials (e.g., estuarine).

SITE-SPECIFIC CLASSIFICATION

The use of the AMIRA (2002) and Price (2009) classification system for BCM results in many samples being classified as Uncertain due to negligible ANC and low sulfur content, which generates operational issues for materials scheduling, management, and placement as well as AMD treatment requirements. The Escarpment Peer Review Panel identified this as an issue in 2014 during the development of the Escarpment AMD Management Plan (in respect to the existing Escarpment Mine, currently on care and maintenance) and requested that it was resolved. In this regard a site-specific AMD classification process was developed for BCM materials.

Other project areas (Cypress, Stockton, UWHR) also have Kaiata Mudstone present, which requires a different AMD classification scheme due to the higher ANC content of the Kaiata Mudstone.

Three AMD classification systems have been developed within the BPCP area through site-specific material geochemical investigations. A summary of each classification system is provided below.

Cypress Area

The Cypress classification process is used to classify KMS, which is present in the northern sections of the UWHR.

Overburden at the Cypress Mine consists of BCM and Kaiata Mudstone where geochemical variation is observed through a marine transgression sequence from PAF at the base to NAF higher (younger) in the stratigraphic column. The transition from NAF to PAF (where ANC > MPA) occurs ~30 m above the BCM/Kaiata Mudstone contact.

An original geochemical block model was produced in 2018 based on NAPP values to determine the NAPP = 0 surface (where NAPP < 0 = NAF; NAPP ≥ 0 = PAF). However, during mining and subsequent stage development, issues were identified regarding materials classification with overburden being incorrectly classified due to limited geochemical data in the block model (McLachlan, 2022).

Further work was undertaken to develop a site-specific classification scheme using acid base accounting (ABA) data and pXRF[1] results. Results obtained from an RC drilling program were used to develop a new geochemical block model and establish a relationship between the pXRF and laboratory NAPP data. Results indicated that:

- Laboratory total wt% sulfur data demonstrated that pXRF is not sufficiently sensitive to detect the small changes in sulfur that occur throughout the Kaiata Mudstone (where there is a change from NAF to PAF).
- Sulfur content is relatively consistent within the Cypress sub-area and is not the determining factor for classification of Kaiata Mudstone as PAF or NAF. Rather the ANC was the driving factor.
- pXRF-Ca is well correlated with ANC across the project area between 5,000 and 30,000 mg/kg Ca.
- A relationship between pXRF-Ca and laboratory ANC and NAPP data was defined with a value of 14,000 mg Ca/kg most closely representing the PAF/NAF cutoff of NAPP = 0 (McLachlan, 2022). Samples with > 14,000 mg Ca/kg are classified as NAF.

A stratigraphic column is provided in Figure 3 that shows at ~30 m above the BCM/Kaiata Mudstone contact that the MPA is equivalent to the ANC such that the NAPP is 0 kg H_2SO_4/t (Hughes, 2007), i.e., rocks above 30 m are generally considered NAF.

Further details are provided in McLachlan (2022) and BRL (2024) – see Attachment A and Cypress pXRF data – see Attachment B.

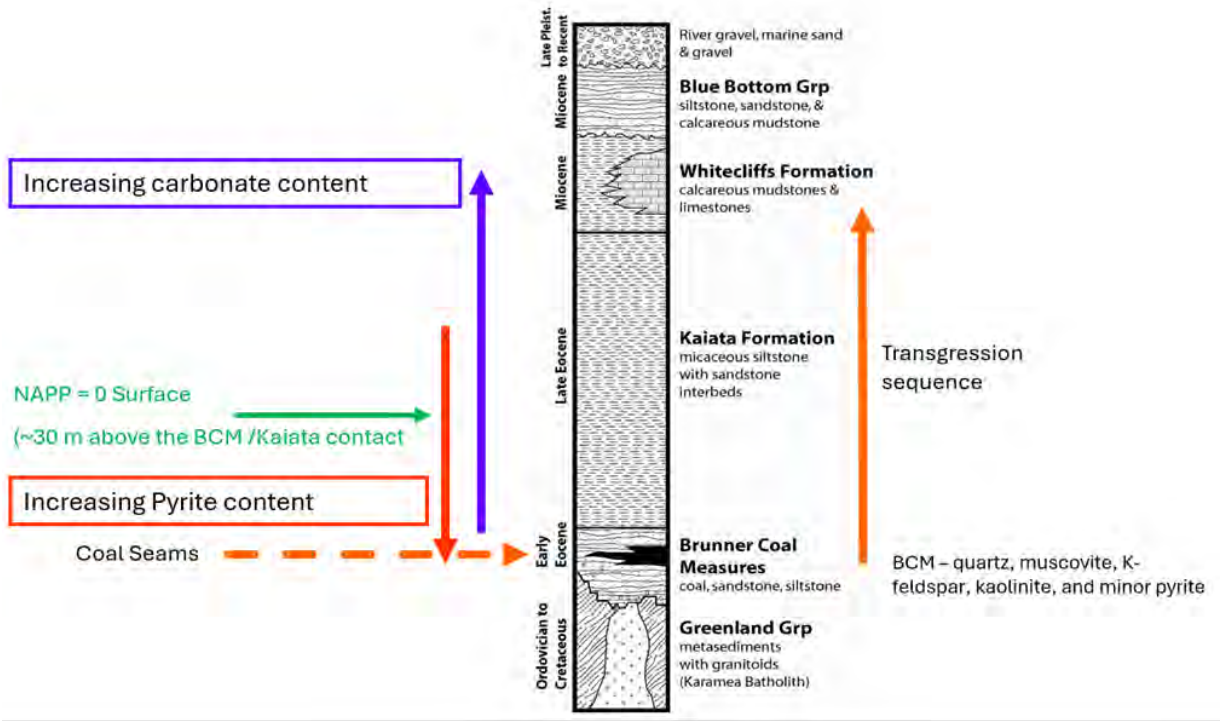


Figure 3: Stratigraphic column of the Denniston and Stockton Plateaux.

[1] *Portable x-ray fluorescence*

ESE

Using the AMIRA (2002) classification approach for waste rock at the existing Escarpment Mine (currently on care and maintenance) resulted in a significant number of samples being classified as UC. To assist with classification, a revised geochemical classification model was developed for the existing Escarpment Mine utilising a process flow approach that was validated by column leach test data (Olds et al., 2015). The model incorporated aspects of the original Escarpment Mine AMD classification resource consent (RC10193). The existing Escarpment Mine process flow classification system was accepted by the regulator and the appointed peer review panel as being appropriate.

This process flow approach reduces the requirement of blanket testing of samples reducing costs and optimising turn-around times. The following comments are provided:

- The key defining attribute of whether a sample will generate AMD is the sulfur content. If there is no sulfur, then there is no AMD potential. Hence total sulfur is used as a screening tool for classification of materials.
- If the maximum expected ANC in a dataset is never greater than a certain value, then this value can be used to classify materials as PAF if the MPA (calculated from sulfur content is greater than this value). For instance:
    - At ESE, the majority of samples had an ANC < 10 kg H_2SO_4/t. To be conservative, an ANC of 14 kg H_2SO_4/t was chosen as the threshold for PAF and NAF (where the ANC is equivalent to an MPA of 14 kg H_2SO_4/t; or for screening of samples a sulfur content of 0.45 wt%.
- Hence, any sample with an MPA > 14 kg H_2SO_4/t (i.e., >0.45 wt% sulfur) was classified as PAF as it was assumed there is insufficient ANC available to change the PAF classification.
- Other classifications were developed and included:
    - Low Risk (NAPP ≤ 5 kg H_2SO_4/t) to align with previous resource consent conditions (RC10193).
    - High acid forming (HAF) (wt% S > 0.7) to identify the highest risk PAF materials (Olds et al., 2015).

Further details are provided in Olds et al. (2015) – see Attachment C and BRL (2025a) – see Attachment D.

MFS

Both ESE and MFS are located within lithologies that are dominated by fluvial materials and therefore have potentially similar material characteristics. The geoenvironmental hazards associated with the MFS project were investigated using acid-base accounting (ABA) data from 24 drillholes completed in the MFS area during 2023/2024 (MWM, 2026b). Results were reviewed using the existing Escarpment Mine process flow model approach with a view to adjust the model as required based on site-specific MFS material characteristics.

Data demonstrated that 99.2% of samples had an ANC <10 kg H_2SO_4/t (Figure 4). Material with ANC ≥10 kg H_2SO_4/t is either Greenland Group basement or breccia immediately overlying the Greenland Group basement. Hence, an ANC value of 10 kg H_2SO_4/t was selected as an appropriate value to define

PAF. Hence, any sample with a MPA > 10 kg H_2SO_4/t (i.e., >0.33 wt% S) was classified as PAF as it was assumed there is insufficient ANC available to change the PAF classification. HAF categories remained the same as the Escarpment Mine classification. Review of NAF samples indicated a value of 0.05 wt% sulfur could be used as a cutoff value to define NAF without further testing (MWM, 2026b).

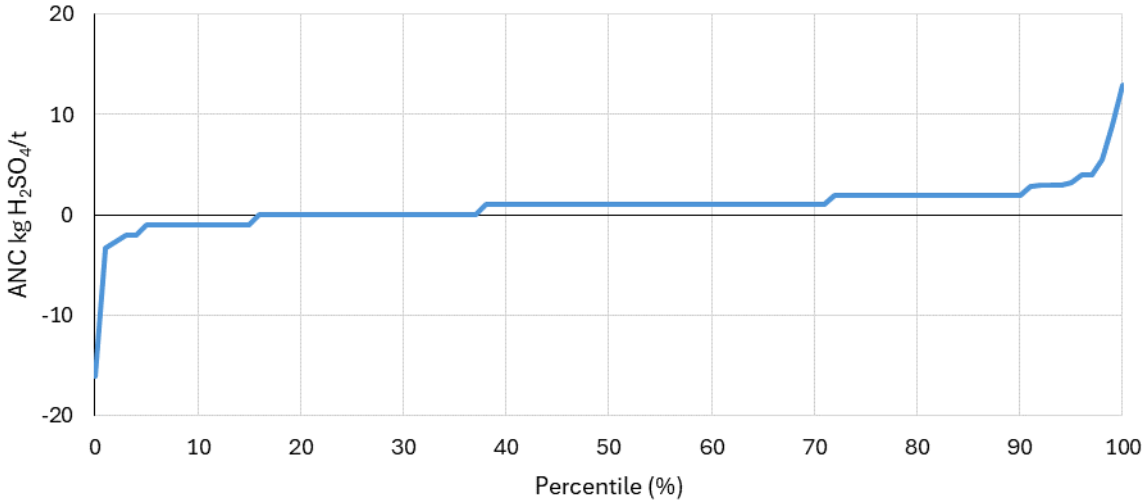


Figure 4: ANC distribution of MFS samples.

At MFS, samples with a sulfur (S) content of 0.05 < S ≤ 0.2 wt% and NAG pH ≤4.5 can be classified as NAF (0.2%), Low Risk (3.6%), or PAF (0.4%) using NAPP data (where the percentage data reflects the proportion of the total sample population). However, this requires ANC data, which is an expensive and time-consuming test. Given this is a small percentage of the sample population, the majority of samples are Low Risk, it was decided that materials having a sulfur content of 0.05 < S ≤ 0.2 wt% and NAG pH ≤4.5 would be classified as Low Risk. This allows all material to be classified from wt% S and NAG pH only (MWM, 2026b).

Further details are provided in MWM (2026b) and BRL (2025b) – see Attachment E.

Upper Waimangaroa Haul Road

Previous studies (MWM, 2025a) have presented ABA data for the proposed Upper Waimangaroa Haul Road (UWHR) and have shown that BCM, Kaiata Mudstone, and colluvium are present within the proposed road corridor. Kaiata Mudstone includes both NAF and PAF materials according to the geological model (MWM, 2025a). Data also suggest significant colluvium sourced from the Mount William Range, some of which represents landslide material.

The development of the UWHR will need to classify materials with regards to AMD potential. In this regard:

- Kaiata Mustone will be classified using McLachlan (2002) and BRL (2022).
- BCM will be classified using the MFS Classification process (MWM, 2026b).
- Colluvium remains of unknown origin and could include BCM, KMS, and/or basement materials. Colluvium is considered PAF unless proven otherwise as previous studies (Malloch et al., 2017) have indicated landslide materials (i.e., colluvium) derived from the Denniston area can be PAF.

Testing being completed as part of the Feasibility Study, will confirm geochemical nature and hence management requirements.

SUMMARY

Geochemical and geological variability of overburden throughout the BPCP area reduces the suitability of a singular AMD classification system for the Project. Non-site-specific classification based on industry guidance (e.g., AMIRA, 2002; Price, 2009) includes UC categories that are problematic for determining appropriate material management and all materials should then be classified as PAF. Site specific classification systems are required. Three classification systems have been developed for, and applied to, the BPCP area (Table 3).

APPLICATION

The various classification schemes are used by BRL to determine the quantities of various overburden materials (i.e., HAF, PAF, Low Risk, and NAF) within each Project area. Understanding the quantities of materials and the materials schedule is important for mine planning to ensure sufficient NAF is available for rehabilitation purposes (e.g., cover systems) and other activities. Further details on how overburden quantities (based on ABA data) have been calculated are provided in:

- Attachment D for the Escarpment Extended sub-area, and
- Attachment E for the Mount Frederick South sub- area.

These reports summarise:

- A data summary of the information available including maps of drillhole locations to provide context as to spatial representativeness.
- The modelling process undertaken to determine material quantities.
- Total project material quantities; and
- Material quantities by year versus material quantities required for progress rehabilitation.

\

Table 3: AMD Classification schemes for the BPCP.

	NAF	LOW RISK	PAF	HAF
CYPRESS[1] FOR KMS ALONG THE UWHR	• NAPP < 0 / pXRF-Ca > 14,000mg/kg	NA	• NAPP ≥ 0/pXRF-Ca ≤ 14,000 mg/kg	NA
ESE [2]	• S wt% ≤ 0.015 • 0.015 < S wt% ≤ 0.2, NAPP ≤ 0 • 0.015 < S wt% ≤ 0.45, NAG pH > 4.5	• 0.015 < S wt% ≤ 0.2, NAG pH ≤ 4.5, 0 < NAPP ≤ 5	• 0.015 < S wt% ≤ 0.2, NAG pH ≤ 4.5, NAPP > 5 • 0.2 < S wt% ≤ 0.45, NAG pH ≤ 4.5 • 0.45 < S wt% ≤ 0.7	S wt% > 0.7
MFS [3]	• S wt% ≤ 0.05 • 0.05 < S wt% ≤ 0.33, NAG pH > 4.5	• 0.05 < S wt% ≤ 0.2, NAG pH ≤ 4.5	• 0.2 < S wt% ≤ 0.33, NAG pH ≤ 4.5 • 0.33 < S wt% ≤ 0.7	S wt% > 0.7

[1] *McLachlan (2022)*

[2] *Olds et al. (2015)*

[3] *MWM (2026b)*

NA – Not applicable, no classification values identified.

REFERENCES

AMIRA, 2002. ARD Test Handbook - Project P387A Prediction and Kinetic Control of Acid Mine Drainage. AMIRA International Limited. Melbourne, Australia.

BRL (Bathurst Resources Limited), 2022. Cypress Mine Geochemistry and Overburden Management Plan, 23 pp.

BRL (Bathurst Resources Limited), 2024. Acid and Metalliferous Drainage (AMD) Environment Management Sub Plan, Stockton Mine. STO-ENV-PLN-016.

BRL (Bathurst Resources Limited), 2025a. Denniston ABA Block Model Memo. Dated 4 February 2025.

BRL (Bathurst Resources Limited), 2025b. MFS ABA Block Model Memo V4- Buller Plateaux Continuation Project. Dated 17 February 2025.

Flores, R.M., Sykes, R., 1996. Depositional controls on coal distribution and quality in the Eocene Brunner Coal Measures, Buller Coalfield, South Island, New Zealand. International Journal of Coal Geology 19: 291-336.

Hughes, J.B., Craw, D., Peake, B., Lindsay, P., Weber, P.A., 2007. Environmental characterisation of coal mine waste rock in the field: an example from New Zealand. Environmental Geology 52: 1501-1509.

Malloch, K.R., Weber, P.A., Olds, W.E., 2017. Acid and Metalliferous Drainage Potential of an Alluvial Gold Mine Operation. New Zealand Annual AusIMM Branch Conference, Christchurch, 10 - 13 September, 154 – 163.

McLachlan, C., 2022. Determination of Acid Producing Potential Using pXRF: A Case Study from Cypress Mine, Stockton Plateau. In IMWA 2022 Proceedings, Pope, J.; Wolkersdorfer, C.; Rait, R.; Trumm, D.; Christenson, H.; Wolkersdorfer, K. (Editors), pp 253 - 258.

MWM (Mine Waste Management), 2026a. Upper Waimangaroa Haul Road Site Visit. Mine Waste Management Report J-NZ0453-001-M-FINAL.

MWM (Mine Waste Management), 2026b. Factual Report: Geoenvironmental Hazards, Mount Frederick South Sub-area. Mine Waste Management Report J-NZ0377-001-R- FINAL.

Olds, W.E., Bird, B., Pearce, J.I., Sinclair, E., Orr, M., Weber, P.A., 2015. Geochemical Classification of Waste Rock using Process Flow Diagrams. New Zealand Annual AusIMM Branch Conference, Dunedin, 31 August – 2 September 2015, pp 307-318.

Pope, J., Christenson, H., Gordon, K., Newman, N., Trumm, D., 2018. Decrease in acid mine drainage release rate from mine pit walls in Brunner Coal Measures. New Zealand Journal of Geology and Geophysics 2018, Vol. 61, No. 2, 195–206.

Price, W.A. 2009. Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials. MEND Report 1.20.1 December 2009.

ATTACHMENT A: MCLACHLAN (2022)

Determination of Acid Producing Potential Using pXRF: A Case Study from Cypress Mine, Stockton Plateau

Christine McLachlan[1]

[1]*BT Mining, Stockton Coal Mine, Stockton Road 7823, Westport, christine.mcLachlan@bathurst.co.nz*

Abstract

Management of acid producing materials is critical to responsible mining using best practicable approaches to protect the environment and ensure effective mine closure that achieves closure objectives. At Cypress Mine the pyritic Kaiata Mudstone changes geochemically from potentially acid forming (PAF) at the base to non-acid forming (NAF), determined by acid base accounting (ABA), as part of a marine transgression sequence, but changes back to PAF at the ground surface. A drill program together with ABA testing was initiated to determine the PAF and NAF material quantities for mine closure planning. A reliable relationship between p-XRF calcium and laboratory analysed acid neutralisation capacity (ANC) was determined. This relationship was used to create a geochemical block model for the project area, which has facilitated the development of a materials schedule.

Keywords: Acid and Metalliferous Drainage, AMD, p-XRF, material schedules

Introduction

The Cypress Mine is owned by BT Mining and is located adjacent to the Stockton Mine on the Stockton Plateau, 35 km northeast of Westport, South Island, New Zealand. Cypress Mine is key to Stockton Mine's future as a blending partner for metallurgical coal exports. Stockton is a historical mine and extends back to 1906 while Cypress Mine commenced operation in 2014 and is in a pristine, high value ecological valley. The mine plan for Cypress was in 2 stages and started with a boxcut on the valley floor followed by a push-back into the flanks of the Mt William Range.

The coal is contained within the acidic Brunner Coal Measures, which is overlain by the pyritic Kaiata Mudstone. Much of the Kaiata Mudstone has been eroded from the Stockton Plateau, leaving a wedge along the eastern margin of the plateau against the Mt William Fault of the Mt William Range where the Cypress Mine is located (Nathan 1996).

The Kaiata Mudstone has an average total sulfur of 1.6 wt% but can be up to 4 wt% and is highly reactive (comprised of reactive framboidal pyrite) (Weber *et al.* 2006). At Cypress Mine the pyritic Kaiata Mudstone changes geochemically from potentially acid forming (PAF) at the base to non-acid forming (NAF), determined by acid base accounting (ABA), as part of a marine transgression sequence, but changes back to PAF at the ground surface.

It is important for BT Mining to ensure the material classification of PAF and NAF are correct as there is currently an excess of PAF material and a deficit of NAF material in Cypress. The majority of waste rock is stored on the ex-pit Northern engineered landform (NELF) which has 2.75 Mm^3 PAF and produces ~1,000 t H_2SO_4/yr. Some of the PAF within the NELF will be placed back within the Cypress pit as backfill. This will be capped by NAF, which is limited, as part of the final cover design.

Any NAF being placed with PAF results in the loss of a valuable resource. If PAF is dumped on the NAF dump it will decrease the integrity of the NAF dump and limit future reuse and closure options for the NAF such as cover construction and rehabilitation activities.

The original 2018 geochemical block model was a good working model for the original valley floor boxcut. However, BT Mining faced issues with material classification once the push-back started as the PAF and NAF material model had significant uncertainties due to limited drill

data in the push-back. This resulted in PAF and NAF materials being sent to the wrong facility.

The model was based on the net acid producing potential (NAPP) value where NAPP was greater than or less than 0 kg H_2SO_4/t. This NAPP = 0 surface was fit for purpose for the boxcut in the valley floor but proved to be inadequate for the push-back leading to: contaminated NAF stockpiles; NAF materials being disposed of as PAF; and the introduction of a low acid forming zone (due to model uncertainty with this zone containing both PAF and NAF materials). Additional in-pit sampling was also required, which incurred additional costs as well as production delays.

In 2021 a drilling program was undertaken in the push-back to develop a new geochemical block model. These samples were analysed by the pXRF and validated with laboratory testing.

Methods

A reverse circulation (RC) drilling program (50 holes) was undertaken in late 2021 in Stages 3 and 4 of the Mt William push-back targeting the NAPP = 0 surface, which is ~30 m above the interface with the Brunner Coal Measures. The RC drill produces a reasonably dry and fine, homogenised drill-chip, which was directly analysed with the pXRF.

Each of the 50 RC holes ranged in depth between 9 and 48 m and 1,019 m of drill-chip was collected. Each meter of drill-chip was riffle split to obtain a sample of ~2 - 5 kg and these samples were analysed 4 times with the pXRF. A total of 318 samples were selected to be sent to the laboratory for analysis for total S (wt%) and ANC to determine the NAPP value. NAPP was determined by:

NAPP (kg H_2SO_4/t) = (wt%S*30.6) – ANC (kg H_2SO_4/t)
where a NAPP value >0 is PAF and ≤0 is NAF.

pXRF-S and pXRF-Ca analyses were corrected for the blank and calibration reference samples, then the 4 analyses were averaged to give a single result for each 1 m of drill core. Samples sent to the laboratory were selected based on the geochemical model with samples being selected from the transition zones from PAF to NAF as well as some longer sections to ensure any relationships held across all samples. A relationship was established between the pXRF-Ca and laboratory NAPP values which formed the basis of the block model.

During the development of the geochemical block model any unclear transitions between PAF and NAF were assessed to see the variation in NAPP value as well as the trend of the surrounding holes and where the surface would geologically and geochemically align. If there was no clear understanding of where the NAPP = 0 surface should lie then a conservative approach was undertaken.

Results

Comparison of the results for pXRF-S and laboratory total S% showed that the pXRF is not sufficiently sensitive to detect the small changes in sulfur that occur throughout the Kaiata Mudstone. Data indicates that sulfur content only has a minor change within the project area and is not the determining factor for classification of PAF or NAF.

A good relationship between pXRF-Ca and laboratory ANC and NAPP was established with a degree of certainty – R^2 of 0.76 and 0.72 respectively (Figure 1). For the creation of the geochemical block model samples only need to be classified as PAF or NAF (i.e., NAPP >0 for PAF and NAPP ≤0 for NAF) and a pXRF-Ca value of 14,000 mg Ca/kg was determined to represent this change in the material from PAF to NAF.

Using this cutoff value of 14,000 mg Ca/kg the pXRF-Ca and laboratory NAPP value were in agreement 90% of the time and are within NAPP -5 to 5 for 95% of the time, meaning that about half of the samples incorrectly classified by the pXRF are low acid forming zone (Figure 2).

At ~14,000 mg Ca/kg pXRF-Ca there is commonly a distinct change with a sudden drop in Ca value to the 1,000's for PAF from the 10,000's for NAF (Figure 2). This occurs for both the upper and lower NAPP = 0 surfaces. Consequently, 14,000 mg Ca/kg pXRF-Ca was selected as the cutoff in the pXRF-Ca data to define PAF and NAF. This is supported by the laboratory data (Figure 2).

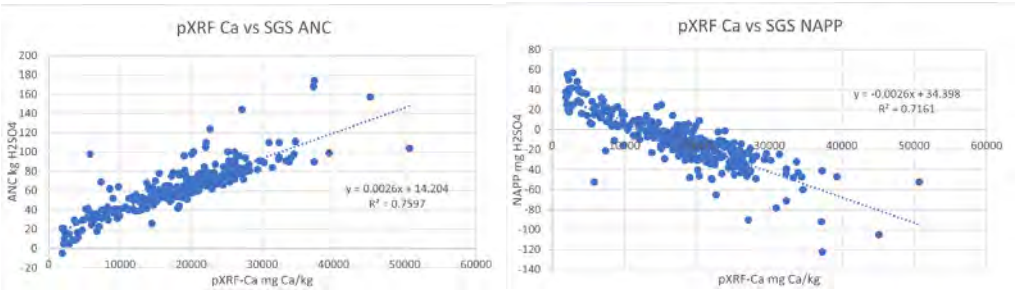


Figure 1 *Graphs showing the correlation between pXRF-Ca and laboratory ANC (R2 = 0.76) and pXRF-Ca and Laboratory NAPP (R^2 = 0.72).*

The results showed that there are 2 surfaces within the data, which is consistent across the drillholes with the lower surface occurring at ~30 m above the interface with the Brunner Coal Measures and the upper surface occurring ~5-10 m below the ground surface.

From the data collected from the drilling program a geochemical block model was developed for use in daily operations at Cypress Mine. The block model has 2 NAPP = 0 surfaces.

Discussion

The Kaiata Mudstone was deposited in the Late Eocene during a marine transgression (Flores *et al.* 1996) and the geochemical change from PAF at the base of the formation to NAF higher up due to the steady transgression through to the Nile River Limestone (i.e., increasing carbonate) (Nathan 1996), which resulted in increasing Ca. There is a minor decrease in S with younger lithologies, but it was not sufficient or consistent enough to reliably affect the NAPP prediction of the material. Rather it

DH 3878R pXRF-Ca (14000	SGS NAPP	DH 3539 pXRF-Ca (14000	SGS NAPP	DH 3909 pXRF-Ca (14000	SGS NAPP	DH 3973 pXRF-Ca (14000	SGS NAPP	DH 4011 pXRF-Ca (14000	SGS NAPP	DH 4078 pXRF-Ca (14000	SGS NAPP
3666	41	1371		1140		5458		3995		1653	
6795	32	1411		548		2218		2466		1440	
3711	39	2361	41	1095		2737	42	2208	19	1699	
3444	48	4133	37	831		3905	27	3585	29	2575	
2891	57	16284	-13	2031		18779	-14	13137		2771	
2112	55	9848	5	4100		32369	-71	8240	4	2812	
2295	50	21430	-26	15931		26110	-39	14753	-4	4830	14
4743	36	24860	-38	17170		20600	-17	11914	4	20084	-31
2413	22	24472		28574		22866	-14	15207	-3	34642	-60
19344	-23	21803		24065		24246	-14	13945	-1	20878	
26914	-46	24563		23812		29299	-30	18344	3	19403	
34467	-47	23800		31634		39358	-47	17481	-26	32728	
33748	-32	35891		20323		19428	-8	23914	-18	19695	
26381		22224		25840		18189	-4	17828	-21	25154	
14 pXRF NAF values		23325		24647		20909	-14	22455	-21	31003	
removed		21818		26352	-26	23255	-11	26183	-35	21627	
21418		22737		18866	-11	25155	-20	27415	-41	26405	-32
27113	-24	25933		17080	-11	17884	3	22922	-2	23202	-25
13034	14	17684	-7	33318	-48	25617	-21	17504	-3	9023	23
16408	-4	26255	-28	32349	-39	28239	-26	19793	4	6961	17
17529	-12	33983	-43	18795	6	25941	-21	22638	-65	19261	-30
17194	-4	6007	23	22110	-50	27116	-90	20492	-8	5802	15
17943	-16	6730	14	21429	-20	27141	-23	25113	-13	9879	
13825	1	7052	29	9055	3	9974	15	16639	14	7010	
19266	-3	6335		8054	16	11773	-5	12081	-10	5155	
22936				4842		6401	16	7909	11	5185	
7 pXRF NAF values				14182		9833		16716	-9	5565	
removed						5802		10792	5	4738	
25495						5 pXRF PAF values				5967	
18916	-22					removed				5783	
13208	0										

Figure 2 *Comparison of allocation of NAF (green) and PAF (red) for the pXRF-Ca and SGS NAPP values. For the pXRF-Ca there is often a step change from the 1,000's for PAF to 10,000's for PAF.*

is the carbonate content that controls NAPP and can be used for the prediction of AMD potential using the pXRF.

Results from the pXRF work and validated by the laboratory analyses show that it is possible to reliably predict acid producing potential from the Kaiata Mudstone, in particular from the sediment from the RC drill, when Ca is used as the indicator element with a cutoff of 14,000 mg Ca/kg. Work with the pXRF-S show that S is not a reliable indicator of acid producing potential.

For the development of the geochemical block model only a binary result of either PAF or NAF was required and this increased the correlation between the pXRF-Ca and laboratory NAPP results to 90%. However, when the NAPP values are set to between -5 and 5 kg H_2SO_4/t, indicating that the material has low acid producing potential, the correlation between the pXRF-Ca and laboratory NAPP values increases to 95%.

The geochemical model shows a wedge of NAF Kaiata, which is terminated to the east by the east dipping Mt William Fault, to the west, at surface, by the westerly dipping topographic surface and at depth by the underlying stratigraphically controlled PAF Kaiata (Figure 3). The lower NAPP = 0 surface is stratigraphically controlled and is ~30 m above the interface with the underlying acidic Brunner Coal Measures and is analogous to the original NAPP surface from the boxcut. The upper NAPP = 0 surface is topographically controlled and is likely a leaching zone on the flank of the Mt William Range. This surface was unknown prior to this work.

Prior to the development of this geochemical block model a single NAPP = 0 surface was used which was suitable for the boxcut on the valley floor. However, when the pushback into Mt William ranges was started PAF was occurring in unexpected zones which led to increased in-pit sampling, production delays or NAF being disposed of on the PAF dump to avoid production delays, planning for a low acid forming dump and PAF being deposited on the NAF dump decreasing its integrity. The development of the new block model has alleviated these issues.

The geochemical block model NAPP surfaces are used every day by the operations team and are a fundamental part of all overburden stripping plans where the

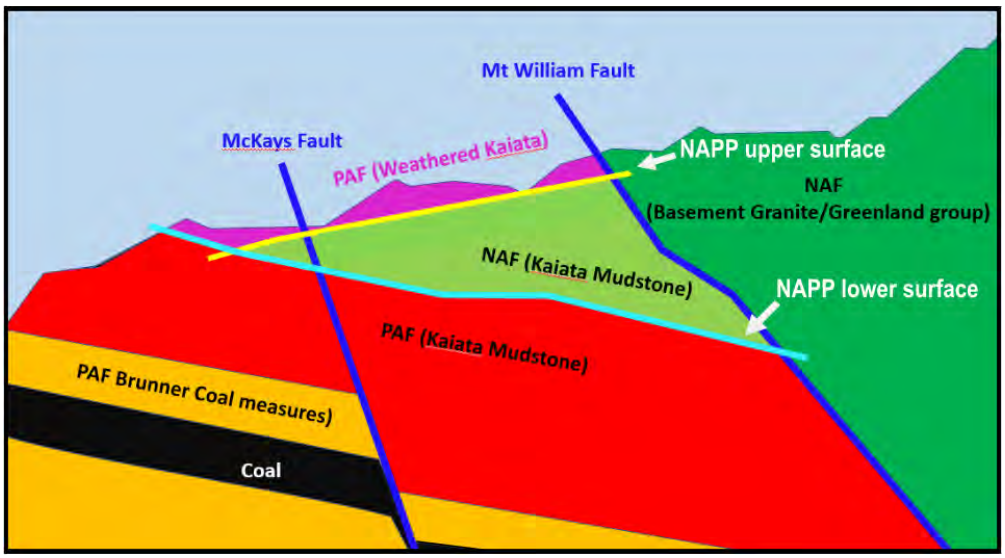


Figure 3 *The geochemical block model showing a wedge of NAF Kaiata Mudstone created using the pXRF-Ca data and validated by laboratory ABA analyses. The model shows 2 NAPP = 0 surfaces with the NAPP upper surface being topographically controlled and the NAPP lower surface being stratigraphically controlled (block model created by Phillip Fick).*

material type changes across the flitch. There is conservatism built into the system bought about through the method of stripping. The stripping blocks are 3 – 5 m high horizontal flitches and the NAPP surfaces are dipping. Therefore, with a vertical dig face there is a wedge of NAF in each flitch that is taken as PAF material. This means that any undulation in the NAPP surfaces has little to no effect on the integrity of the NAF dumps. The result of the introduction of the new block model is that the old NAF dump has an average NAPP value of -5.5 H_2SO_4/T whereas the new NAF dump has an average NAPP value of -19 H_2SO_4/T.

The establishment of the relationship between pXRF-Ca and NAPP means that in-pit operational decisions regarding uncertainty in PAF or NAF can be dealt with instantaneously rather than waiting in excess of 24 hours for laboratory results. This ensures no production delays, loss of NAF or incorrect material designation.

As mining progresses south the block model will be extended as the mining area is extended and cleared for stripping. This will ensure the continued correct material designation for the life of mine.

Conclusions

The use of the pXRF in determining the acid producing potential has been proven to be successful for use in the Kaiata Mudstone at Cypress Mine. The implementation of the new geochemical block model has been critical to operational activities to ensure the correct material designation of PAF and NAF. This has allowed for a decrease in in-pit sampling, costs associated with production delays and NAF being dumped on the PAF dump as well as increasing the integrity of the NAF dump, which is a scarce resource required for closure and the protection of the waterways.

Acknowledgements

The author would like to thank all co-organisers for hosting the IMWA2022 Conference as well as Paul Weber and Barry Walker for comments on this paper. The author would like to acknowledge and thank Phillip Fick for the development of the block model,

References

Flores R, Sykes R (1996) Depositional controls on coal distribution and quality in the Eocene

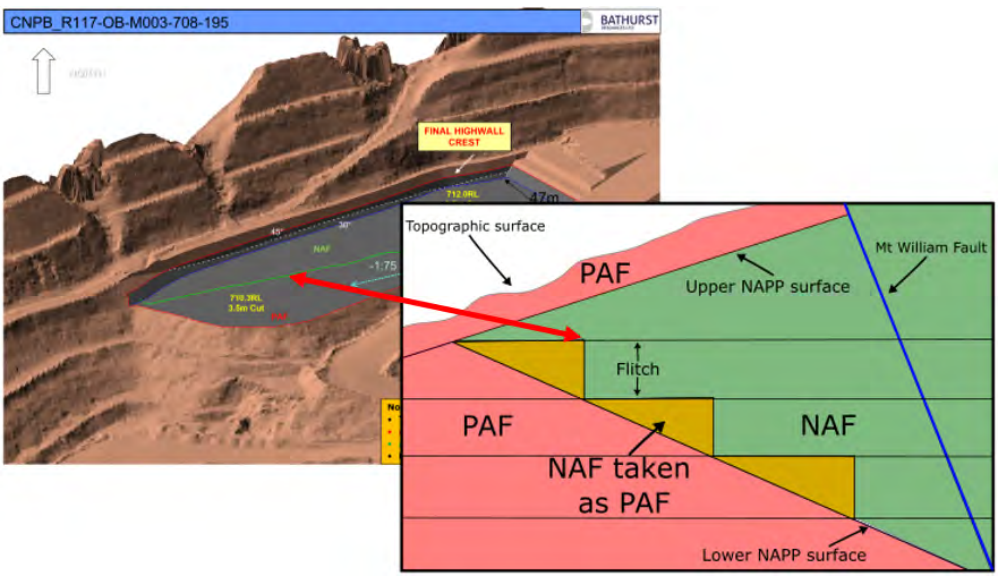


Figure 4 *Schematic of the flitches in-pit which transition from PAF to NAF showing that a wedge of NAF is taken as PAF material above the lower NAPP surface. The PAF/NAF line on the Engineers digplans relates to base of the flitch to ensure no PAF ends up on the NAF dump.*

Brunner Coal Measures, Buller Coalfield, South Island, New Zealand. International Journal of

Coal Geology 29: 291-336

Nathan S (1996) Geology of the Buller Coalfield, scale 1:50 000. Institute of Geological & Nuclear Sciences geological map 23. Lower Hutt, New Zealand: Institute of Geological & Nuclear Sciences Limited

Weber PA, Skinner WM, Hughes JB, Lindsay P, Moore TA (2006) Source of Ni in coal mine acid rock drainage, West Coast, New Zealand. International Journal of Coal Geology 67:214-220

ATTACHMENT B: CYPRESS pXRF DATA (MCLACHLAN, 2022)

Date	SGS Lab Report Lunber	Info	m from	m to	pXRF Ca (ppm)	pXRF S (ppm)	ANC pulp eqn (pXRF calc)	SGS ANC (kg H2SO4/t)	SGS Total S % (LECO)	MWM NAPP Calculation
9/11/2021	WP21-09138	cpo3539	6.00	7.00	2361	8942	17.86	6	1.53	40.818
9/11/2021	WP21-09138	cpo3539	7.00	8.00	4133	9858	22.36	12	1.6	36.96
9/11/2021	WP21-09138	cpo3539	8.00	9.00	16284	9690	53.18	62	1.58	-13.652
9/11/2021	WP21-09138	cpo3539	9.00	10.00	9848	8784	36.85	41	1.5	4.9
9/11/2021	WP21-09138	cpo3539	10.00	11.00	21430	12421	66.24	65	1.26	-26.444
9/11/2021	WP21-09138	cpo3539	11.00	12.00	24860	14238	74.94	77	1.25	-38.75
9/11/2021	WP21-09138	cpo3539	22.00	23.00	17684	16505	56.73	54	1.55	-6.57
9/11/2021	WP21-09138	cpo3539	23.00	24.00	26255	11874	78.48	77	1.59	-28.346
9/11/2021	WP21-09138	cpo3539	24.00	25.00	33983	12331	98.09	94	1.68	-42.592
9/11/2021	WP21-09138	cpo3539	25.00	26.00	6007	16178	27.11	25	1.57	23.042
9/11/2021	WP21-09138	cpo3539	26.00	27.00	6730	14906	28.94	33	1.55	14.43
9/11/2021	WP21-09138	cpo3539	27.00	28.00	7052	13706	29.76	23	1.71	29.326
20/09/2021	WP21-09138	cpo3876	4.00	5.00	29587	10119	86.93	91	2.18	-24.292
20/09/2021	WP21-08677	cpo3876	5.00	6.00	23660	12316	71.89	67	1.78	-12.532
20/09/2021	WP21-08677	cpo3876	6.00	7.00	23861	11773	72.40	70	2.27	-0.538
20/09/2021	WP21-08677	cpo3876	7.00	8.00	37201	9688	106.25	168	2.49	-91.806
2/11/2021	WP21-09139	cpo3878r	0.00	1.00	3666	10658	21.17	9	1.66	41.796
2/11/2021	WP21-09139	cpo3878r	1.00	2.00	6795	7252	29.11	18	1.62	31.572
2/11/2021	WP21-09139	cpo3878r	2.00	3.00	3711	8345	21.28	9	1.58	39.348
2/11/2021	WP21-09139	cpo3878r	3.00	4.00	3444	7512	20.61	9	1.85	47.61
2/11/2021	WP21-09139	cpo3878r	4.00	5.00	2891	8245	19.20	5	2.02	56.812
2/11/2021	WP21-09139	cpo3878r	5.00	6.00	2112	9230	17.23	5	1.98	55.588
2/11/2021	WP21-09139	cpo3878r	6.00	7.00	2295	7347	17.69	5	1.79	49.774
2/11/2021	WP21-09139	cpo3878r	7.00	8.00	4743	7683	23.90	19	1.8	36.08
2/11/2021	WP21-09139	cpo3878r	8.00	9.00	2413	10887	17.99	16	1.24	21.944
2/11/2021	WP21-09139	cpo3878r	9.00	10.00	19344	12526	60.95	60	1.2	-23.28
2/11/2021	WP21-09139	cpo3878r	10.00	11.00	26914	12624	80.15	83	1.18	-46.892
2/11/2021	WP21-09139	cpo3878r	11.00	12.00	34467	12132	99.31	98	1.65	-47.51
2/11/2021	WP21-09139	cpo3878r	12.00	13.00	33748	10989	97.49	90	1.9	-31.86
1/11/2021	WP21-09139	cpo3878r	29.00	30.00	27113	7601	80.65	77	1.72	-24.368
1/11/2021	WP21-09139	cpo3878r	30.00	31.00	13034	8498	44.94	40	1.76	13.856
1/11/2021	WP21-09139	cpo3878r	31.00	32.00	16408	9144	53.50	54	1.65	-3.51
1/11/2021	WP21-09139	cpo3878r	32.00	33.00	17529	8687	56.34	59	1.54	-11.876
1/11/2021	WP21-09139	cpo3878r	33.00	34.00	17194	10099	55.49	50	1.5	-4.1
1/11/2021	WP21-09139	cpo3878r	34.00	35.00	17943	9608	57.39	63	1.53	-16.182
1/11/2021	WP21-09139	cpo3878r	35.00	36.00	13825	7194	46.94	47	1.58	1.348
1/11/2021	WP21-09139	cpo3878r	36.00	37.00	19266	9307	60.75	53	1.64	-2.816
1/11/2021	WP24-13565	cpo3878r	43.00	44.00	24647	8047	74.40	56	1.48	-10.712
1/11/2021	WP24-13565	cpo3878r	44.00	45.00	22579	12817	69.15	56	1.42	-12.548
1/11/2021	WP24-13565	cpo3878r	45.00	46.00	25495	14766	76.55	66	1.82	-10.308
1/11/2021	WP21-09139	cpo3878r	46.00	47.00	18916	10875	59.86	65	1.4	-22.16
1/11/2021	WP21-09139	cpo3878r	47.00	48.00	13208	10221	45.38	49	1.6	-0.04
29/09/2021		cpo3907	4.00	5.00	21847	7366	67.30	85	1.69	-33.286
29/09/2021		cpo3907	5.00	6.00	19406	9542	61.10	70	1.53	-23.182
29/09/2021		cpo3907	6.00	7.00	17371	9049	55.94	58	1.7	-5.98
29/09/2021		cpo3907	7.00	8.00	15841	9557	52.06	54	1.62	-4.428
29/09/2021		cpo3907	8.00	9.00	18334	8930	58.38	76	1.63	-26.122
29/09/2021		cpo3907	9.00	10.00	15354	8754	50.82	56	1.79	-1.226
29/09/2021		cpo3907	10.00	11.00	16698	11405	54.23	62	1.39	-19.466
29/09/2021		cpo3907	11.00	12.00	17845	10080	57.14	57	1.62	-7.428
29/09/2021		cpo3907	12.00	13.00	14393	7504	48.38	56	1.6	-7.04
29/09/2021		cpo3907	13.00	14.00	18103	10506	57.80	54	1.71	-1.674

Date	SGS Lab Report Lunber	Info	m from	m to	pXRF Ca (ppm)	pXRF S (ppm)	ANC pulp eqn (pXRF calc)	SGS ANC (kg H2SO4/t)	SGS Total S % (LECO)	MWM NAPP Calculation
29/09/2021		cpo3907	14.00	15.00	15494	8451	51.18	55	1.63	-5.122
29/09/2021		cpo3907	15.00	16.00	21979	10550	67.63	77	1.48	-31.712
29/09/2021		cpo3907	16.00	17.00	19386	11542	61.05	66	1.27	-27.138
29/09/2021		cpo3907	17.00	18.00	24351	12963	73.65	76	1.27	-37.138
29/09/2021		cpo3907	18.00	19.00	28120	18245	83.21	87	1.24	-49.056
29/09/2021		cpo3907	19.00	20.00	22845	13695	69.83	68	1.74	-14.756
29/09/2021		cpo3907	20.00	21.00	25999	12913	77.83	78	1.84	-21.696
29/09/2021		cpo3907	21.00	22.00	25037	13382	75.39	75	1.56	-27.264
29/09/2021		cpo3907	22.00	23.00	24505	13437	74.04	76	1.39	-33.466
29/09/2021		cpo3907	23.00	24.00	20128	13411	62.93	61	1.37	-19.078
29/09/2021		cpo3907	24.00	25.00	18284	12811	58.26	63	1.38	-20.772
28/09/2021	WP21-08729	cpo3909	19.00	20.00	26352	10834	78.72	80	1.75	-26.45
28/09/2021	WP21-08729	cpo3909	20.00	21.00	18866	13159	59.73	62	1.69	-10.286
28/09/2021	WP21-08729	cpo3909	21.00	22.00	17080	14239	55.20	61	1.62	-11.428
28/09/2021	WP21-08729	cpo3909	22.00	23.00	33318	13358	96.40	91	1.43	-47.242
28/09/2021	WP21-08729	cpo3909	23.00	24.00	32349	11920	93.94	95	1.81	-39.614
28/09/2021	WP21-08729	cpo3909	24.00	25.00	18795	12476	59.55	53	1.93	6.058
28/09/2021	WP21-08729	cpo3909	25.00	26.00	22110	8284	67.96	110	1.96	-50.024
28/09/2021	WP21-08729	cpo3909	26.00	27.00	21429	12269	66.24	76	1.84	-19.696
29/09/2021	WP21-08729	cpo3909	27.00	28.00	9055	15020	34.84	52	1.78	2.468
29/09/2021	WP21-08729	cpo3909	28.00	29.00	8054	13238	32.30	37	1.74	16.244
3/11/2021	WP21-09047	cpo3918	17.00	18.00	15078	15462	50.12	59	1.34	-17.996
3/11/2021	WP21-09047	cpo3918	18.00	19.00	12168	15040	42.74	52	1.72	0.632
3/11/2021	WP21-09047	cpo3918	19.00	20.00	27001	13037	80.37	40	1.46	4.676
3/11/2021	WP21-09047	cpo3918	20.00	21.00	10007	12532	37.26	71	1.52	-24.488
3/11/2021	WP21-09047	cpo3918	21.00	22.00	12633	14310	43.92	39	1.51	7.206
3/11/2021	WP21-09047	cpo3918	22.00	23.00	12133	15606	42.65	39	1.59	9.654
3/11/2021	WP21-09047	cpo3918	23.00	24.00	9239	13982	35.31	41	1.48	4.288
3/11/2021	WP21-09047	cpo3918	24.00	25.00	8120	16934	32.47	33	1.56	14.736
3/11/2021	WP21-09047	cpo3918	25.00	26.00	9643	19600	36.33	31	1.62	18.572
17/09/2021	WP21-08749	cpo3973	2.00	3.00	2737	9121	18.81	15	1.88	42.528
17/09/2021	WP21-08749	cpo3973	3.00	4.00	3905	8193	21.78	27	1.75	26.55
17/09/2021	WP21-08749	cpo3973	4.00	5.00	18779	10151	59.51	61	1.52	-14.488
17/09/2021	WP21-08749	cpo3973	5.00	6.00	32369	16048	93.99	110	1.27	-71.138
17/09/2021	WP21-08749	cpo3973	6.00	7.00	26110	18496	78.11	81	1.38	-38.772
17/09/2021	WP21-08749	cpo3973	7.00	8.00	20600	14228	64.13	67	1.64	-16.816
17/09/2021	WP21-08749	cpo3973	8.00	9.00	22866	12328	69.88	68	1.78	-13.532
17/09/2021	WP21-08749	cpo3973	9.00	10.00	24246	11040	73.38	71	1.86	-14.084
17/09/2021	WP21-08749	cpo3973	10.00	11.00	29299	10787	86.20	82	1.7	-29.98
17/09/2021	WP21-08749	cpo3973	11.00	12.00	39358	10604	111.72	99	1.69	-47.286
17/09/2021	WP21-08749	cpo3973	12.00	13.00	19428	11535	61.16	62	1.77	-7.838
17/09/2021	WP21-08749	cpo3973	13.00	14.00	18189	12179	58.02	61	1.87	-3.778
17/09/2021	WP21-08749	cpo3973	14.00	15.00	20909	14553	64.92	70	1.83	-14.002
17/09/2021	WP21-08749	cpo3973	15.00	16.00	23255	16369	70.87	69	1.89	-11.166
17/09/2021	WP21-08749	cpo3973	16.00	17.00	25155	18372	75.69	75	1.81	-19.614
17/09/2021	WP21-08749	cpo3973	17.00	18.00	17884	15046	57.24	57	1.97	3.282
17/09/2021	WP21-08749	cpo3973	18.00	19.00	25617	12343	76.86	76	1.78	-21.532
17/09/2021	WP21-08749	cpo3973	19.00	20.00	28239	12609	83.51	81	1.79	-26.226
17/09/2021	WP21-08749	cpo3973	20.00	21.00	25941	12076	77.68	76	1.78	-21.532
17/09/2021	WP21-08749	cpo3973	21.00	22.00	27116	12692	80.66	144	1.75	-90.45
17/09/2021	WP21-08749	cpo3973	22.00	23.00	27141	14852	80.73	77	1.8	-21.92
17/09/2021	WP21-08749	cpo3973	23.00	24.00	9974	18858	37.17	34	1.6	14.96

Date	SGS Lab Report Lunber	Info	m from	m to	pXRF Ca (ppm)	pXRF S (ppm)	ANC pulp eqn (pXRF calc)	SGS ANC (kg H2SO4/t)	SGS Total S % (LECO)	MWM NAPP Calculation
17/09/2021	WP21-08749	cpo3973	24.00	25.00	11773	19848	41.74	53	1.57	-4.958
17/09/2021	WP21-08749	cpo3973	25.00	26.00	6401	23554	28.11	30	1.51	16.206
17/09/2021	WP21-08679	cpo3977	1.00	2.00	9767	6869	36.65	37	1.47	7.982
17/09/2021	WP21-08679	cpo3977	2.00	3.00	19274	10250	60.77	59	1.56	-11.264
17/09/2021	WP21-08679	cpo3977	3.00	4.00	27340	10185	81.23	72	1.73	-19.062
17/09/2021	WP21-08679	cpo3977	4.00	5.00	22562	10113	69.11	71	1.73	-18.062
17/09/2021	WP21-08679	cpo3977	5.00	6.00	22425	11936	68.76	79	1.48	-33.712
17/09/2021	WP21-08679	cpo3977	6.00	7.00	26034	17572	77.92	79	1.47	-34.018
17/09/2021	WP21-08679	cpo3977	7.00	8.00	21057	12716	65.29	66	1.77	-11.838
17/09/2021	WP21-08679	cpo3977	8.00	9.00	23725	13284	72.06	73	1.81	-17.614
17/09/2021	WP21-08679	cpo3977	9.00	10.00	25260	13522	75.95	76	1.84	-19.696
17/09/2021	WP21-08679	cpo3977	10.00	11.00	25846	14797	77.44	77	1.49	-31.406
17/09/2021	WP21-08679	cpo3977	11.00	12.00	26811	15326	79.89	80	1.4	-37.16
17/09/2021	WP21-08679	cpo3977	12.00	13.00	25547	16000	76.68	71	1.43	-27.242
17/09/2021	WP21-08679	cpo3977	13.00	14.00	25434	18931	76.39	69	1.43	-25.242
17/09/2021	WP21-08679	cpo3977	14.00	15.00	22968	16309	70.14	72	1.43	-28.242
17/09/2021	WP21-08679	cpo3977	15.00	16.00	24787	19556	74.76	81	1.44	-36.936
17/09/2021	WP21-08679	cpo3977	16.00	17.00	50686	12070	140.46	104	1.72	-51.368
17/09/2021	WP21-08679	cpo3977	17.00	18.00	8566	17002	33.60	62	1.68	-10.592
17/09/2021	WP21-08679	cpo3977	18.00	19.00	6880	19566	29.32	32	1.9	26.14
17/09/2021	WP21-08679	cpo3977	19.00	20.00	15520	19204	51.24	78	1.59	-29.346
11/10/2021	WP22-10652	cpo3981	1.00	2.00	14788	7996	49.39	52	1.42	-8.548
11/10/2021	WP22-10652	cpo3981	2.00	3.00	1899	6699	16.69	-5	1.26	43.556
11/10/2021	WP22-10652	cpo3981	3.00	4.00	2874	5935	19.16	15	1.32	25.392
11/10/2021	WP22-10652	cpo3981	4.00	5.00	14386	6660	48.37	56	1.85	0.61
11/10/2021	WP22-10652	cpo3981	5.00	6.00	37310	5725	106.52	174	1.73	-121.062
11/10/2021	WP22-10652	cpo3981	6.00	7.00	24528	6826	74.10	85	1.74	-31.756
11/10/2021	WP22-10652	cpo3981	7.00	8.00	20343	5633	63.48	100	1.76	-46.144
11/10/2021	WP22-10652	cpo3981	8.00	9.00	22024	7908	67.74	105	1.85	-48.39
11/10/2021	WP22-10652	cpo3981	9.00	10.00	26757	6932	79.75	96	1.77	-41.838
11/10/2021	WP22-10652	cpo3981	10.00	11.00	18364	8748	58.46	78	1.54	-30.876
11/10/2021	WP22-10652	cpo3981	11.00	12.00	15007	10973	49.94	70	1.77	-15.838
11/10/2021	WP22-10652	cpo3981	12.00	13.00	19082	8240	60.28	81	1.74	-27.756
11/10/2021	WP22-10652	cpo3981	13.00	14.00	25307	6363	76.07	91	1.76	-37.144
11/10/2021	WP22-10652	cpo3981	14.00	15.00	17253	6497	55.64	75	1.84	-18.696
11/10/2021	WP22-10652	cpo3981	15.00	16.00	16353	8041	53.36	65	1.91	-6.554
11/10/2021	WP22-10652	cpo3981	16.00	17.00	14567	9006	48.83	63	1.98	-2.412
11/10/2021	WP22-10652	cpo3981	17.00	18.00	14033	10377	47.47	62	2.09	1.954
11/10/2021	WP22-10652	cpo3981	18.00	19.00	30937	9546	90.36	110	1.04	-78.176
11/10/2021	WP22-10652	cpo3981	19.00	20.00	5233	13651	25.15	41	1.57	7.042
11/10/2021	WP22-10652	cpo3981	20.00	21.00	5483	10856	25.78	42	1.56	5.736
11/10/2021	WP22-10652	cpo3981	21.00	22.00	18999	9505	60.07	96	1.57	-47.958
11/10/2021	WP22-10652	cpo3981	22.00	23.00	5970	9806	27.02	37	1.78	17.468
11/10/2021	WP22-10652	cpo3981	23.00	24.00	5532	9703	25.91	33	1.97	27.282
16/09/2021	WP21-08671	4011	2.00	3.00	2208	4625	17.47	10	0.968	19.6208
16/09/2021	WP21-08671	4011	3.00	4.00	3585	7365	20.97	30	1.92	28.752
16/09/2021	WP21-08671	4011	5.00	6.00	8240	10485	32.77	43	1.54	4.124
16/09/2021	WP21-08671	4011	6.00	7.00	14753	8780	49.30	55	1.67	-3.898
16/09/2021	WP21-08671	4011	7.00	8.00	11914	12160	42.10	50	1.77	4.162
16/09/2021	WP21-08671	4011	8.00	9.00	15207	13992	50.45	49	1.48	-3.712
16/09/2021	WP21-08671	4011	9.00	10.00	13945	12270	47.25	49	1.56	-1.264
16/09/2021	WP21-08671	4011	10.00	11.00	18344	10969	58.41	44	1.52	2.512

Date	SGS Lab Report Lunber	Info	m from	m to	pXRF Ca (ppm)	pXRF S (ppm)	ANC pulp eqn (pXRF calc)	SGS ANC (kg H2SO4/t)	SGS Total S % (LECO)	MWM NAPP Calculation
16/09/2021	WP21-08671	4011	11.00	12.00	17481	10657	56.22	79	1.72	-26.368
16/09/2021	WP21-08671	4011	12.00	13.00	23914	10191	72.54	68	1.64	-17.816
16/09/2021	WP21-08671	4011	13.00	14.00	17828	13823	57.10	61	1.29	-21.526
16/09/2021	WP21-08671	4011	14.00	15.00	22455	16126	68.84	65	1.43	-21.242
16/09/2021	WP21-08671	4011	15.00	16.00	26183	12422	78.30	92	1.84	-35.696
16/09/2021	WP21-08671	4011	16.00	17.00	27415	15141	81.42	83	1.36	-41.384
16/09/2021	WP21-08671	4011	17.00	18.00	22922	14192	70.02	62	1.96	-2.024
16/09/2021	WP21-08671	4011	18.00	19.00	17504	10029	56.28	58	1.79	-3.226
16/09/2021	WP21-08671	4011	19.00	20.00	19793	12201	62.08	57	1.98	3.588
16/09/2021	WP21-08671	4011	20.00	21.00	22638	12396	69.30	124	1.94	-64.636
16/09/2021	WP21-08671	4011	21.00	22.00	20492	10726	63.86	68	1.96	-8.024
16/09/2021	WP21-08671	4011	22.00	23.00	25113	13237	75.58	75	2.03	-12.882
16/09/2021	WP21-08671	4011	23.00	24.00	16639	16786	54.08	52	2.16	14.096
16/09/2021	WP21-08671	4011	24.00	25.00	12081	10402	42.52	53	1.4	-10.16
16/09/2021	WP21-08671	4011	25.00	26.00	7909	13086	31.93	38	1.6	10.96
16/09/2021	WP21-08671	4011	26.00	27.00	16716	15345	54.28	52	1.42	-8.548
16/09/2021	WP21-08671	4011	27.00	28.00	10792	17697	39.25	43	1.57	5.042
23/09/2021	WP21-08751	cpo4012	0.00	1.00	4058	8032	22.16	17	1.08	16.048
23/09/2021	WP21-08751	cpo4012	1.00	2.00	9636	14435	36.32	37	1.66	13.796
23/09/2021	WP21-08751	cpo4012	2.00	3.00	21710	13589	66.95	75	1.62	-25.428
23/09/2021	WP21-08751	cpo4012	3.00	4.00	23037	12300	70.31	68	1.74	-14.756
23/09/2021	WP21-08751	cpo4012	4.00	5.00	24705	8943	74.55	75	1.73	-22.062
23/09/2021	WP21-08751	cpo4012	5.00	6.00	21796	10014	67.17	71	1.8	-15.92
23/09/2021	WP21-08751	cpo4012	6.00	7.00	16829	12929	54.56	54	1.79	0.774
29/09/2021	WP21-08751	cpo4012	7.00	8.00	45136	12135	126.38	157	1.71	-104.674
29/09/2021	WP21-08751	cpo4012	8.00	9.00	14166	16620	47.81	51	1.67	0.102
16/09/2021	WP21-08680	4014	0.00	1.00	4780	2382.25	24.00	14	0.386	-2.1884
16/09/2021	WP21-08680	4014	1.00	2.00	2004	5868.00	16.95	20	1.48	25.288
16/09/2021	WP21-08680	4014	2.00	3.00	2296	4316.25	17.69	16	1.75	37.55
16/09/2021	WP21-08680	4014	3.00	4.00	7170	9348.25	30.06	32	1.71	20.326
16/09/2021	WP21-08680	4014	4.00	5.00	14060	10316.25	47.54	48	1.31	-7.914
16/09/2021	WP21-08680	4014	5.00	6.00	13766	9855.50	46.79	48	1.5	-2.1
16/09/2021	WP21-08680	4014	6.00	7.00	11861	5926.25	41.96	54	1.58	-5.652
16/09/2021	WP21-08680	4014	7.00	8.00	25763	5648.50	77.23	79	1.58	-30.652
16/09/2021	WP21-08680	4014	8.00	9.00	27706	8509.25	82.16	80	1.65	-29.51
16/09/2021	WP21-08680	4014	9.00	10.00	22049	9036.00	67.81	65	1.54	-17.876
16/09/2021	WP21-08680	4014	10.00	11.00	25116	10674.75	75.59	73	1.33	-32.302
16/09/2021	WP21-08680	4014	11.00	12.00	27318	13374.00	81.18	82	1.28	-42.832
16/09/2021	WP21-08680	4014	12.00	13.00	21697	11726.50	66.91	79	1.49	-33.406
16/09/2021	WP21-08680	4014	13.00	14.00	21095	12015.75	65.39	68	1.64	-17.816
16/09/2021	WP21-08680	4014	14.00	15.00	21830	10731.25	67.25	70	1.72	-17.368
16/09/2021	WP21-08680	4014	15.00	16.00	21821	11844.00	67.23	66	1.73	-13.062
16/09/2021	WP21-08680	4014	16.00	17.00	22082	13455.25	67.89	69	1.71	-16.674
16/09/2021	WP21-08680	4014	17.00	18.00	25128	10162.75	75.62	86	1.73	-33.062
16/09/2021	WP21-08680	4014	18.00	19.00	23028	9126.75	70.29	65	1.75	-11.45
16/09/2021	WP21-08680	4014	19.00	20.00	18529	13186.50	58.88	56	1.84	0.304
16/09/2021	WP21-08680	4014	22.00	23.00	20117	19536.75	62.91	98	1.89	-40.166
16/09/2021	WP21-08680	4014	21.00	22.00	23120	21357.50	70.53	68	1.46	-23.324
16/09/2021	WP21-08680	4014	23.00	24.00	9813	18732.75	36.76	64	1.58	-15.652
16/09/2021	WP21-08680	4014	24.00	25.00	7368	14182.50	30.56	69	1.59	-20.346
16/09/2021	WP21-08680	4014	26.00	27.00	6452	20746.75	28.24	35	1.63	14.878
16/09/2021	WP21-08680	4014	25.00	26.00	6767	18325.00	29.04	33	1.5	12.9

Date	SGS Lab Report Lunber	Info	m from	m to	pXRF Ca (ppm)	pXRF S (ppm)	ANC pulp eqn (pXRF calc)	SGS ANC (kg H2SO4/t)	SGS Total S % (LECO)	MWM NAPP Calculation
16/09/2021	WP21-08680	4014	27.00	28.00	8356	17719.00	33.07	30	1.66	20.796
16/09/2021	WP21-08680	4014	28.00	29.00	14487	17067.00	48.62	26	1.61	23.266
16/09/2021	WP21-08680	4014	29.00	30.00	5816	15646.50	26.63	98	1.52	-51.488
16/09/2021	WP21-08680	4014	30.00	31.00	5742	14645.50	26.44	34	1.79	20.774
6/10/2021	WP21-08752	cpo4015	8.00	9.00	25476	9919	76.50	87	1.75	-33.45
6/10/2021	WP21-08752	cpo4015	9.00	10.00	18102	9757	57.79	56	1.56	-8.264
6/10/2021	WP21-08752	cpo4015	10.00	11.00	16828	11324	54.56	55	1.35	-13.69
6/10/2021	WP21-08752	cpo4015	11.00	12.00	18716	12641	59.35	62	1.35	-20.69
6/10/2021	WP21-08752	cpo4015	12.00	13.00	19805	11949	62.12	69	1.76	-15.144
6/10/2021	WP21-08752	cpo4015	13.00	14.00	20958	12607	65.04	66	1.35	-24.69
6/10/2021	WP21-08752	cpo4015	14.00	15.00	18214	11352	58.08	56	1.54	-8.876
6/10/2021	WP21-08752	cpo4015	15.00	16.00	20800	10659	64.64	66	1.68	-14.592
6/10/2021	WP21-08752	cpo4015	16.00	17.00	21255	9840	65.79	69	1.58	-20.652
6/10/2021	WP21-08752	cpo4015	17.00	18.00	17595	11915	56.51	57	1.39	-14.466
6/10/2021	WP21-08752	cpo4015	18.00	19.00	20368	11358	63.54	70	1.38	-27.772
6/10/2021	WP21-08752	cpo4015	19.00	20.00	26782	12502	79.81	78	1.38	-35.772
6/10/2021	WP21-08752	cpo4015	20.00	21.00	20088	11520	62.83	64	1.49	-18.406
6/10/2021	WP21-08752	cpo4015	21.00	22.00	19168	11949	60.50	65	1.42	-21.548
6/10/2021	WP21-08752	cpo4015	22.00	23.00	19786	13373	62.07	62	1.73	-9.062
6/10/2021	WP21-08752	cpo4015	23.00	24.00	17790	15053	57.00	54	1.76	-0.144
6/10/2021	WP21-08752	cpo4015	24.00	25.00	20542	16256	63.99	61	1.64	-10.816
20/09/2021	WP21-08676	cpo4047	9.00	10.00	15759.25	14137.75	51.85	57	1.37	-15.078
20/09/2021	WP21-08676	cpo4047	10.00	11.00	22439.00	14791.50	68.80	75	1.32	-34.608
20/09/2021	WP21-08676	cpo4047	11.00	12.00	20376.25	15776.75	63.56	72	1.4	-29.16
20/09/2021	WP21-08676	cpo4047	12.00	13.00	23396.75	17521.50	71.23	75	1.56	-27.264
14/09/2021	WP21-08610	4048	2.00	3.00	2368	3991	17.88	16	1.13	18.578
14/09/2021	WP21-08610	4048	3.00	4.00	1907	7267	16.71	21	1.75	32.55
14/09/2021	WP21-08610	4048	4.00	5.00	2087	12715	17.17	21	1.8	34.08
14/09/2021	WP21-08610	4048	5.00	6.00	10447	15019	38.37	42	1.37	-0.078
14/09/2021	WP21-08610	4048	6.00	7.00	13140	12852	45.21	53	1.5	-7.1
14/09/2021	WP21-08610	4048	7.00	8.00	16209	11220	52.99	59	1.64	-8.816
14/09/2021	WP21-08610	4048	8.00	9.00	16923	9647	54.80	57	1.6	-8.04
14/09/2021	WP21-08610	4048	9.00	10.00	18006	8420	57.55	64	1.77	-9.838
14/09/2021	WP21-08610	4048	10.00	11.00	27607	11509	81.91	94	2.07	-30.658
14/09/2021	WP21-08610	4048	11.00	12.00	16901	8692	54.75	65	1.88	-7.472
14/09/2021	WP21-08610	4048	12.00	13.00	18374	10916	58.49	54	1.77	0.162
14/09/2021	WP21-08610	4048	13.00	14.00	32300	11295	93.82	93	1.59	-44.346
14/09/2021	WP21-08610	4048	14.00	15.00	23008	18869	70.24	68	1.4	-25.16
14/09/2021	WP21-08610	4048	15.00	16.00	26457	14582	78.99	78	1.53	-31.182
14/09/2021	WP21-08610	4048	16.00	17.00	31410	9749	91.56	84	1.91	-25.554
14/09/2021	WP21-08610	4048	17.00	18.00	27248	11369	81.00	81	1.87	-23.778
15/09/2021	WP21-08610	4048	18.00	19.00	26077	10972	78.03	100	1.88	-42.472
15/09/2021	WP21-08610	4048	19.00	20.00	17305	13706	55.77	60	1.9	-1.86
16/09/2021	WP21-08610	4048	20.00	21.00	22543	16505	69.06	71	1.88	-13.472
16/09/2021	WP21-08610	4048	21.00	22.00	19543	13573	61.45	72	1.51	-25.794
16/09/2021	WP21-08610	4048	22.00	23.00	24919	18002	75.09	80	1.43	-36.242
16/09/2021	WP21-08610	4048	23.00	24.00	20946	16339	65.01	76	1.71	-23.674
16/09/2021	WP21-08610	4048	24.00	25.00	37259	14842	106.40	90	1.61	-40.734
16/09/2021	WP21-08610	4048	25.00	26.00	17081	17052	55.20	58	1.73	-5.062
16/09/2021	WP21-08610	4048	26.00	27.00	13756	17070	46.77	42	1.65	8.49
16/09/2021	WP21-08610	4048	27.00	28.00	13792	16685	46.86	68	1.47	-23.018
16/09/2021	WP21-08610	4048	28.00	29.00	17043	18347	55.11	49	1.59	-0.346

Date	SGS Lab Report Lunber	Info	m from	m to	pXRF Ca (ppm)	pXRF S (ppm)	ANC pulp eqn (pXRF calc)	SGS ANC (kg H2SO4/t)	SGS Total S % (LECO)	MWM NAPP Calculation
16/09/2021	WP21-08610	4048	29.00	30.00	18146	18293	57.91	42	1.54	5.124
16/09/2021	WP21-08610	4048	30.00	31.00	11229	11787	40.36	40	1.62	9.572
16/09/2021	WP21-08610	4048	31.00	32.00	13622	10330	46.43	51	1.78	3.468
4/10/2021	WP21-08750	cpo4078	9.00	10.00	4830	10376	24.12	30	1.43	13.758
4/10/2021	WP21-08750	cpo4078	10.00	11.00	20084	12416	62.82	72	1.33	-31.302
4/10/2021	WP21-08750	cpo4078	11.00	12.00	34642	10227	99.76	111	1.66	-60.204
4/10/2021	WP21-08750	cpo4078	19.00	20.00	26405	11448	78.86	85	1.74	-31.756
4/10/2021	WP21-08750	cpo4078	20.00	21.00	23202	13828	70.73	79	1.77	-24.838
4/10/2021	WP21-08750	cpo4078	21.00	22.00	9023	12575	34.76	37	1.95	22.67
4/10/2021	WP21-08750	cpo4078	22.00	23.00	6961	16811	29.53	33	1.62	16.572
4/10/2021	WP21-08750	cpo4078	23.00	24.00	19261	14570	60.73	76	1.49	-30.406
4/10/2021	WP21-08750	cpo4078	24.00	25.00	5802	12920	26.59	31	1.52	15.512
9/09/2021	WP21-08558	4079	3.00	4.00	7500	10182	30.90	31	1.74	22.244
9/09/2021	WP21-08558	4079	4.00	5.00	13184	11369	45.32	44	1.74	9.244
9/09/2021	WP21-08558	4079	5.00	6.00	21041	13651	65.30	60	1.57	-11.958
9/09/2021	WP21-08558	4079	6.00	7.00	21608	11937	66.69	66	1.59	-17.346
9/09/2021	WP21-08558	4079	7.00	8.00	15821	9153	52.01	53	1.68	-1.592
9/09/2021	WP21-08558	4079	8.00	9.00	14687	8897	49.13	45	1.7	7.02
10/09/2021	WP21-08558	4079	9.00	10.00	14543	8993	48.76	50	1.63	-0.122
10/09/2021	WP21-08558	4079	10.00	11.00	14939	11532	49.77	48	1.5	-2.1
10/09/2021	WP21-08558	4079	11.00	12.00	24462	11567	73.93	66	1.59	-17.346
10/09/2021	WP21-08558	4079	12.00	13.00	24911	6523	75.07	74	1.68	-22.592
10/09/2021	WP21-08558	4079	13.00	14.00	19370	11002	61.01	71	1.75	-17.45
10/09/2021	WP21-08558	4079	14.00	15.00	19442	8087	61.19	51	1.62	-1.428
10/09/2021	WP21-08558	4079	15.00	16.00	22668	7533	69.38	78	1.59	-29.346
10/09/2021	WP21-08559	4079	16.00	17.00	21877	10649	67.37	66	1.73	-13.062
10/09/2021	WP21-08559	4079	17.00	18.00	23662	10563	71.90	74	1.57	-25.958
10/09/2021	WP21-08559	4079	18.00	19.00	24344	12065	73.63	75	1.91	-16.554
10/09/2021	WP21-08559	4079	19.00	20.00	20419	11016	63.67	67	1.92	-8.248
10/09/2021	WP21-08559	4079	20.00	21.00	26130	8817	78.16	72	1.87	-14.778
10/09/2021	WP21-08559	4079	21.00	22.00	25174	8473	75.74	100	1.81	-44.614
10/09/2021	WP21-08559	4079	22.00	23.00	17325	9634	55.82	54	1.92	4.752
10/09/2021	WP21-08559	4079	23.00	24.00	26640	12510	79.46	78	1.76	-24.144
10/09/2021	WP21-08559	4079	24.00	25.00	8745	14812	34.05	40	1.52	6.512
10/09/2021	WP21-08559	4079	25.00	26.00	11860	14317	41.96	41	1.67	10.102
10/09/2021	WP21-08559	4079	26.00	27.00	12906	17437	44.61	48	1.53	-1.182
9/09/2021	WP21-08559	4079	27.00	28.00	11245	19290	40.40	52	1.49	-6.406
9/09/2021	WP21-08559	4079	28.00	29.00	7491	16964	30.88	40	1.58	8.348
10/09/2021	WP21-08560	4079	29.00	30.00	6668	19987	28.79	36	1.58	12.348
23/09/2021	WP21-08678	cpo4087	8.00	9.00	12247	9743	42.94	56	1.91	2.446
23/09/2021	WP21-08678	cpo4087	9.00	10.00	15490	7688	51.17	61	1.61	-11.734
23/09/2021	WP21-08678	cpo4087	10.00	11.00	26154	6750	78.22	91	1.85	-34.39
23/09/2021	WP21-08678	cpo4087	11.00	12.00	23416	6963	71.28	87	1.4	-44.16
23/09/2021	WP21-08678	cpo4087	12.00	13.00	17692	9349	56.76	61	1.47	-16.018
23/09/2021	WP21-08678	cpo4087	13.00	14.00	21198	8364	65.65	78	1.5	-32.1
23/09/2021	WP21-08678	cpo4087	14.00	15.00	17931	7433	57.36	63	1.73	-10.062
23/09/2021	WP21-08678	cpo4087	15.00	16.00	20196	7204	63.11	67	1.74	-13.756
23/09/2021	WP21-08678	cpo4087	16.00	17.00	20939	7830	64.99	73	1.82	-17.308
23/09/2021	WP21-08678	cpo4087	17.00	18.00	16617	8353	54.03	61	1.7	-8.98
23/09/2021	WP21-08678	cpo4087	18.00	19.00	16688	8179	54.21	61	1.48	-15.712
20/10/2021	WP24-13562	cpo3849	3.00	4.00	3326	9120.25	20		0.991	30.3246
20/10/2021	WP24-13562	cpo3849	4.00	5.00	19345	9308.00	61	62.000	2	-0.8

Date	SGS Lab Report Lunber	Info	m from	m to	pXRF Ca (ppm)	pXRF S (ppm)	ANC pulp eqn (pXRF calc)	SGS ANC (kg H2SO4/t)	SGS Total S % (LECO)	MWM NAPP Calculation
20/10/2021	WP24-13562	cpo3849	5.00	6.00	12655	9946.25	44	25.000	1.74	28.244
20/10/2021	WP24-13562	cpo3849	6.00	7.00	5275	11563.00	25	4.000	1.51	42.206
20/10/2021	WP24-13562	cpo3849	7.00	8.00	14609	12176.00	49	32.000	1.32	8.392
20/10/2021	WP24-13562	cpo3849	8.00	9.00	14723	12454.75	49	43.000	1.35	-1.69
20/09/2021	WP21-08670	cpo3877	5.00	6.00	30217	11731	88.53	89	1.92	-30.248
20/09/2021	WP21-08670	cpo3877	6.00	7.00	20324	13287	63.43	58	2.19	9.014
20/09/2021	WP21-08670	cpo3877	7.00	8.00	15101	12839	50.18	51	2.49	25.194
20/09/2021	WP21-08670	cpo3877	8.00	9.00	20534	10789	63.96	64	1.61	-14.734
	WP24-13566	CPO3873	1.00	2.00				3	1.6	45.96
	WP24-13566	CPO3873	2.00	3.00				7	1.56	40.736
	WP24-13566	CPO3873	3.00	4.00				40	1.29	-0.526
	WP24-13566	CPO3873	4.00	5.00				58	1.49	-12.406
	WP24-13566	CPO3873	5.00	6.00				55	1.36	-13.384
	WP24-13566	CPO3873	6.00	7.00				32	1.58	16.348
	WP24-13566	CPO3873	7.00	8.00				33	1.61	16.266
	WP24-13566	CPO3873	8.00	9.00				57	1.42	-13.548
	WP24-13566	CPO3873	9.00	10.00				25	1.5	20.9
	WP24-13566	CPO3873	10.00	11.00				20	1.56	27.736
	WP24-13566	CPO3873	11.00	12.00				32	1.68	19.408
12/11/2021	WP24-13564	cpo3916	6.00	7.00	6122	10686	27.40		1.68	51.408
12/11/2021	WP24-13564	cpo3916	7.00	8.00	12341	12840	43.18	30	1.65	20.49
12/11/2021	WP24-13564	cpo3916	8.00	9.00	17887	11031	57.25	42	1.37	-0.078
12/11/2021	WP24-13564	cpo3916	9.00	10.00	36161	10357	103.61	75	1.41	-31.854
12/11/2021	WP24-13564	cpo3916	10.00	11.00	16768	12684	54.41	46	1.42	-2.548
12/11/2021	WP24-13564	cpo3916	11.00	12.00	17618	12747	56.57	52	1.36	-10.384
12/11/2021	WP24-13564	cpo3916	12.00	13.00	12446	12771	43.45	34	1.54	13.124
12/11/2021	WP24-13564	cpo3916	13.00	14.00	13928	12543	47.20	34	1.72	18.632
12/11/2021	WP24-13564	cpo3916	14.00	15.00	20132	13447	62.94	55	1.82	0.692
12/11/2021	WP24-13564	cpo3916	15.00	16.00	14381	12988	48.35	46	1.50	-0.1
12/11/2021	WP24-13564	cpo3916	16.00	17.00	16534	11783	53.82	81	1.43	-37.242
12/11/2021	WP24-13564	cpo3916	17.00	18.00	11086	12022	39.99	40	1.43	3.758
12/11/2021	WP24-13564	cpo3916	18.00	19.00	11865	11176	41.97	37	1.70	15.02
12/11/2021	WP24-13564	cpo3916	19.00	20.00	10564	8224	38.67	55	1.73	-2.062

	pXRF Ca (ppm)	pXRF S (ppm)	ANC pulp eqn (pXRF calc)	SGS ANC (kg H2SO4/t)	SGS Total S % (LECO)	MWM NAPP Calculation
Average	18075	11920	57.73	60	1.63	-9.85
Min	1899	2382	16.69	-5	0.39	-121.06
Max	50686	23554	140.46	174	2.49	56.81
Median	18747	11729	59.43	61	1.62	-11.26
# Samples	320	320	320	343	345	345

ATTACHMENT C: OLDS ET AL. (2015)

Geochemical classification of waste rock using process flow diagrams

W.E. Olds[1], B. Bird[2], J.I. Pearce[3], E. Sinclair[4], M. Orr[5] and P.A. Weber[1]

1 O'Kane Consultants (NZ) Ltd, Castle Hill Village, New Zealand. pweber@okc-sk.com
2 O'Kane Consultants (Australia) Pty Ltd, Belmont, NSW, Australia. bbird@okc-sk.com
3 O'Kane Consultants (Australia) Pty Ltd, Perth, Australia. jpearce@okc-sk.com
4 Bathurst Resources Limited, Westport, New Zealand. ESinclair@bathurstresources.co.nz
5 G Resources, Martabe Mine Site, Sumatra. Matthew.Orr@G-Resources.net

Abstract

Traditional geochemical classification of waste rock involves a range of acid base accounting (ABA) tests, which can be exhaustive and sometimes unnecessary. The established approach to classifying mine waste rock is to use a simple combination of acid base accounting tests, such as NAPP and NAG, to provide two methods to assess whether the sample is acid forming or not. This matrix-style classification system, which is often a requirement of consent conditions, is expensive and time consuming when applied as a blanket approach to classification. It can lead to a large proportion of samples with conflicting results or incorrect classification of samples.

An alternative waste rock geochemical classification methodology is to use a process flow diagram to optimise the testing regime. This can reduce the number of tests required, the cost of testing, and the time required to make informed classification decisions. To be confident in the use of a process flow methodology for waste rock classification requires detailed knowledge of site geology and geochemistry; and the completion of a suitable sampling programme, incorporating acid-base accounting before the development of a process flow methodology.

At the Escarpment Coal Mine, West Coast, New Zealand, a new process flow methodology for geochemical classification is being trialled. Results indicate that classification by a process flow methodology results in far fewer samples being classified as uncertain compared to the current resource consent matrix-style classification. Results presented in this paper indicate that ABA data and field column leach trials validate this approach.

At the Martabe Gold Mine, Sumatra, following a detailed ABA classification programme, a process flow methodology for geochemical classification of waste rock was developed as a tool for the operational management of overburden. This has become a quality control phase for confirmation of the geochemical waste rock block model and ensures that waste rock is correctly identified in the field and handled as per the management plan. Findings of the revised classification method are discussed in this paper.

Keywords: Acid and metalliferous drainage, waste rock classification, geochemistry, acid base accounting.

Introduction

To obtain regulatory consent for a mining project to proceed, there is typically a requirement for geochemical classification of the overburden in the planning and operational phases, to determine the potential for acid and metalliferous drainage; and to understand the kinetics of the geochemical reactions. This is undertaken by a variety of laboratory and field based geochemical tests. If the classification process identifies the potential for AMD, additional work may be required to prevent, minimise and potentially treat AMD after operation begins. These geochemical tests are often collectively used for acid base accounting (ABA) purposes.

There needs to be confidence in the relative accuracy of the classification method used for an operation. Over estimation of AMD may prevent projects from starting due to high capex and

opex costs for treatment; underestimation may result in unanticipated treatment costs and legacy issues for the project. It is important that the best estimate of AMD potential is provided so that suitable management measures, such as engineered covers and treatment systems can be designed to address the likely scale of environmental issues, and meet the approval of regulators and the community.

A risk-based process flow chart for waste rock classification has been developed for two mining operations and is discussed in the following paper.

Classification methods

Acid base accounting

Geochemical classification of waste rock overburden involves a variety of ABA techniques. The industry standard approach includes the determination of the net acid production potential (NAPP) (Equation 1). This is the difference between the acid neutralisation capacity (ANC) and the maximum potential acidity (MPA). Sulfur is typically determined through analysis of total sulfur. However, sulfide sulfur is also frequently determined for NAPP calculations as they are considered to be the main acid forming sulfur species. A negative NAPP indicates that the sample has a net neutralising capacity and a positive NAPP indicates the sample has a net acid-generating capacity.

$$NAPP = MPA - ANC \quad (1)$$

The ANC of a sample is often determined by aggressive Sobek-type tests (e.g. Sobek et al., 1978; AMIRA, 2002) using low pH (< 2) digestion to dissolve carbonates and reactive silicate minerals to determine the amount of acid consumed by the sample.

The net acid generation (NAG) test typically involves the addition of 250 mL of 15% unstabilized H_2O_2 to 2.5 g of rock to encourage the oxidation of any sulfide minerals present. Any subsequent acid produced will react with any carbonates (and reactive silicate minerals) present to generate a final NAG pH reflective of the final acid-base characteristics of the sample. Samples with low pH values are back-titrated to pH 4.5 and then 7.0 to determine the NAG acidity (kg H_2SO_4/t or kg $CaCO_3$/t). Samples that have a final NAG pH > 4.5 are non-acid forming, although the amount of excess ANC is not quantified by this method (AMIRA, 2002).

Paste pH is determined by mixing 1 part of pulverized rock (< 75 μm) and 2 parts of deionized water, followed by pH measurement of the paste as per the AMIRA (2002) methodology. Paste pH is a very simple test but can provide an indication of the immediate acid-base nature of the sample. If the pH is less than 5.5, it suggests the sample contains stored acidity in the form of acidic oxidation products such as melanterite and jarosite type minerals; the lower the pH the greater the stored acidity content. Samples having a low paste pH are nearly always considered potentially acid forming (PAF) as the immediate acid generating reactions outweigh any immediate acid neutralizing reactions generated from fast dissolving minerals such as carbonates. Further discussion on stored acidity is provided by Weber et al. (2015).

Conventional AMD classification

The established approach to classifying mine waste rock is to use a simple combination of ABA tests, such as NAPP and the NAG acidity of the sample (e.g. AMIRA, 2002), to provide two methods to assess whether the sample is PAF or non-acid forming (NAF).

One approach for AMD sample classification is to plot NAG pH versus NAPP (e.g. AMIRA, 2002). If there is good correlation between NAG pH and NAPP then a clear classification process can be developed identifying NAF and PAF samples. However, often uncertain (UC) classification can occur, as identified on Fig. 1A.

The Mine Environment Neutral Drainage Program (MEND) guidelines (Price, 2009) utilise the ANC/MPA ratio (Fig. 1B). Typically material with an ANC/MPA < 2 ratio are classified as non-acid forming material while ANC/MPA < 1 indicates potentially acid generating material. If the ANC/MPA is between 1 and 2 the sample classification is uncertain, possibly PAF if ANC is insufficiently reactive or is depleted at a faster rate than sulfide oxidation and subsequent acid generation.

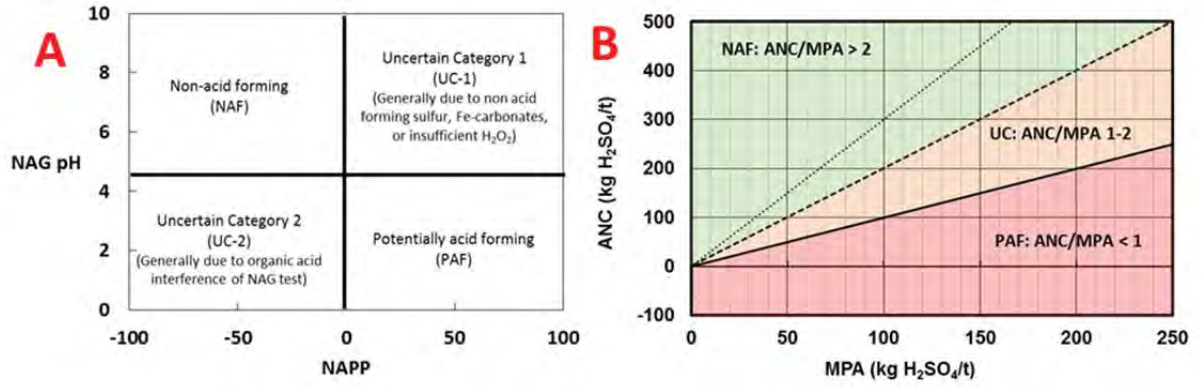


Figure 1. The modified (A) AMIRA (2002) NAPP and NAG pH and (B) Price (2009) MPA and ANC.

Populating these classification schemes can be expensive and time consuming when applied as a blanket approach to classification. It can also lead to a large proportion of samples with conflicting results or incorrect classification of samples.

Case studies

Two case studies where process flow methodologies have been developed to improve waste rock geochemical classification are discussed; the Escarpment Coal Mine and the Martabe gold and silver mine.

Escarpment Coal Mine, New Zealand

The Escarpment Mine, located on the West Coast of the South Island of New Zealand, is approximately 13 km northeast of Westport. The mine occurs within the Brunner Coal Measures which are often deficient in carbonate minerals such that the oxidation of pyrite typically leads to the rapid formation of acid mine drainage (AMD).

Current consent classification system

Bathurst Resources Limited (BRL) are required to carry out geochemical sampling and analysis of overburden to determine the acid generating potential of waste rock. Testing results in classification of the waste rock based on risk of generating acidity. Once classified, waste rock is then managed to minimise acidity generation, for example by disposing PAF material at the core of the waste rock dump and restricting cover system construction materials to NAF waste rock only. The current Resource Consent conditions allow for classification of waste rock as non-acid forming (NAF), low risk (LR), and potentially acid-forming (PAF) based on the criteria shown in Table 1.

Table 1. Current Resource Consent classification by geochemistry for the Escarpment Coal Mine.

Classification	Paste pH	NAG pH	NAPP Acidity (kg $CaCO_3$ eq./t)
NAF	> 4.5	> 4.5	< 0
Low Risk	> 4.5	> 4.5	< 5
PAF	< 4.5	< 4.5	> 2

Currently BRL undertake a matrix-style classification approach for waste rock (Table 1), although currently a NAPP acidity of > 0 kg $CaCO_3$ eq./t is used for PAF classification based on recommendations by the Escarpment Peer Review Panel. Using the AMIRA NAPP versus NAG pH classification approach (as shown in Fig. 1A), a significant number of samples from the Escarpment Mine are classified as uncertain (Fig. 2).

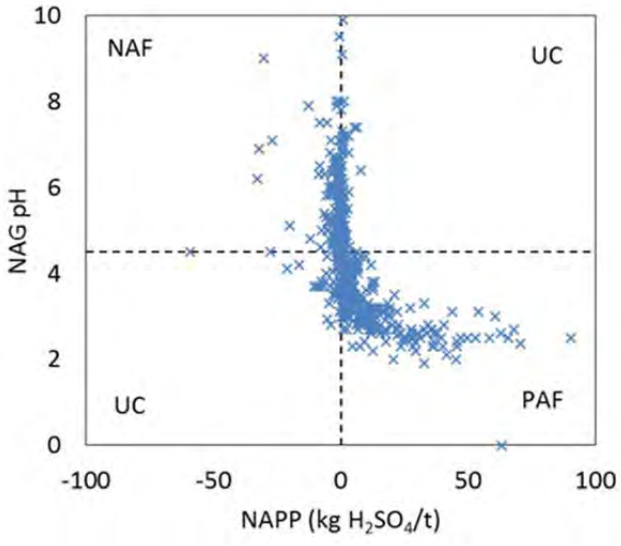


Figure 2. NAPP versus NAG pH for rock samples from the Escarpment Mine project.

Process flow classification

A revised process flow methodology for geochemical classification has been developed for the Escarpment Mine (Fig. 3). This approach limits the amount of testing on samples that are clearly PAF and NAF, allowing the operator to focus on the more difficult to classify, low risk materials. The end point of each branch of the process flow methodology is a classification rather than a set of data from which a classification is derived.

A thorough understanding of site geochemistry is required before adopting this type of classification method. For example, any materials with total sulfur > 0.45 wt% (14 kg H_2SO_4 eq./t) have been classified as PAF without any further testing. The Escarpment Mine ABA database shows that for the vast majority of samples the ANC is much less than 10 kg H_2SO_4 eq./t, validating the assumption that ANC is negligible (in terms of classification) in samples with high sulfur content.

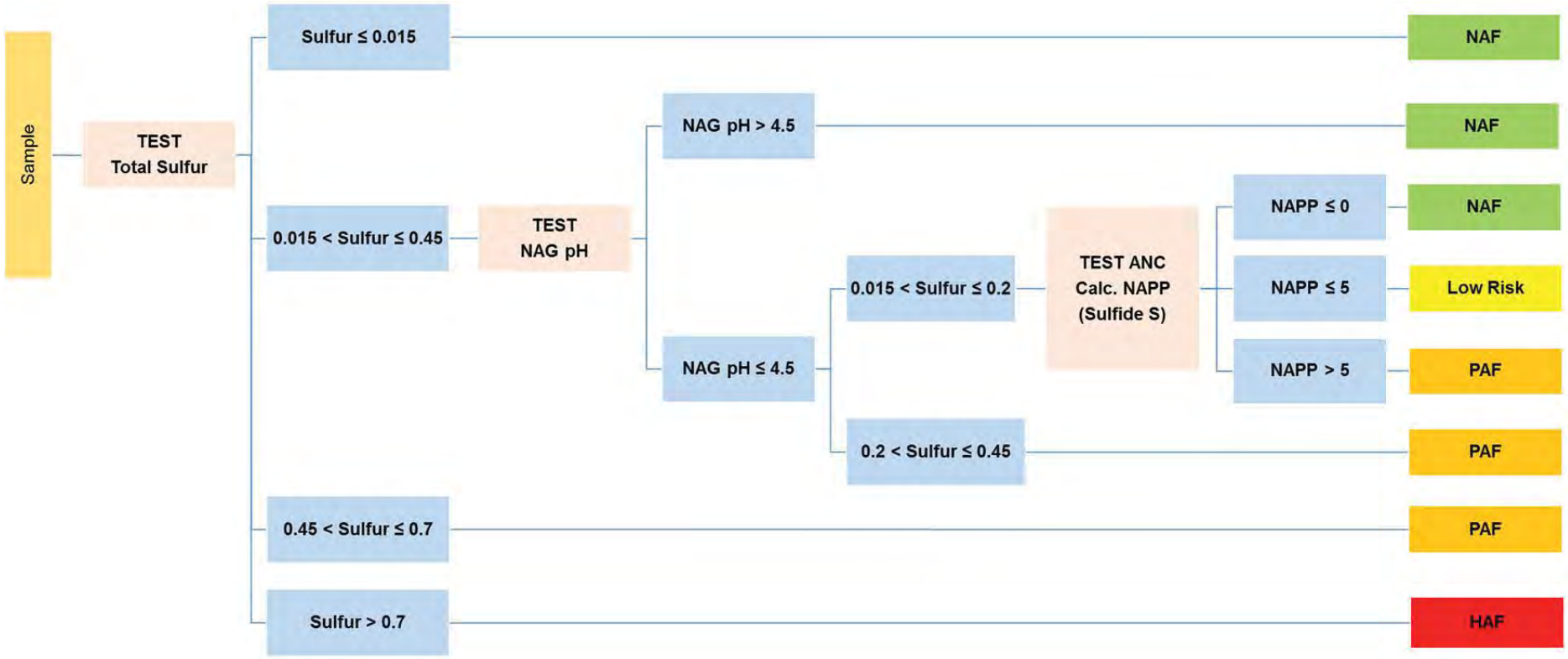


Figure 3. Escarpment Mine waste rock geochemical classification process flow methodology. Sulfur values are wt%.

The Escarpment Mine process flow methodology is an iterative process. Initially all samples are tested for total sulfur. Any samples with total sulfur less than 0.015 wt% are immediately classified as NAF while samples with between 0.45 and 0.7 wt%, and over 0.7 wt% are classified PAF and high acid forming (HAF), respectively. The remaining samples (total sulfur between 0.015 and 0.45 wt%) are then analysed for NAG pH. Samples with a NAG pH of greater than 4.5 are considered NAF while further classification of samples with NAG pH less than or equal to 4.5 is undertaken in conjunction with the original total sulfur content. Material with a total sulfur content between 0.2 and 0.45 wt% are classified PAF while samples with total sulfur between 0.015 and 0.2 wt% are tested for ANC. These samples are finally classified based on NAPP using sulfide sulfur content (rather than total sulfur) into NAF (NAPP $\leq$ 0 kg $CaCO_3$ eq./t), Low Risk (NAPP $\leq$ 5 kg $CaCO_3$ eq./t), and PAF (NAPP > 5 kg $CaCO_3$ eq./t).

Further work is being undertaken to consider any benefits of including paste pH into the process flow methodology. As it does not quantify PAF nor confirm NAF samples it may have limited value.

The process flow methodology removes the uncertainty field from the matrix-style classification system. The only samples with potential for an uncertain classification occur where analytical data were missing, however, it remains relatively resilient to incomplete datasets. For example, samples that are HAF are able to be classified if only total sulfur data are available (and they meet the HAF criteria) unlike a matrix system which requires multiple parameters for classification.

Classification results

BRL have compiled a geochemical testing database consisting of over 700 samples. The majority of these samples have been subjected to acid base accounting (ABA) testing including ANC, Total S, Sulfide S, NAG, NAG pH, and paste pH.

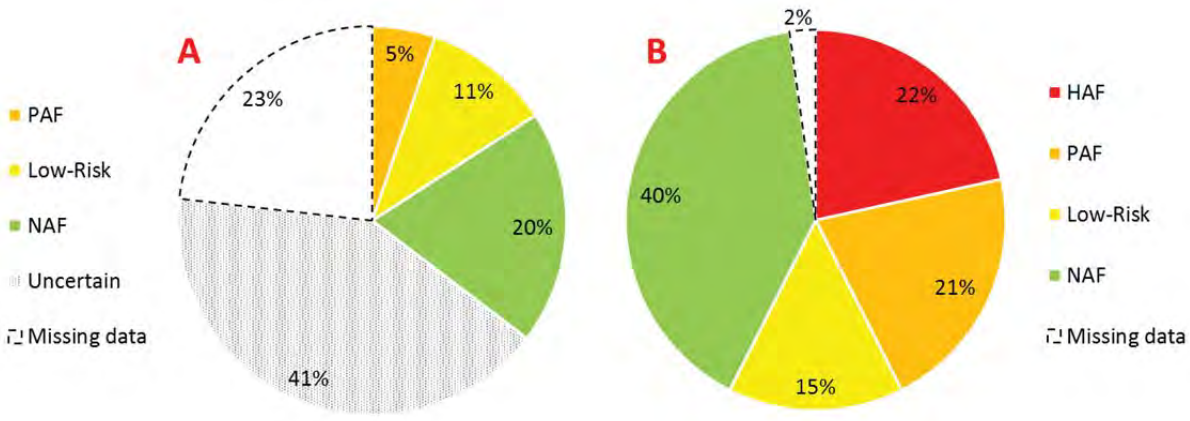


Figure 4. Sample classification by the (A) matrix-style and (B) process flow methodologies.

Using the current Resource Consent matrix-style AMD classification process results in 41% of samples being unclassified (Fig. 4A). A further 23% had insufficient data for classification under the matrix-style system. This lack of a definitive classification is likely to require further test work to confirm geochemical classification possibly delaying operational activities until confirming data are available.

Using the process flow methodology eliminates the uncertain category as the end point of each branch of the flow chart is a classification. Thus, 98% of materials (Fig. 4B) were classified using the process flow methodology. There were insufficient data for classification of the remaining 2% of samples, which is far superior to the matrix-style approach.

At the time of writing this paper the ABA database included 726 samples. Using the matrix-style method a total of 256 samples were successfully classified (as PAF, Low-Risk, or NAF) using ~1800 individual ABA analyses (total S, NAG pH, paste pH, ANC, sulfide S). Using the process flow methodology a total of 708 samples were successfully classified (HAF, PAF, Low-Risk, or NAF) utilising 1130 individual ABA analyses. On average, successful classification of a sample using the matrix-style and process flow methodologies took a total of 7 and 1.6 tests respectively, indicating the process flow methodology is more efficient to classify samples robustly.

Twenty field columns have been setup to test the reliability of the process flow methodology. The field columns consist of individual 20 L buckets filled with approximately 20 kg of crushed drill core (14 columns) and blast hole cuttings (6 columns) that has been classified for geochemistry based on the process flow methodology. Leachate volumes and chemistry (including pH and acidity) are monitored on a weekly to monthly basis. The leachate pH of the HAF and PAF lysimeters dropped rapidly to less than pH 3. The leachate pH from the low risk material varies, but is typically in the pH 3 to 4 range. The NAF leachate (and rainwater control) remained circum-neutral at around pH 5.

There is a limited acidity dataset from the field columns available at the time of writing this paper. The three available data points show a clear stepwise increase in leachate acidity from NAF rock to Low Risk to PAF to HAF. NAF leachate acidity was negligible at less than 20 mg $CaCO_3$/L for the most acidic column. The Low Risk rock leachate acidity varied between 30 and 100 mg $CaCO_3$/L. The PAF and HAF columns may have had a short time lag to acidity onset, with relatively low leachate acidity in the first sample collected. However, the PAF acidity increased to 300 to 500 mg $CaCO_3$/L and the HAF acidity increased to 800 to 1800 mg $CaCO_3$/L. In terms of acidity, the process flow classification method accurately identifies material likely to generate acidity with generated acidity increasing by a factor of five at each classification step.

This work confirms this site specific process flow methodology is robust. Further work is required to understand the benefits of utilising paste pH, assessment of stored acidity, and any refinements that can be made to the current process flow.

Martabe, Indonesia

Site description

The Martabe gold and silver mine, located in the Province of North Sumatra, is approximately 3 kilometres north of the township of Batangtoru and approximately 40 km south of the port of Sibolga (BDA, 2009). The mining operations active waste rock dump (WRD) is a valley-fill type WRD located south of the existing tailings storage facility.

The deposit is a high sulfidation epithermal deposit with fairly complex local geology that contains a package of altered volcanics. Generally mineralised quartz veins (that contain high grade sulfide ore) cut through a package of volcanics that include various altered breccias and

more competent andesite rock. Alteration types include shallow oxide materials, argillic, advanced argillic, and silicified material (mainly at depth). Acid generating minerals identified from mineralogical analyses and ABA undertaken during the geochemical assessment program were pyrite, jarosite and alunite. Other influential minerals with respect to acid-base accounting interpretations were gypsum, calcite and ankerite.

Geochemical classification program

G Resources have expended a significant effort on geochemical characterisation of the waste rock at the Martabe mine site such that it is not only in-line with industry best practice but exceeds it. Several sources of geochemical data was available to develop the risk-based waste rock classification process flow methodology for operational use in characterising blocks of waste rock:

- Resource assay database – more than 10,000 data points for total sulfur, sulfide sulfur, and calcium content;
- Phase 1 geochemical testing programme – 225 samples analysed for acid base accounting (ABA): ANC, NAG, and paste pH;
- Phase 2 detailed testing – second phase of detailed testing including a range of laboratory analyses performed on ~50 samples, including total elemental analysis, (stored) acidic salt analysis, mineralogical analysis, static leach testing, kinetic NAG testing (KNAG), and acid buffering characteristic curves; and,
- Large scale leach columns –which have been operating at site for more than 10 years.

Data collected from the geochemical testing program generally shows samples contain a reasonable proportion of stored acidity. This is likely, in part, to be due to aging of the sample prior to analysis and may not be a true representation of the fresh rock in the field following blasting and excavation. However, it does provide a good indication of the potential weathering (oxidation) effects if the materials are left exposed to oxygen and moisture. The low paste pH values suggest significant water soluble acid salts such as melanterite and adsorbed/readily available H^+ acid. The higher paste pH values greater than pH 7 for PAF waste rock suggests there are some samples that have good initial ANC, greater than the initial acid generating reactions in the sample.

NAG pH, NAG acidity, and NAPP confirm that a significant proportion of the waste rock is PAF, although there are a number of NAF samples as indicated by negative NAPP values. ANC data indicated that some samples have a good capacity to neutralise acid generation (> 40 kg H_2SO_4/t equivalent). Effective neutralising capacities (ENC) determined by acid buffering characteristic curves (ABCCs) showed that generally, ENC was greater than 70% of ANC for these higher ANC bearing samples.

Field testing process flow methodology

The waste classification process flow methodology utilises simple tests that can be collected rapidly to reduce operational delays. Although the process flow methodology only requires basic parameters for the classification process it utilises the knowledge gained from the previous detailed geochemical data sources. The use of such data allowed the consideration of kinetic factors for a risk-based waste rock classification process that differentiates between the various PAF materials.

The parameters required to implement the process flow methodology are paste pH, NAG pH, and NAPP, which require laboratory analysis and up to 7 days for results to be available. To reduce turn-around time for ABA data the laboratory methods were substituted for quicker field compatible methods.

The AMIRA paste pH method (AMIRA, 2002) was adapted to a field pH method, and the field oxidation pH method was adapted from the 'Acid Sulfate Soils Laboratory Methods Guidelines' (Ahern et al., 2004) to replace the NAG test. The typical methods to determine total sulfur (LECO) and ANC for NAPP calculations were substituted for sulfur and calcium assay results routinely determined on site as part of grade control activities. A process flow methodology was created to explain this approach and the subsequent geochemical classification (Fig. 5).

The results from earlier geochemical testing showed that sulfur and calcium data collected either with a field portable XRF or through routine assay analyses for grade control provided good proxies for maximum potential acidity (MPA) and ANC. MPA is calculated from Total S and ANC is calculated by multiplying calcium (wt%) by 0.04. NAPP was calculated from these parameters.

Field pH and field NAG pH results can be applied directly to the waste classification system without any data manipulation. Rock is classified as NAF if the field pH and field NAG pH results are greater than 5.5 and 4.5 respectively and if its NAPP is negative (i.e. ANC exceeds MPA). Rock is classified as PAF if it has a positive NAPP and NAG pH below 4.5. Classification is then split into four sub-categories (PAF, PAF - Low Risk, High PAF, and PAF – LAG) as per Fig. 5 depending on the magnitude of NAG pH and NAPP.

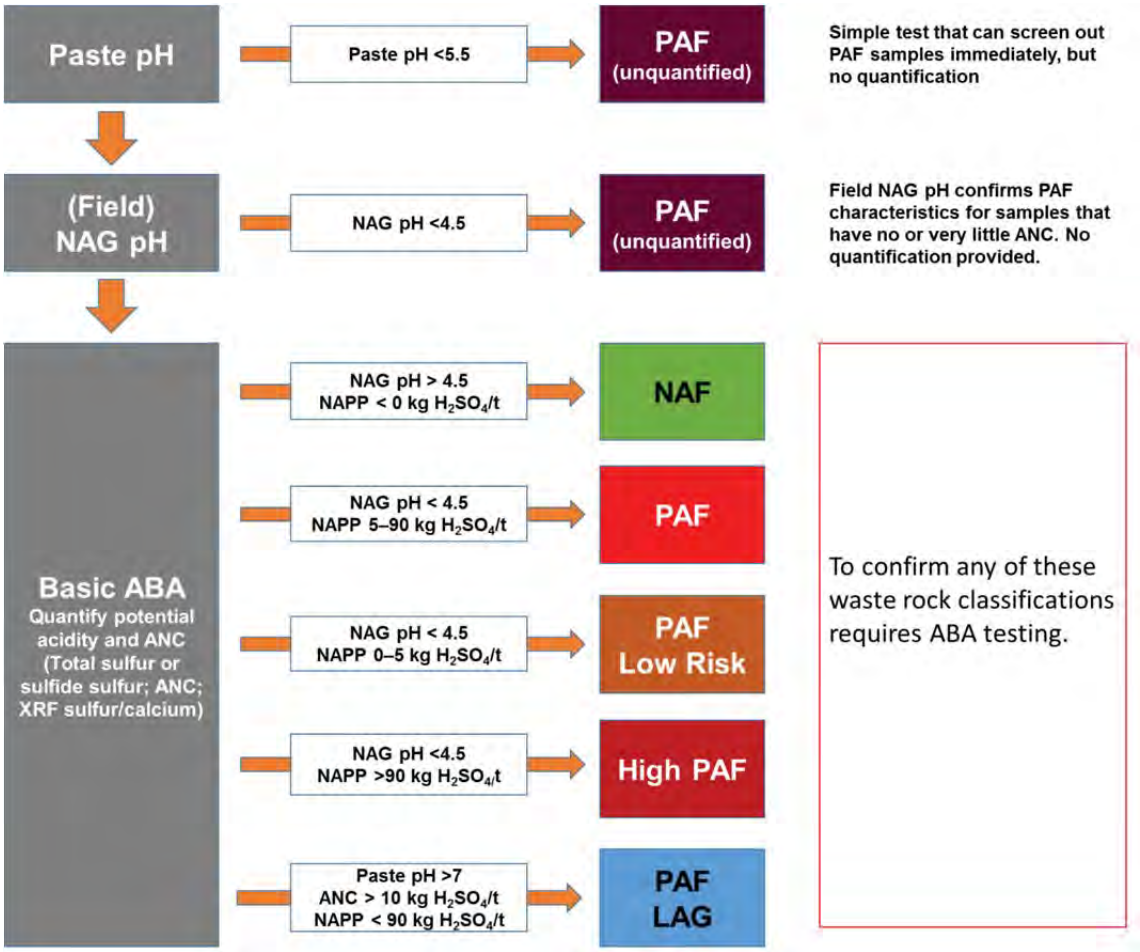


Figure 5. Process flow methodology for onsite waste classification at Martabe Gold Mine.

PAF – Low Risk materials are those with acidic field oxidation pH results (< 4.5) and a slightly positive NAPP (0 – 5 kg H_2SO_4/tonne). These materials require less strict handling and management requirements compared to the materials classified as PAF and High PAF. Data analysis in combination with the waste rock schedule indicates that although the volume of PAF – High Risk is small, it represents a large proportion of the total potential acidity load for the site and thus requires robust management techniques to minimise AMD from the rock. Waste material containing stored acidity can be identified through field pH testing (pH less than 5.5). Acidic material can be treated or managed as per the PAF waste class.

PAF – LAG materials are likely to have a time lag to acid onset and thus provide an opportunity to prioritise the management of PAF waste rock. Detailed geochemical data indicates that PAF – LAG waste rock can be left exposed for a reasonable time before any cover is required, unlike PAF and High PAF rock which has no time to acid onset. PAF – LAG rocks are identified by a combination of NAPP, paste pH and ANC (calcium assay data) for samples that have already oxidised. Preliminary test work indicates that a paste pH of greater than 7 and ANC greater than 10 kg H_2SO_4/t may indicate a time lag to acid onset for materials with a NAPP less than 90 kg H_2SO_4/t.

This field-based process flow methodology was developed for the rapid assessment of waste rock to enable rapid waste rock classification for AMD management. It is performing well, although further refinements may be needed and the methodology should be considered organic in nature.

Conclusions

Process flow methodologies for waste rock classification applied to the existing ABA data for the Escarpment Mine has been shown to eliminate uncertain samples from the classification process, which previously accounted for 41% of all classification outcomes. This resulted in a 98% successful classification rate for the Escarpment Mine ABA database. The ability to focus time and resources on classification of difficult to define materials increases confidence in the overall geochemical classification process. With the process flow methodology there was a 38% reduction in testing from the previous matrix classification method, reducing the cost of geochemical analyses. Further savings could be realised by stopping sulfide sulfur analysis and reducing ANC testing.

At Martabe, the field based process flow methodology has been developed as a screening tool for the classification of waste rock. This process can be applied to validate the waste rock block model as part of operational activities. The testing process has been designed to provide an initial rapid screening tool to separate out potentially acid forming (PAF) waste rock, streamlining waste rock management procedures.

Process flow methodologies are best designed after an initial general ABA testing phase such that site knowledge can be incorporated into the process flow. Both Bathurst and G resources have undertaken such an approach. However, site based validation of the any process flow methodology is also required for confidence by the operators and stakeholders and may help fine-tune the process flow classification. At the Escarpment Mine data from field columns is already being used to support the process flow classification of waste rock. At Martabe, the process flow methodology is being used to confirm the initial waste rock block model and is in itself a quality control step.

Acknowledgements

The authors would like to acknowledge the support of Bathurst Resources Limited and G Resources for this work and permission to present data relating to their sites. Funding for this work was provided by the Ministry for Business, Innovation and Employment, Contract CRL1202 as part of research efforts by the Centre for Minerals Environmental Research (CMER).

References

Ahern, C.R., McElnea, A.E. and Sullivan, L.A. 2004. Acid Sulfate Soils Laboratory Methods Guidelines. Queensland Department of Natural Resources, Mines and Energy. Indooroopilly, Queensland, Australia.

AMIRA. 2002. ARD Test Handbook – Project P387A Prediction and Kinetic Control of Acid Mine Drainage. Ian Wark Research Institute and Environmental Geochemistry International. Pub. By AMIRA International Limited. Melbourne, Australia.

BDA. 2009. Independent Technical Review Martabe Gold-Silver Project – Sumatra – Indonesia. Behre Dolbear Australia. Sydney, NSW.

Sobek, A.A., Schuller, W.A., Freeman, J.R. and Smith, R.M. 1978. Field and laboratory methods applicable to overburden and minesoils. EPA 600/2-78-054. Environmental Protection Agency, Washington, DC.

Price, W.A. 2009. Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials. MEND Report 1.20.1 December 2009.

Weber, P.A., Olds, W.E. and Bird, B. 2015. Forecasting long term water quality at closure for current mining operations. New Zealand Annual AusIMM Conference, Dunedin, 31 August – 2 September 2015.

ATTACHMENT D: ESCARPMENT EXTENDED OVERBURDEN QUANTITIES

[redacted]

Memo

To: [redacted], Mine Waste Management

From: [redacted], Bathurst Resources Limited

cc: [redacted]

Date: 04 February 2025

Re: Denniston ABA Block Model As part of the Escarpment Extension Project

---

1 Executive Summary

This Memo provides:

- An overview of the Acid Base Accounting (ABA) data and it's spatial coverage across the Denniston ABA 3d Block Model area. The Model area includes the Escarpment Extension Project (EEP).
- An overview of the site-specific ABA process flow classification scheme used at the project.
- A summary of the stratigraphic and geological domains identified.
- A breakdown of how the ABA block model is constructed and ABA parameters estimated.
- A summary of the ABA classification and confidence in that classification within the EEP pit design.
- Recommendations for continued work to control and improve the effectiveness of the ABA model to predict acid and metalliferous drainage (AMD) source hazards.

2 Introduction

This memo provides a summary of the geochemical characterisation process used to classify overburden on the Denniston Plateau using ABA data. The Denniston Plateau includes mines and project areas such as Escarpment Mine, EEP, Cascade Mine, and Sullivan Mine. The Denniston ABA 3d Block Model covers all of these mines and project areas. The EEP forms part of the wider Buller Plateau Continuation Project (BPCP). These areas are shown on Figure 1 below.

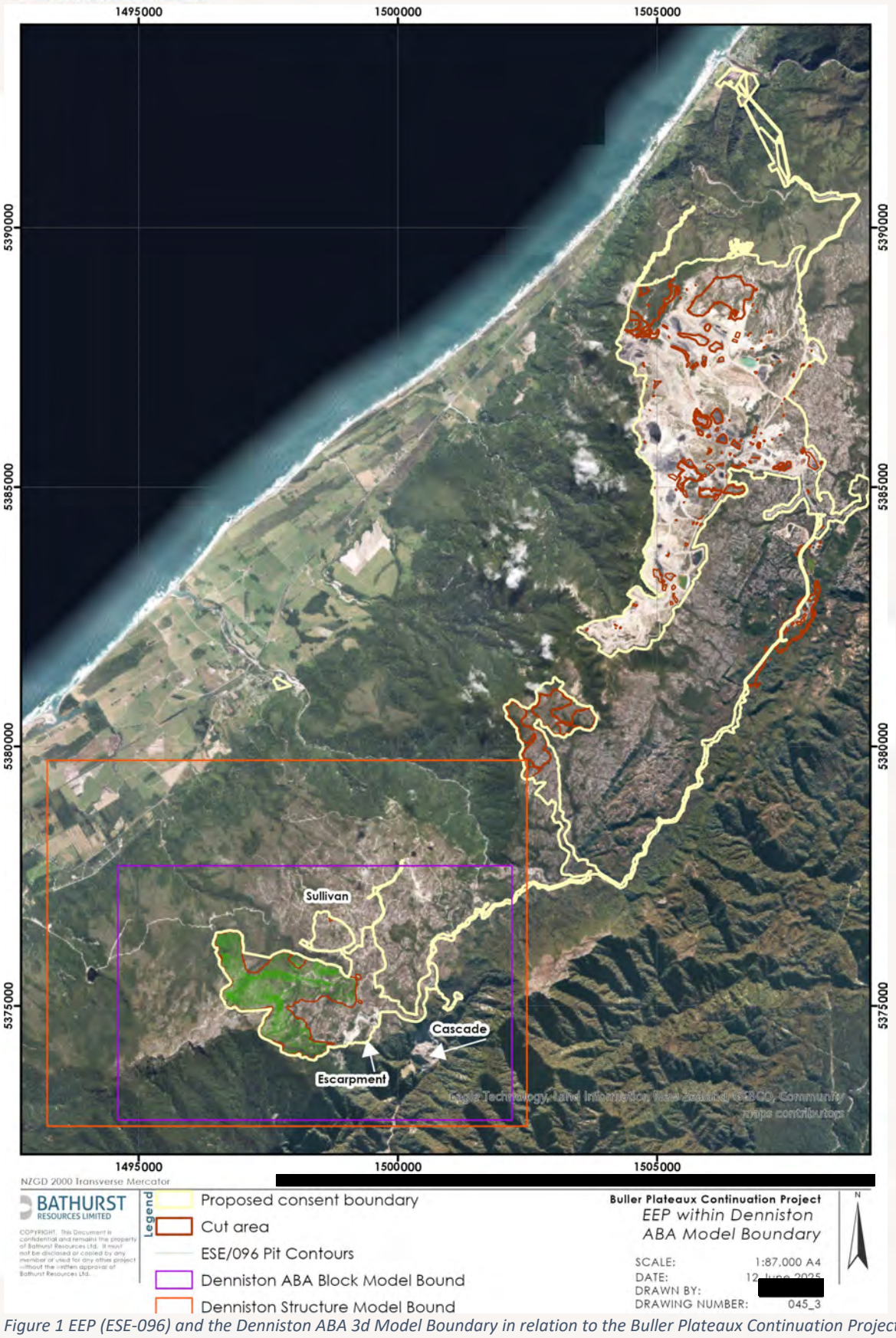


Figure 1 EEP (ESE-096) and the Denniston ABA 3d Model Boundary in relation to the Buller Plateaux Continuation Project

3 Denniston ABA Dataset

BRL have compiled the available ABA geochemical data into an AcQuire (SQL) database. As at the date of this memo the database for Denniston Plateau including Cascade Coal Mine contains 1412 total samples from 138 drill holes; and includes:

- 1380 samples (134 drill holes) having total sulphur data;
- 280 samples (42 drill holes) having sulphide sulphur data;
- 710 samples (80 drill holes) having Net Acid Generation (NAG) pH data;
- 856 samples (94 drill holes) having Acid Neutralising Capacity (ANC) data;
- 907 samples (94 drill holes) having paste pH data;
- 31 samples (4 drill holes) missing all data (lost samples); and
- 709 samples (134 drill holes) having analysis for total sulphur, ANC, NAG pH and Paste pH.

Additional analysis types have been carried out on some samples such as:

- rinse pH (51 samples),
- paste pH 1 hour (90 samples),
- paste pH aged (42 samples),
- chromium reducible sulphur (14 samples), and
- conductivity (42 samples)

but these are not discussed further in this report.

ABA risk is predominantly driven by total sulphur content. Figure 2 below shows the total sulphur distribution within the Denniston ABA dataset. Note, sample length is an important factor to take into account when assessing the ABA data. The mean length of for the top three sulphur values is only 0.3m vs a mean length for the population of 1.86m and indicates the nuggety nature of total sulphur content.

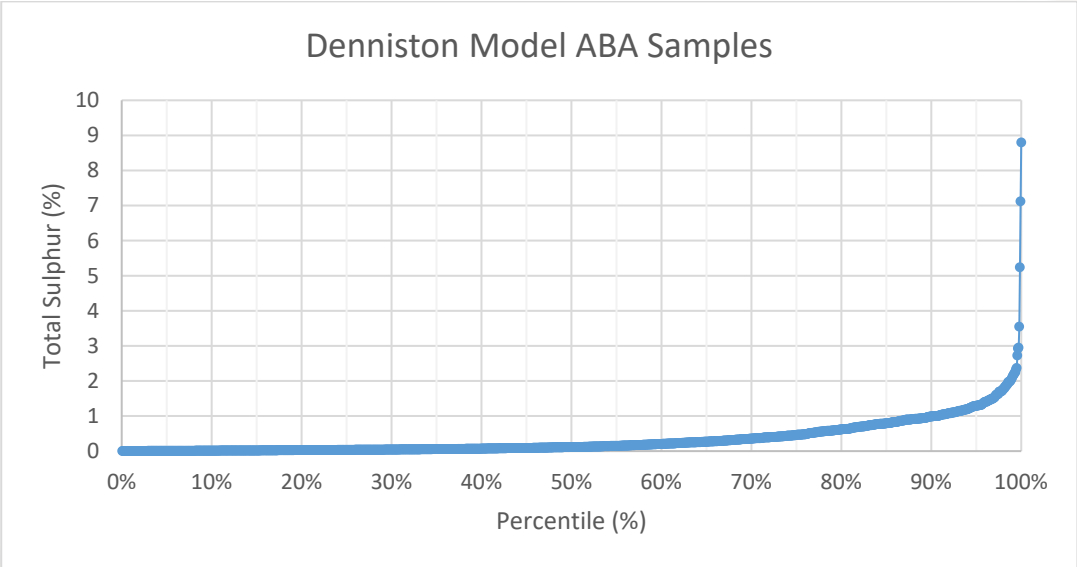


Figure 2 Total Sulphur distribution through the sample population within the Denniston ABA Model.

3.1 Spatial distribution

Samples are distributed spatially across the project area and down hole.

Some earlier ABA sampling for the Escarpment area utilized spot sampling to select representative samples from drill core, however most recent sampling processes have sampled all drill core available from the drill hole. This results in higher representativity of the overburden, and lower risk of bias and error.

It is noted that, with particular regard to sulphur, the analysis results can be quite nuggety across and through the overburden sequence. The smaller the sample, the higher the variability of result.

Sampling was carried out to target a downhole sample length of 2-3 m or where changes to lithology dictate smaller or sometimes larger samples. Mean downhole thickness of samples is 1.86 m.

It is noted that the sample database population is biased towards the eastern side of the project area where infill sampling at the Escarpment Mine resulted in more densely spaced drilling. Much of the difference in spatial coverage of total sulphur vs ANC or NAG pH results is due to the analysing laboratory following the Escarpment process flow classification scheme (e.g., Olds et al., 2015 – see section 4) when analysing the samples. When total sulphur was enough to classify the sample then the remaining analysis was not carried out. Spatial distribution is shown in Figure 3 to Figure 5 below.

3.1.1 Total Sulphur Sample Distribution

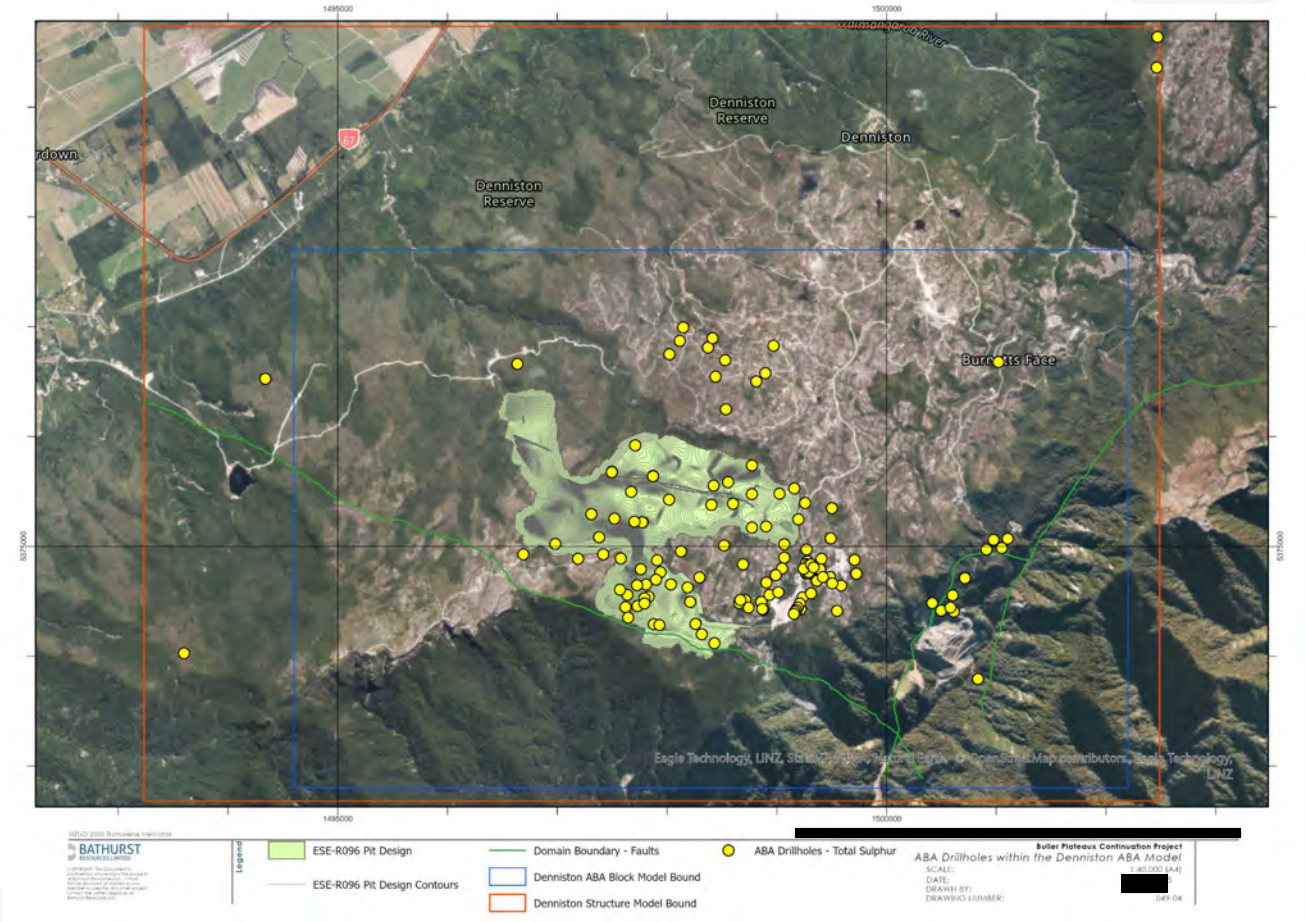


Figure 3 Sample spatial distribution for total sulphur results

3.1.2 ANC Sample Distribution

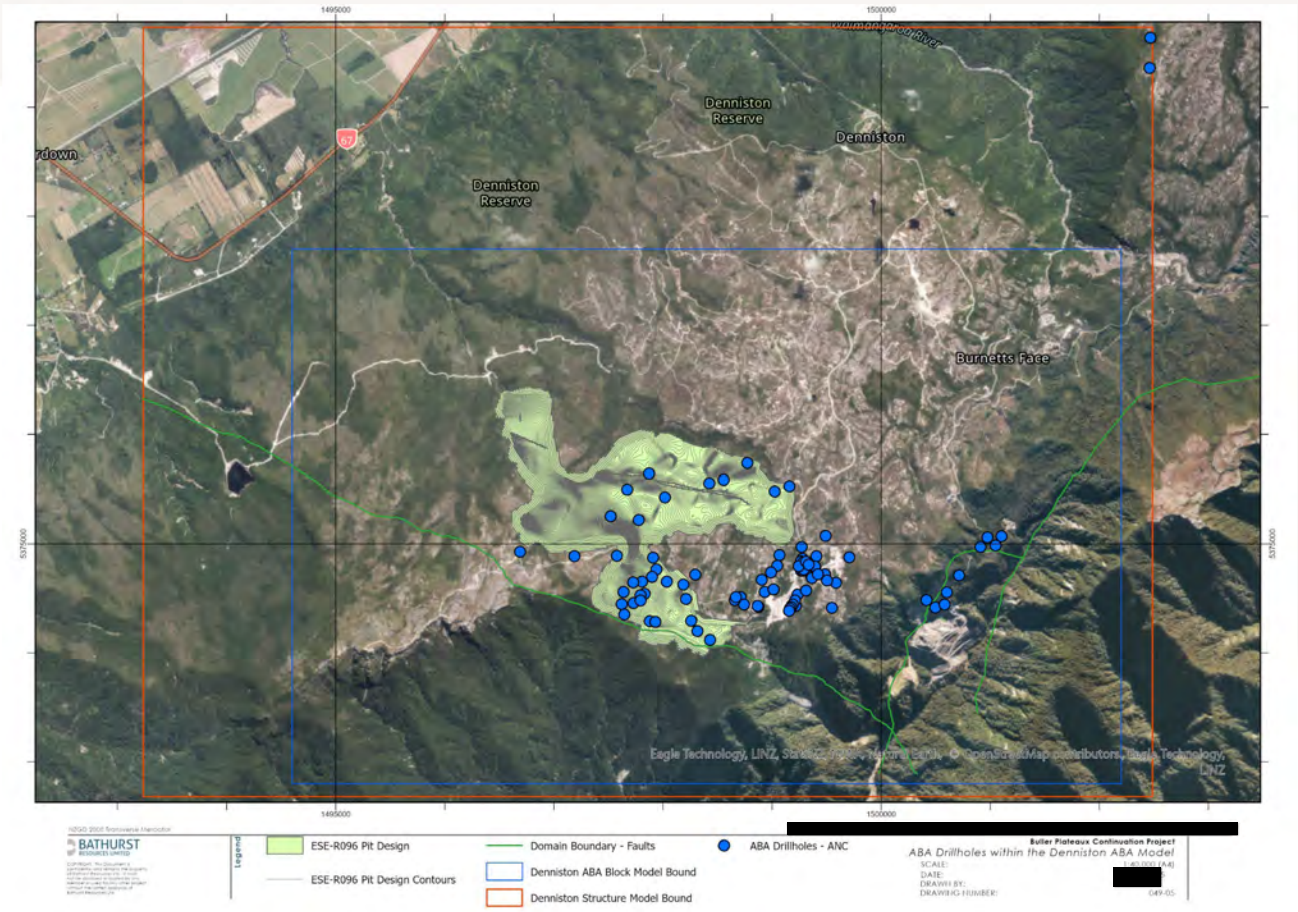


Figure 4 Sample spatial distribution for ANC results

3.1.3 NAG pH Sample Distribution

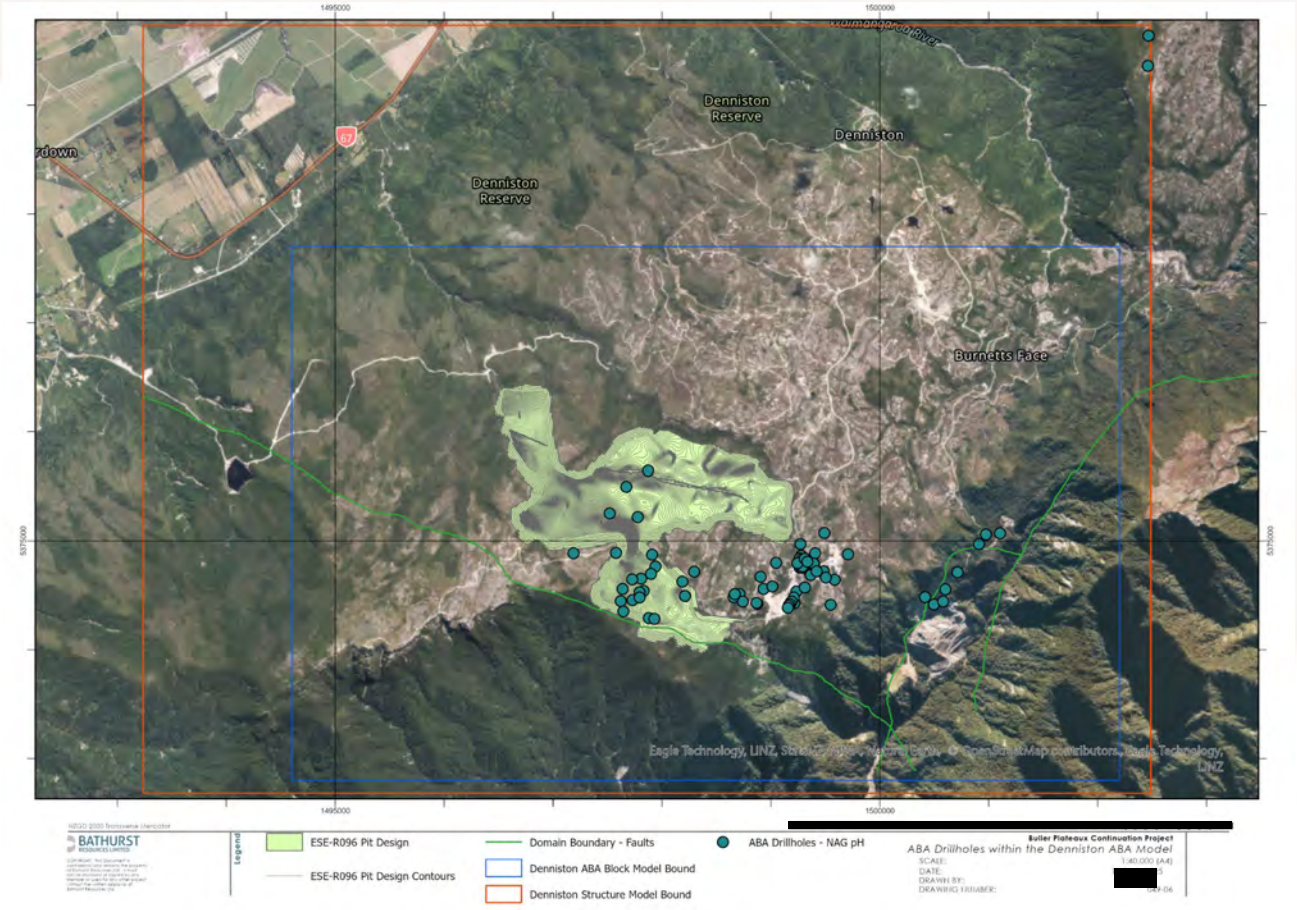


Figure 5 Sample spatial distribution for NAG pH results

4 ABA Classification

At the Escarpment and Cascade Mines, a robust site-specific geochemical classification scheme was developed following a process flow classification approach (PFC) in 2014 as an alternative to a matrix style classification system. This PFC was validated by field column data and was documented (Olds et al., 2015).

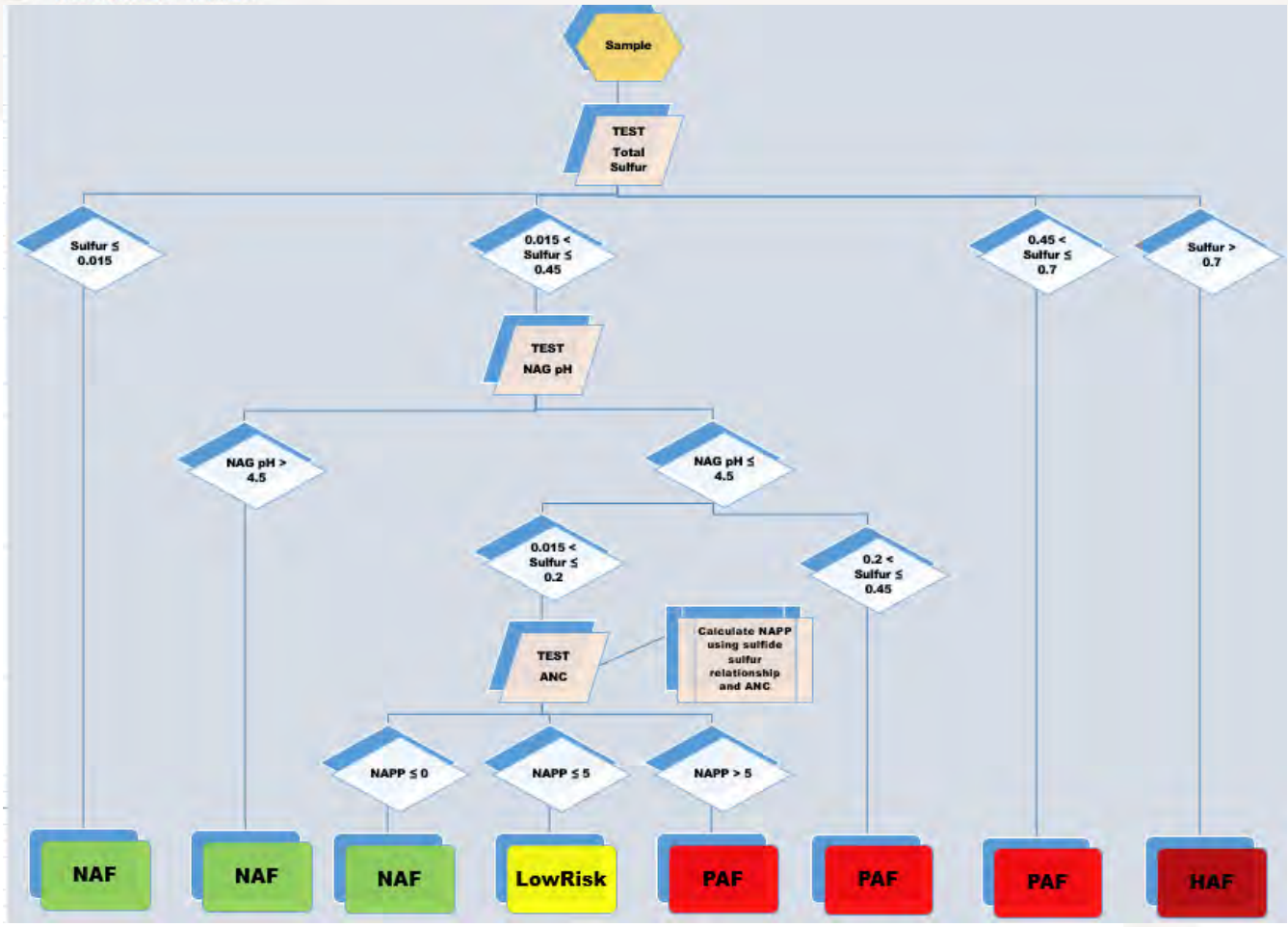


Figure 6 Denniston PFC for waste ABA Characterisation.

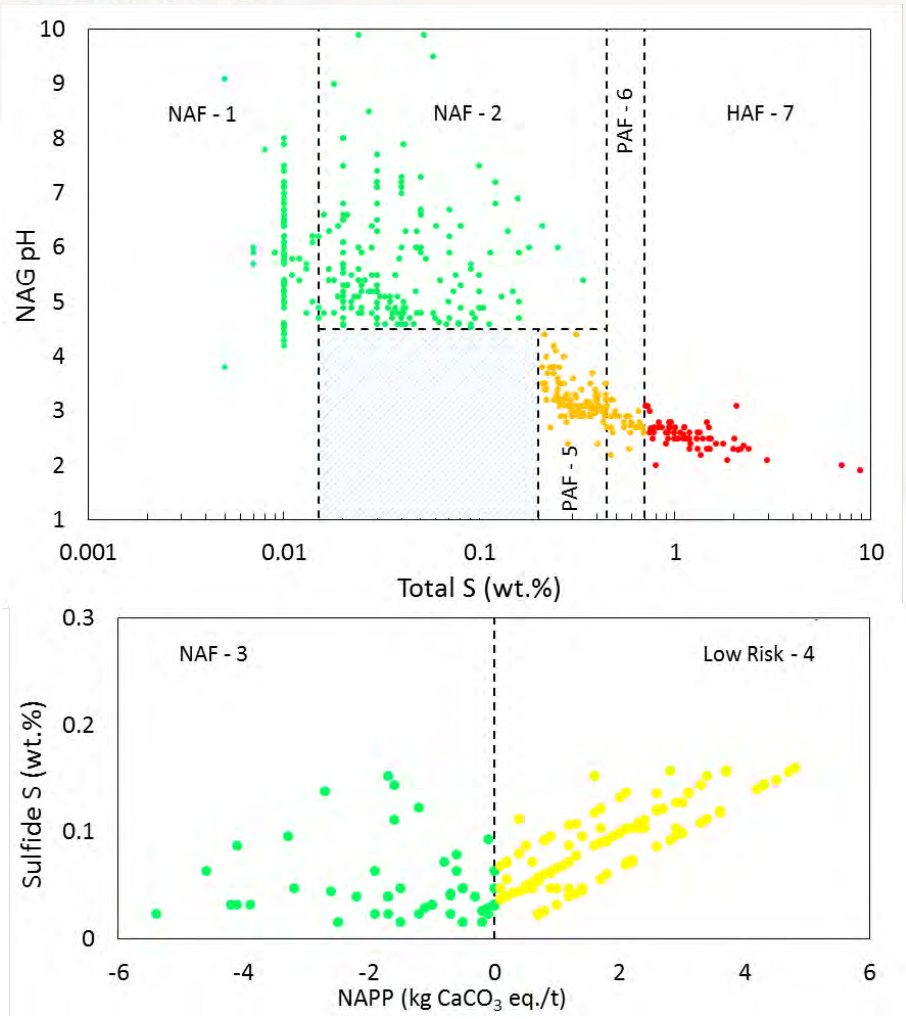


Figure 7 Summary plot of process flow geochemically classified Escarpment ABA database (O'Kane, 2015)

4.1 Field Lysimeters

Results from the field lysimeters were reported by Paul Weber of O'Kane Consultants (NZ) Limited in 2015 (O'Kane, 2015) and are summarised in this section.

Twenty field columns were constructed to validate the PFC as a predictor of waste rock acidity generation potential. The field columns consisted of 20 L buckets filled with approximately 20 kg of crushed drill core (14 columns) and blast hole cuttings (6 columns) that was classified for geochemistry using the PFC. Leachate volumes and chemistry (including pH and acidity) were monitored.

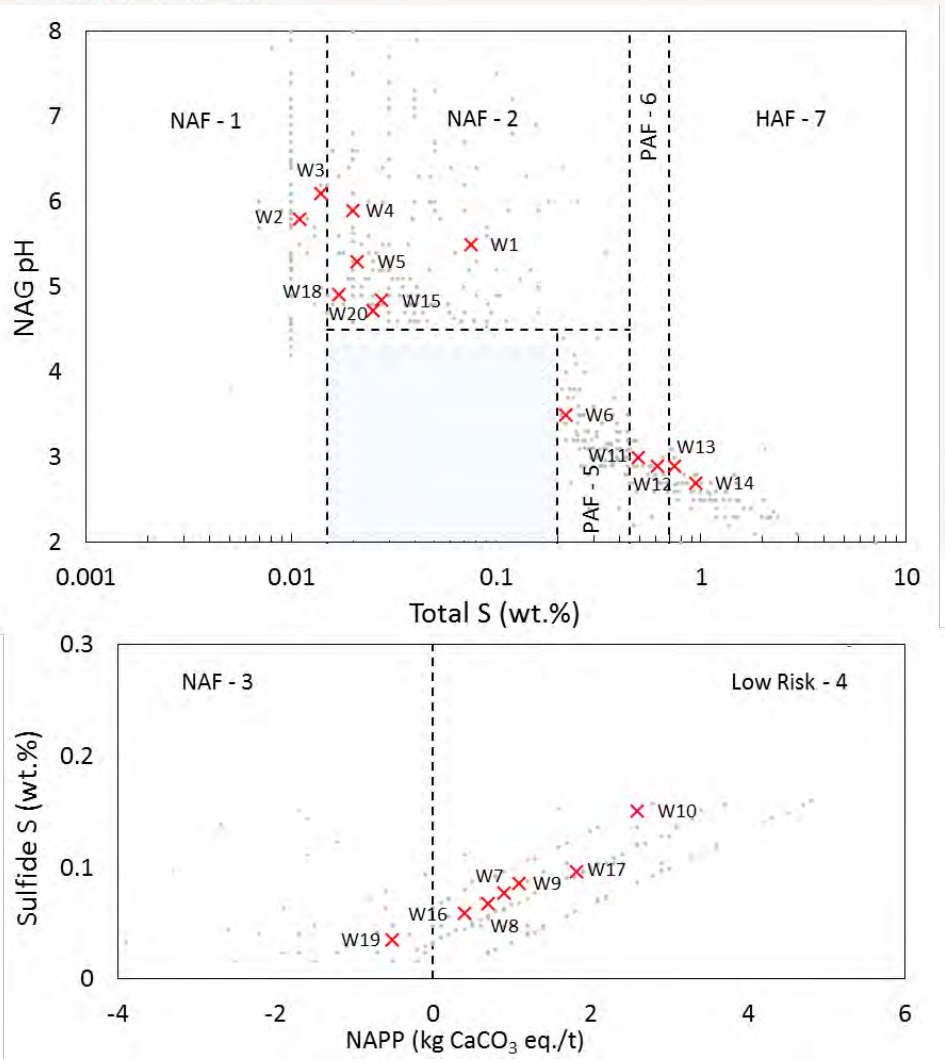


Figure 8 Summary plot showing the Westport field column ABA data within PFC zones (O'Kane, 2015)

The lysimeter leachate pH is shown in Figure 9 which shows trends in the leachate pH from each column (A) and the average pH (based on mean hydrogen ion concentration) for each geochemical class (B).

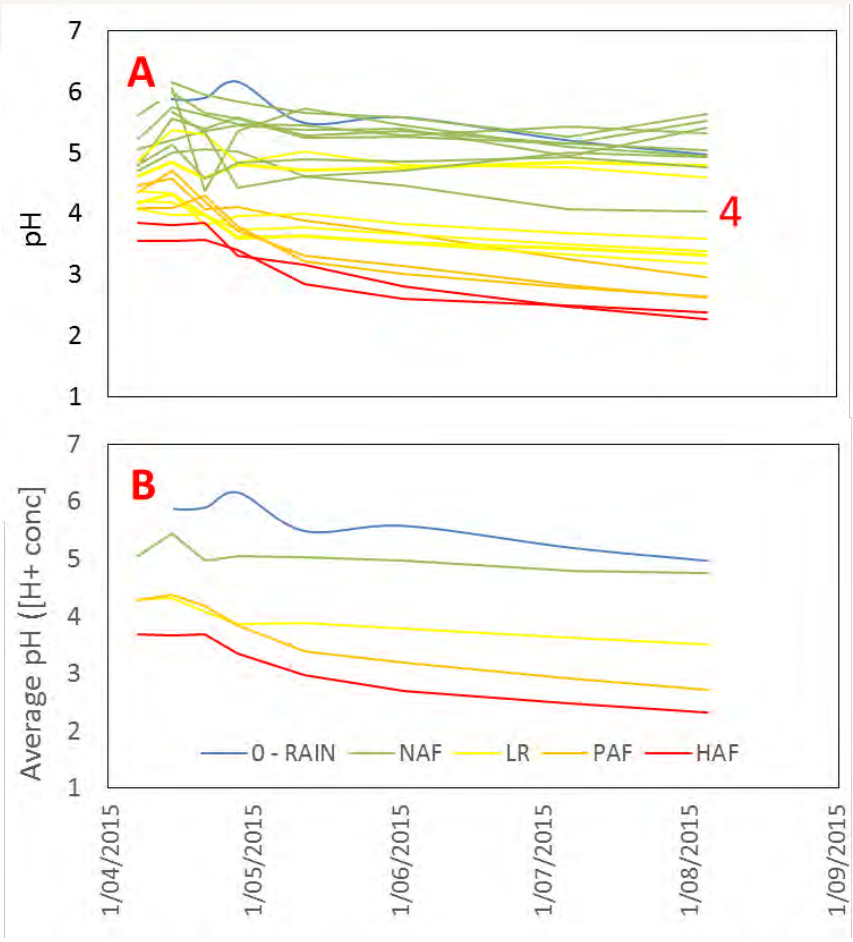


Figure 9 Process flow classification validation field column pH for (A) individual columns and (B) average by classification (O'Kane, 2015)

The lysimeter leachate acidity (Figure 10) data show a clear stepwise increase in leachate acidity from NAF to Low Risk to PAF to HAF materials. NAF leachate acidity was negligible at less than 20 mg $CaCO_3$/L for the most acidic column (column 4-NAF). The Low Risk material leachate acidity varied between 30 and 130 mg $CaCO_3$/L. The PAF and HAF columns may have had a short time lag to acidity onset, with relatively low leachate acidity in the first sample collected. However, the PAF acidity increased to 300 to 1000 mg $CaCO_3$/L and the HAF acidity increased to 800 to 1800 mg $CaCO_3$/L over time.

The composite acidity was calculated based on the average acidity at each sampling round for all the columns in a given classification. The theoretical composite column (Figure 10 B) acidity shows an increase in leachate acidity by approximately a factor of five at each classification step

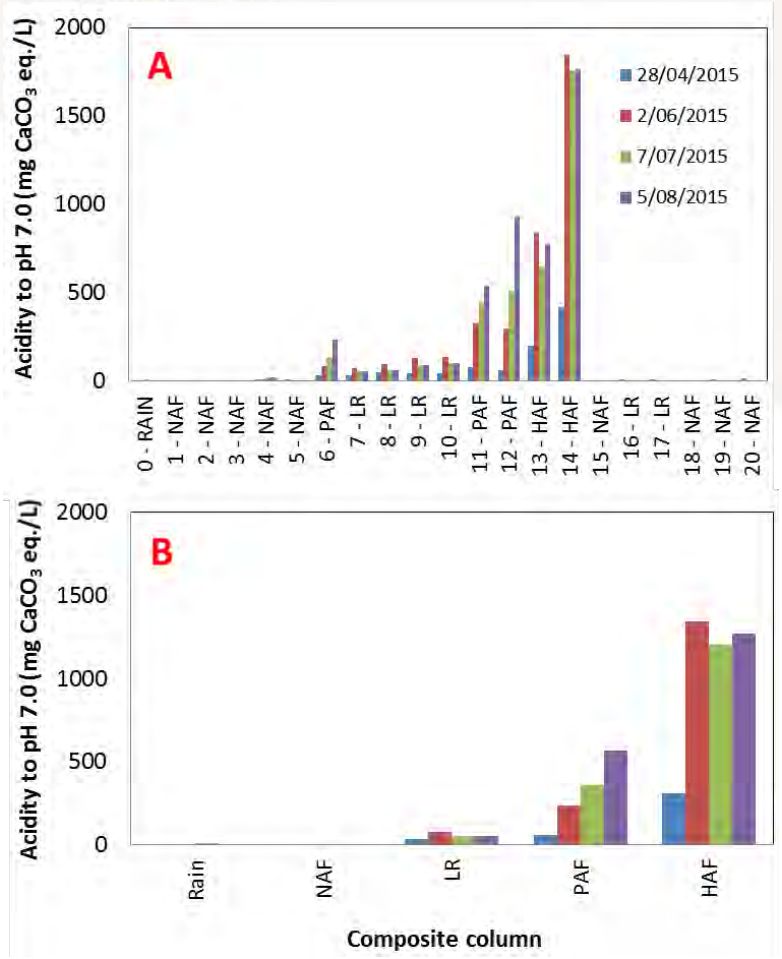


Figure 10 Field column leachate acidity for (A) individual columns and (B) average by classification (O'Kane, 2015)

5 Denniston Stratigraphic Model

The geological model for the Denniston area, including the EEP utilises stratigraphic modelling tools provided in Maptek Vulcan software. The stratigraphic sequence was deposited in layers that are well defined across the plateau, and as with most stratigraphic deposits, relational features of the rock mass are more related on a horizontal horizon than through the sequence (down hole).

This predominately horizontal relationship of the overburden allows for the model used to estimate the coal resources to be utilized for ABA characterisation of the overburden materials.

The major drivers of ABA classification are sulphur and ANC.

ANC content of the rock is function of the mineral type of the grains within the sedimentary rocks within the formation. Therefore, estimation of ANC of the rock mass can utilise stratigraphic domaining to select sample results during grade estimation. Secondary carbonate mineralisation is not prevalent at Denniston within the Brunner Coal Measures.

Metal sulfide precipitation can occur during several stages of diagenesis and burial of sedimentary rocks. Total sulphur content of a siliciclastic sedimentary rock at the Denniston project can be primarily attributed to sedimentary controls. During early stages of diagenesis, anaerobic sulphate-reducing bacteria consume organic carbon and sulphate and produce hydrogen sulfide and bicarbonate. Pyrite (FeS_2) is formed by the reaction of this biogenic sulfide with reactive, detrital iron-bearing minerals near the sediment–water interface (Kaplan et al., 1963; Berner, 1970, 1984). Secondary sulphur mineralisation processes predominantly require fluid flow through the host rock with porosity and connectivity of the formation driven by primary sedimentary processes. Therefore, using stratigraphic domains for sulphur estimation is acceptable for the project area. Fault derived fluid flow and subsequent sulphur deposition has not shown to be prevalent at the Denniston project.

Due to this depositional controlled relationship, it can be shown from the data that the different layers within the stratigraphic deposit can be used to domain datasets and control estimation of the rock mass from the ABA datasets. Six domains have been used as described 6.3.

6 Geostatistical Relationships

6.1 Sample Normalisation / Compositing

The ABA drillhole database is normalised into 1.0 m thick intervals using the Maptek Vulcan sample compositing tool. Normalised datasets are required to determine geostatistical and geospatial relationships between samples.

Compositing of sample sets for each analysis type is completed independently. This avoids issues relating to compositing null values where analysis is not completed for some samples (e.g., ANC or NAG pH data missing due to total sulphur values allowing classification using the PFC without the need to analyse additional parameters).

Log based parameters such as NAG pH and Paste pH have been converted to the hydrogen ion concentration (H+) prior to sample compositing to allow the proton activity mean to be calculated when compositing samples. The use of log would create significant bias and this is avoided.

6.2 Sample Domaining

During sample compositing, samples have been domained both into their respective stratigraphic domain (where in the stratigraphic sequence that sample lies) and a fault domain.

6.3 Stratigraphic domaining

6.3.1 Basement

Basement rocks throughout the project area are predominantly fine-grained quartz porphyry rocks from the intrusive Berlins Quartz Porphyry formation (BQP). Other rock types within the basement formation are Greenland Group metasediments (GG), ranging from low rank greenschist facies up to highly metamorphic gneiss. This formation does not exhibit the strong stratigraphic relationships as the sedimentary sequences above and therefore search ellipses used in grade estimations have been set as spherical rather than elliptical.

A paleo weathering profile has been observed within the basement lithologies, with some elevated sulphur concentrations also observed near the contact with the over lying Brunner Coal Measures.

6.3.2 Basal Brunner Coal Measures

Basal Brunner Coal Measures are characterised by coarse grits and conglomerates. Basal units are a distinct layer modelled within the Denniston stratigraphic model. The Basal domain for the purposes of the ABA model covers the Basal stratigraphic unit plus the overlying coal measure units separating the Basal unit and the first coal seam floor (M1).

6.3.3 Interburden Rocks within Main Coal Seam (M1-M2)

This is a generally very thin or non-existent domain consists of any non-coal material that presents as partings within the main coal bearing seam M1 and M2 which usually make up one single seam but some areas of the deposit the parting between the upper and lower split can reach above 10m thick.

6.3.4 Overburden rocks (M2 -M3)

This domain consists of all overburden rocks between the main coal seam (M1-M2) and first rider seam (M3).

6.3.5 Overburden rocks (M3 -M4)

This domain consists of all overburden rocks between the M3 rider seam and the M4 rider seam.

6.3.6 Overburden rocks (above M4 seam)

This domain consists of all overburden rocks above the M4 rider seam and is the largest domain by volume within the project area.

6.3.7 Coal Seams

Coal seams are retained within the ABA model but are excluded from the ABA classification and estimation process due to the expectation that coal would be extracted and removed and not represent an AMD source hazard. Analysis shows that sulphur contained within coal seams is 80-95% organic sulphur and does not represent a large source hazard for acid generation.

6.4 Fault Block Domaining

Due to the large Boundary normal fault separating the Denniston and Cascade parts of the model, the fault has been used as a boundary to separate samples between the Cascade and Denniston domains. Significant movement on this fault negates the ability to utilise stratigraphic relationships to cross the fault when searching for samples during grade estimation. The grade estimation of ABA data for blocks within each fault block is restricted to samples sets within that fault domain.

Additional fault domains exist within the block model, namely the Mt Rochfort block to the west and the Mt William south block to the east. Neither of these blocks contain any ABA data, and both lie outside of the project footprint. ABA characterisation of these fault domains utilise default ABA values derived from the Denniston Fault domain.

6.5 Sample Summary by Domain

ABA sample data is summarised and presented in Table 1 to Table 6 below.

Both a numeric mean and a length weighted mean of the samples are provided, however only length weighted means are used in the modelling process. pH values have been converted to hydrogen ion concentration (H+) before calculating the length weighted proton activity mean.

Table 1 Total Sulphur Data for the Cascade Domain

Stratigraphic Domain	Sul_T sample mean (%)	Length (m)	Sul_T weighted average (%)
basal	N/A	0.000	**N/A**
m_ib	0.548	0.949	**0.56**
m_ob	0.386	16.589	**0.32**
m3_ob	0.278	8.711	**0.31**
m4_ob	1.249	1.580	**1.07**
base	N/A	0.000	**N/A**

Table 2 NAG pH Data for the Cascade Domain

Stratigraphic Domain	NAG pH sample arithmetic mean	Length (m)	NAG pH weighted arithmetic mean	H^+ concentration weighted average (mol/L)	NAG pH weighted average
basal	N/A	0.0	N/A	N/A	**N/A**
m_ib	3.4	0.3	3.40	0.001219888	**2.9**
m_ob	4.9	10.6	5.17	0.000151080	**3.8**
m3_ob	4.2	4.9	4.11	0.000150699	**3.8**
m4_ob	3.0	0.3	2.90	0.004472546	**2.3**
base	N/A	0.0	N/A	N/A	**N/A**

Table 3 ANC Data for the Cascade domain

Stratigraphic Domain	ANC sample mean (kg H_2SO_4/t)	Length (m)	ANC weighted average (kg H_2SO_4/t)
basal	N/A	0.000	**N/A**
m_ib	1.314	0.349	**1.77**
m_ob	0.786	10.590	**0.48**
m3_ob	1.538	4.870	**0.66**
m4_ob	2.000	0.330	**2.00**
base	N/A	0.000	**N/A**

Table 4 Total sulphur data for the Denniston Domain

Stratigraphic Domain	Sul_T sample mean (%)	Length (m)	Sul_T weighted average (%)
basal	0.221	225.122	**0.225**
m_ib	0.300	172.271	**0.273**
m_ob	0.325	755.615	**0.320**
m3_ob	0.384	507.697	**0.370**
m4_ob	0.285	495.103	**0.273**
base	0.086	74.804	**0.081**

Table 5 NAG pH Data for the Denniston Domain

Stratigraphic Domain	NAG pH arithmetic mean	Length (m)	NAG pH weighted arithmetic mean	H^+ concentration weighted average (mol/L)	NAG pH weighted average
basal	4.9	32.0	4.9	0.000190056	**3.7**
m_ib	3.8	123.6	3.7	0.000504046	**3.3**
m_ob	4.5	404.8	4.5	0.000493520	**3.3**
m3_ob	4.5	310.3	4.5	0.000741135	**3.1**
m4_ob	4.3	243.2	4.3	0.000332437	**3.5**
base	5.9	49.2	6.0	0.000017066	**4.8**

Table 6 ANC data for the Denniston domain

Stratigraphic Domain	ANC sample mean (kg H_2SO_4/t)	Length (m)	ANC weighted ave (kg H_2SO_4/t)
basal	3.679	75.689	**3.64**
m_ib	1.354	127.891	**1.36**
m_ob	2.130	476.631	**2.20**
m3_ob	1.346	384.323	**1.35**
m4_ob	3.652	354.809	**3.67**
base	17.423	59.992	**17.75**

6.6 Geostatistics

Detailed sample geostatistics were investigated in 2015 when determining grade estimation search radius parameters.

For the 2024 model update, initial semi variograms were run for some basic uniaxial stepwise geostatistics on the composited databases utilising Maptek Vulcan Variography module. Figure 11 to Figure 15 shows semi variograms for each stratigraphic domain, within the Denniston domain for total sulphur.

Different domains exhibit different spatial relationships between samples and varying degrees of nugget effect which represents the inherent variability or noise within the dataset at very small distances between samples and is shown as the y-intercept on the semi-variogram plot.

Further work should be undertaken to improve search ellipses and investigation geostatistical relationships for each parameter for each domain.

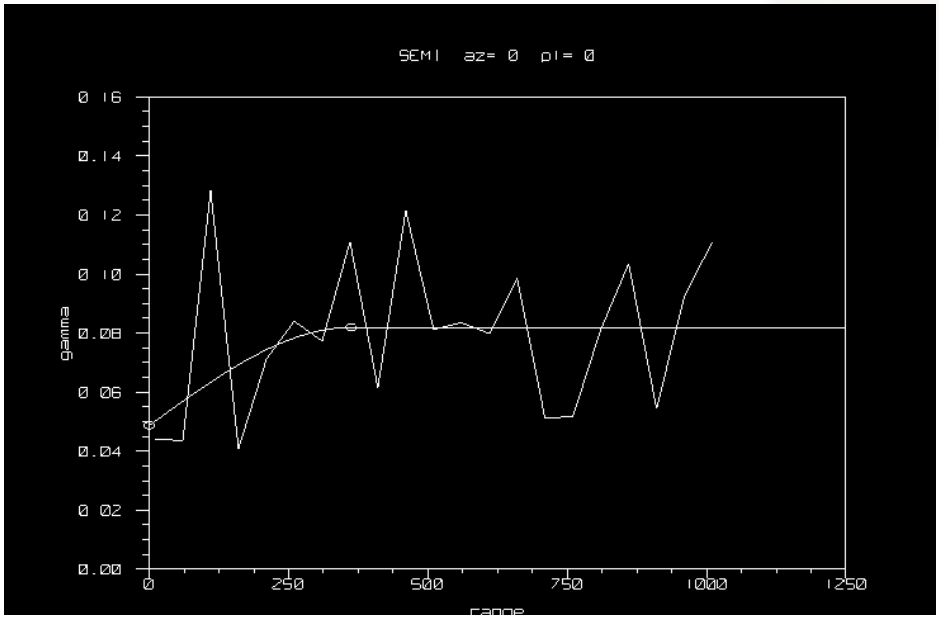


Figure 11 Uniaxial semi variogram for total sulphur within the M4 overburden domain

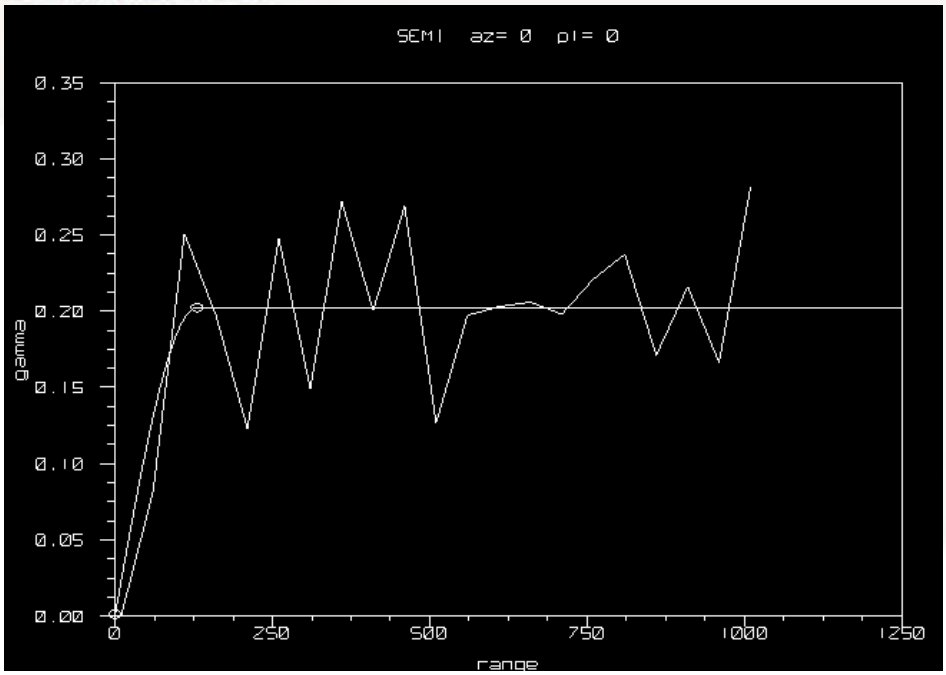


Figure 12 Uniaxial semi variogram for total sulphur within the M3 overburden domain

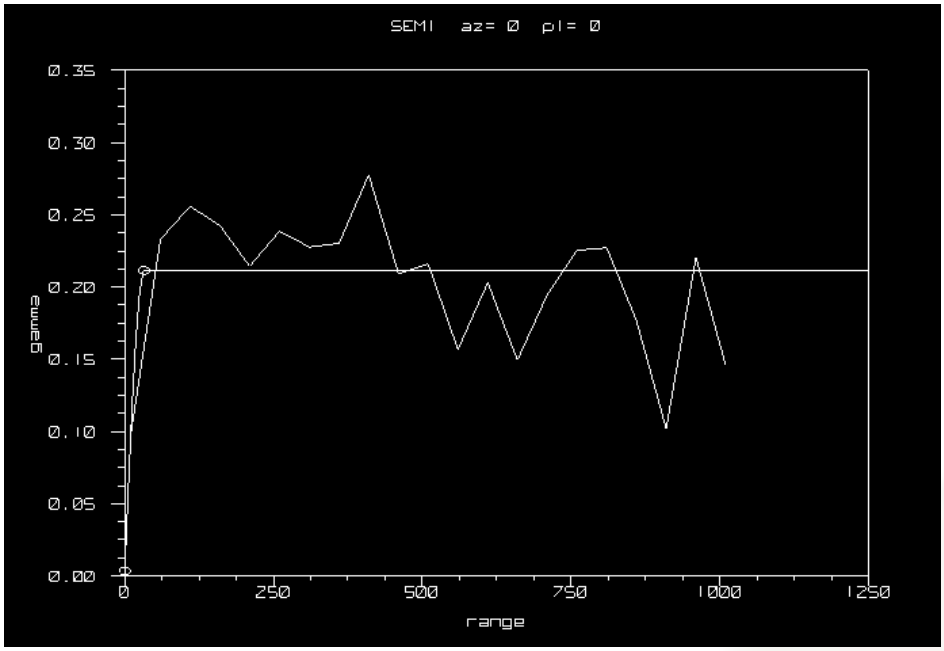


Figure 13 Uniaxial semi variogram for total sulphur within the M2 overburden domain

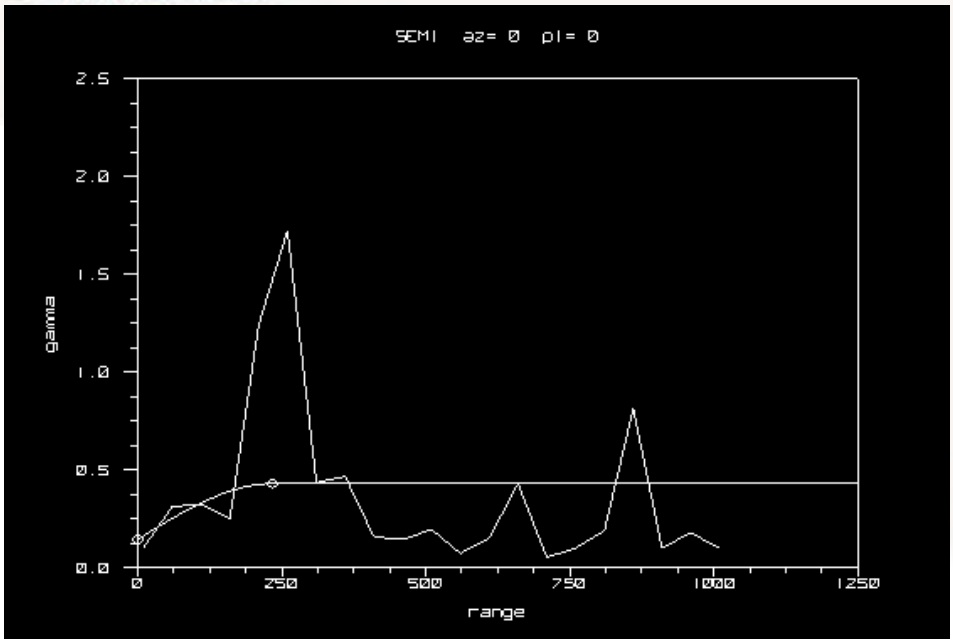


Figure 14 Uniaxial semi variogram for total sulphur within the M1-M2 interburden domain

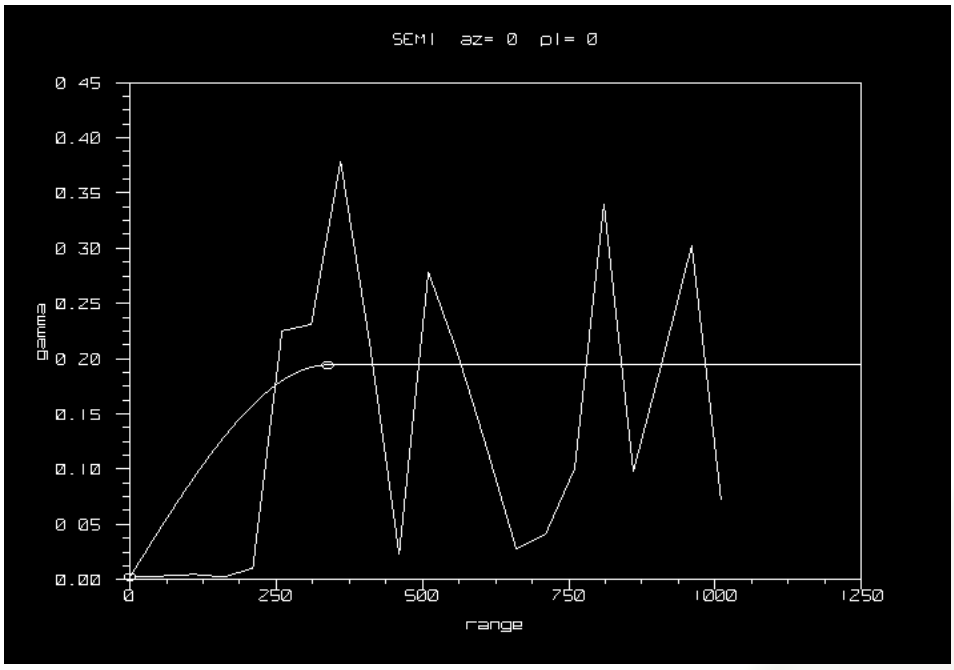


Figure 15 Uniaxial semi variogram for total sulphur within the basal Brunner Coal Measures domain

7 Denniston ABA Block Model

The Denniston ABA Block Model is built using Maptek Vulcans block model build functions. The Model is built using the same stratigraphic surfaces as the Coal Resource model is constructed and is updated from time to time as new ABA data is acquired.

The latest ABA model is names ***den_aba_complete_unmined_20241125.bmf***. Blocks are 10 m x 10 m and minimum block height of 0.5 m. Maximum block height of 0.5 m for coal blocks, and 2.5 m for interburden and overburden, and maximum block height for basal coal measures and basement of 5 m. 2.5 m maximum thickness of interburden and overburden materials aligns with mining bench depth at EEP and the average sample thickness within the dataset.

34 variables are carried through the model for each block. These variables are listed below in Table 7.

Table 7 ABA Block Model List of Variables

Variables	Default	Type	Description
weath_zone	def	name	zone of surface weathering
seam	def	name	seam code
fault	nothing	name	fault block
sgroup	def	name	seam modelled below 50% for estimation
sdomain	def	name	Parent seams
estimation	def	name	estimated or calculated (assigned) value
permit	def	name	Crown minerals permit or licence
density_ps	-99	float	Apparent relative density insitu (after preston saunders)
original_t	-99	float	Original Tonnes in ground before any mining
s_d_sult	-99	integer	sample distance - total sulphur
n_p_sult	-99	integer	current pass number - total sulphur
n_s_sult	-99	integer	number of samples used in estimate - total sulphur
n_h_sult	-99	integer	number of holes used in the estimate - total sulphur
s_d_anc	-99	integer	sample distance - anc
n_p_anc	-99	integer	current pass number - anc
n_s_anc	-99	integer	number of samples used in estimate - anc
n_h_anc	-99	integer	number of holes used in the estimate - anc
s_d_nagph	-99	integer	sample distance - nagph
n_p_nagph	-99	integer	current pass number - nagph
n_s_nagph	-99	integer	number of samples used in estimate - nagph
n_h_nagph	-99	integer	number of holes used in the estimate - nagph
s_d_pstph	-99	integer	sample distance - pasteph
n_p_pstph	-99	integer	current pass number - pasteph
n_s_pstph	-99	integer	number of samples used in estimate - pasteph
n_h_pstph	-99	integer	number of holes used in the estimate - pasteph
aba_anc	-99	float	Acid Neutralizing capacity (kg H2S04)
aba_nagph	-99	float	net acid generating PH.
aba_nagph_l	-99	double	net acid generating PH (inverse log10 used for grade estimation).
aba_pstph	-99	float	paste PH. required for original classification
aba_pstph_l	-99	double	paste PH (inverse log10 used for grade estimation).
aba_sul_t	-99	float	Total sulphur from ABA data.
aba_class_n	def	name	Classification using BRL site specific PFC
aba_class_d	def	name	Old classification using scheme as described in original AMD management plan (flawed)
aba_confidence	-99	integer	indication of confidence in the classification (based on underlying estimation of parameters driving it). 202411

The model is constructed with a weathering variable populated for blocks that lie within 6 m of the surface. This version of the model does not utilise this variable and all samples are grade estimated assuming no weathering effects (beyond those inherent within the ABA samples).

There is a clear paleo weathering profile exhibited in basement rocks lying below the contact with the BCM. Samples taken from within this zone show generally higher total sulphur values than unweathered samples taken from deeper down hole. Due to very limited sample spacing from unweathered basement rocks, this model has not separated the weathered and unweathered zones during grade estimation processes, with all basement blocks estimated using the same search ellipse settings.

8 ABA Grade estimation

ABA variables are grade estimated from the composited database separately for each parameter and for each domain. Only the Denniston fault block is grade estimated in the current ABA model due to both Cascade and Mt Rochfort fault domains lying outside of the proposed project area.

Sedimentary domains (domains other than the Basement domain) are grade estimation utilising Maptek Vulcans unfolding projection process. This process utilises a top and bottom surface (tetra) to unfold/normalise the stratigraphic trend to allow grade estimation using a search ellipse with a variable minor axis (the minor axis is set as a proportion of the thickness of the tetra. This method allows the sample selection and sample weighting used to grade estimate a block to apply higher weightings to samples that lie at the same position within the horizon being estimated.

Log based parameters such as NAG pH and paste pH have been converted to the hydrogen ion concentration (H^+) prior to sample compositing and grade estimation. The H^+ concentrations can then be averaged numerically to normalise the data and estimate blocks within the ABA model. After grade estimation, the H+ concentrations are then converted back to pH using the formula pH = -log(H^+).

Search radius set for each parameter were determined by relative geostatistical relationships derived in 2015. Search distances have been limited to where distance exceeds the identified spatial relationship for each domain.

Maximum number of samples allowed for a single drill hole is set to 3 samples for every pass. Due to sample database being normalised into 1.0 m lengths, and maximum block heights set to 2.5 m.

Table 8 Summary of grade estimation settings for total sulphur for each stratigraphic domain

Sul_t												
	Pass 1				Pass 2				Pass 3			
	search radius	minor axis (m, or ratio)	min # samples	max # samples	search radius	minor axis (m, or ratio)	min # samples	max # samples	search radius	minor axis (m, or ratio)	min # samples	max # samples
base	100 m	50 m	1	10	400 m	100 m	1	16	N/A	N/A	N/A	N/A
basal	100 m	0.2	1	12	500 m	0.5	1	16	N/A	N/A	N/A	N/A
m_ib	150 m	0.2	1	12	400 m	0.5	1	16	N/A	N/A	N/A	N/A
m_ob	150 m	0.25	1	12	400 m	0.25	1	16	950 m	0.5	1	16
m3_ob	150 m	0.2	1	12	300 m	0.5	1	16	N/A	N/A	N/A	N/A

m4_ob	150 m	0.15	1	12	250 m	0.3	1	16	500 m	0.5	1	20

Table 9 Summary of grade estimation settings for ANC for each stratigraphic domain

ANC												
	Pass 1				Pass 2				Pass 3			
	search radius	minor axis (m, or ratio)	min # samples	max # samples	search radius	minor axis (m, or ratio)	min # samples	max # samples	search radius	minor axis (m, or ratio)	min # samples	max # samples
base	100 m	50 m	1	10	400 m	100 m	1	16	N/A	N/A	N/A	N/A
basal	100 m	0.2	1	12	500 m	0.5	1	16	N/A	N/A	N/A	N/A
m_ib	150 m	0.2	1	12	400 m	0.5	1	16	N/A	N/A	N/A	N/A
m_ob	350 m	0.2	1	16	600 m	0.3	1	16	1200 m	0.5	1	20
m3_ob	150 m	0.15	1	12	400 m	0.25	1	16	950 m	0.5	1	20
m4_ob	150 m	0.15	1	12	250 m	0.3	1	16	500 m	0.5	1	20

Table 10 Summary of grade estimation settings for NAG pH for each stratigraphic domain

NAG pH												
	Pass 1				Pass 2				Pass 3			
	search radius	minor axis (m, or ratio)	min # samples	max # samples	search radius	minor axis	min # samples	max # samples	search radius	minor axis (m, or ratio)	min # samples	max # samples
base	100 m	50 m	1	10	400 m	100 m	1	16	N/A	N/A	N/A	N/A
basal	100 m	0.2	1	12	500 m	0.5	1	16	N/A	N/A	N/A	N/A
m_ib	150 m	0.2	1	12	400 m	0.5	1	16	N/A	N/A	N/A	N/A
m_ob	300 m	0.15	1	16	750 m	0.3	1	16	N/A	N/A	N/A	N/A
m3_ob	150 m	0.2	1	12	300 m	0.5	1	16	N/A	N/A	N/A	N/A
m4_ob	150 m	0.15	1	12	250 m	0.3	1	16	500 m	0.5	1	20

Table 11 Summary of grade estimation settings for paste pH for each stratigraphic domain

Paste pH												
	Pass 1				Pass 2				Pass 3			
	search radius	minor axis (m, or ratio)	min # samples	max # samples	search radius	minor axis (m, or ratio)	min # samples	max # samples	search radius	minor axis (m, or ratio)	min # samples	max # samples
base	100 m	50 m	1	10	400 m	100 m	1	16	N/A	N/A	N/A	N/A
basal	100 m	0.2	1	12	500 m	0.5	1	16	N/A	N/A	N/A	N/A
m_ib	150 m	0.2	1	12	400 m	0.5	1	16	N/A	N/A	N/A	N/A
m_ob	100 m	0.15	1	12	250 m	0.25	1	16	700 m	0.5	1	16
m3_ob	150 m	0.15	1	12	400 m	0.3	1	16	880 m	0.5	1	16
m4_ob	150 m	0.15	1	12	250 m	0.3	1	16	500 m	0.5	1	20

8.1 Confidence in the ABA Estimation

The ABA model has been updated with a confidence field (aba_confidence). This is assigned via a script after grade estimation is completed.

The confidence is an integer from 1 – 10 and should be used as a qualitative measure to indicate the reliability of the overall ABA classification depending on the underlying reliability of the input parameters used to classify the block.

The ABA data is grade estimated in multiple passes for each parameter depending on the geostatistical relationships for each parameter/domain. The pass number is tracked in block variables for each parameter.

If a parameter was not grade estimated (no sample near enough to the block being estimated) the pass number is set to 7 and the parameters are assigned to default values derived from the length weighted sample averages for that stratigraphic domain/fault block (see section 6.5).

The confidence is calculated by multiplying the 'pass numbers' for each parameter used in the classification. The resultant multiple is clipped to a maximum of 7. For any parameter that has pass number equal to 7, 1 is added to the confidence. (so the minimum confidence level for a block that has one parameter as default is 8).

Table 12 Summary of how the ABA Confidence variable is determined from search pass number.

Estimation Pass Number				
Sul_t	**NAGpH**	**ANC**	**multiplied**	**ABA Confidence**
1	1	1	1	1
1	2	1	2	2
1	3	1	3	3
1	1	2	2	2
1	1	3	3	3
1	2	2	4	4
1	2	3	6	6
1	3	2	6	6
1	3	3	9	7
2	1	1	2	2
2	2	1	4	4
2	3	1	6	6
2	1	2	4	4
2	1	3	6	6
2	2	2	8	7
2	2	3	12	7
2	3	2	12	7
2	3	3	18	7
3	1	1	3	3
3	1	2	6	6
3	1	3	9	7
3	2	1	6	6
3	2	2	12	7
3	2	3	18	7
3	3	1	9	7
3	3	2	18	7
3	3	3	27	7
default	x	y	>=7	8

Estimation Pass Number				
Sul_t	NAGpH	ANC	multiplied	ABA Confidence
x	default	y	>=7	8
x	y	default	>=7	8
default	default	x	>=7	9
default	x	default	>=7	9
x	default	default	>=7	9
default	default	default	>=7	10

Note. If only one parameter is used in the classification (eg Sul_t > 0.7 and Class = HAF) then confidence is set to the pass number of that parameter. If only two parameters are used in the classification the confidence is set by multiplying only those two pass numbers together.

Figure 20 shows the relative confidence in the PFC for the EEP 096 pit shell. Approximately 50% of the blocks have been classified with ABA parameters estimated in the first or second passes during grade estimation (confidence value of 1, or 2). Approximately 25% of blocks are classified with at least one parameter that is used to classify the block following the PFC being too far away from the nearest sample to be estimated and hence default values for that stratigraphic domain being used (confidence values of 8, 9 and 10). Infill data collection should be undertaken to improve confidence in the classification of these blocks prior to mining.

9 Results

The Denniston ABA Block Model provides a robust estimate of ABA parameters and classification that can be used by BRL to enable selection, planning, scheduling of overburden materials with the aim of reducing potential effects from AMD by better managing materials at source and planning for the levels of effects expected. Figure 16 to Figure 18 show the results of the ABA model displayed in plan and section.

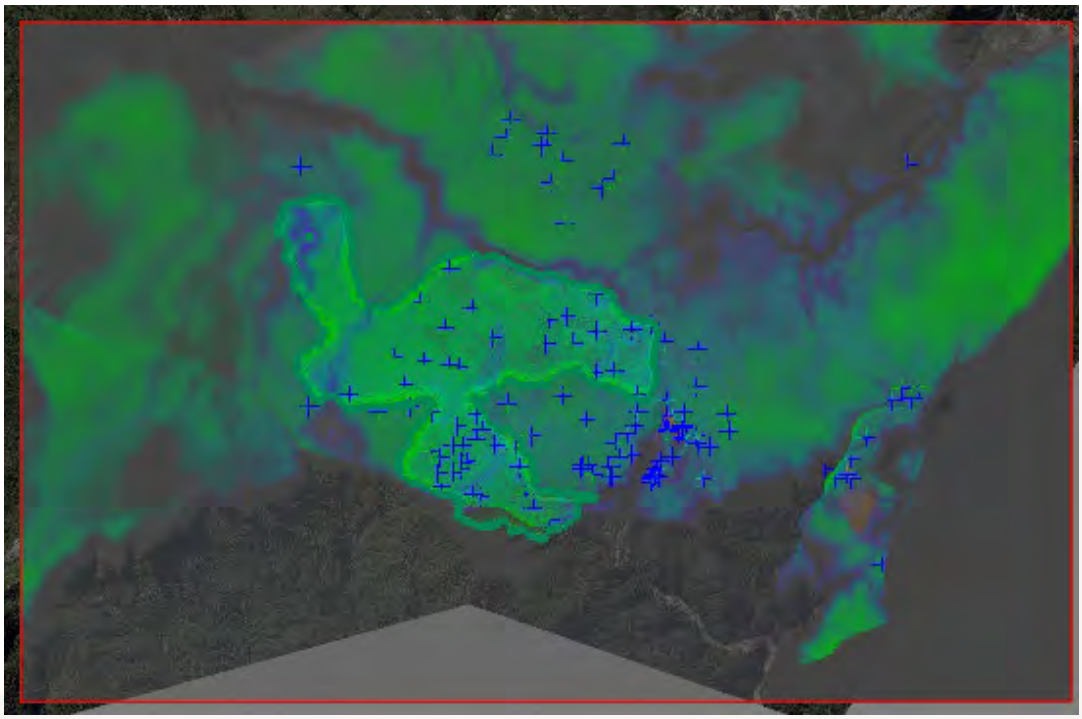


Figure 16 The Denniston ABA model coloured by stratigraphic sequence. Pit Shell design ESE-096 shown. ABA Drill holes shown (+).

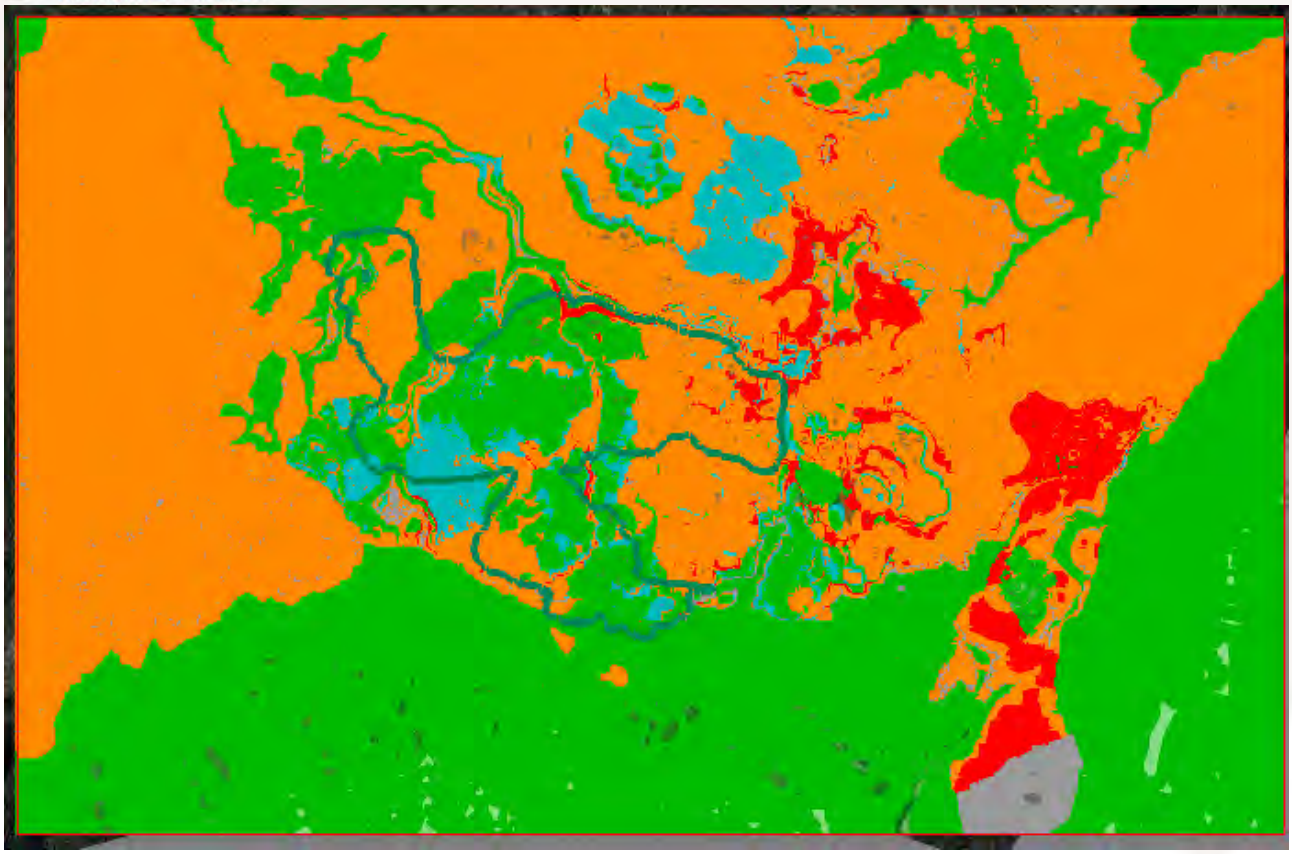


Figure 17 The Denniston ABA Model coloured by PFC Classification (only surface blocks shown: 0.5 m – 2.5m below surface). Green = NAF, Cyan=Low Risk, Orange = PAF, Red = HAF. Pit Shell design ESE-096 shown.

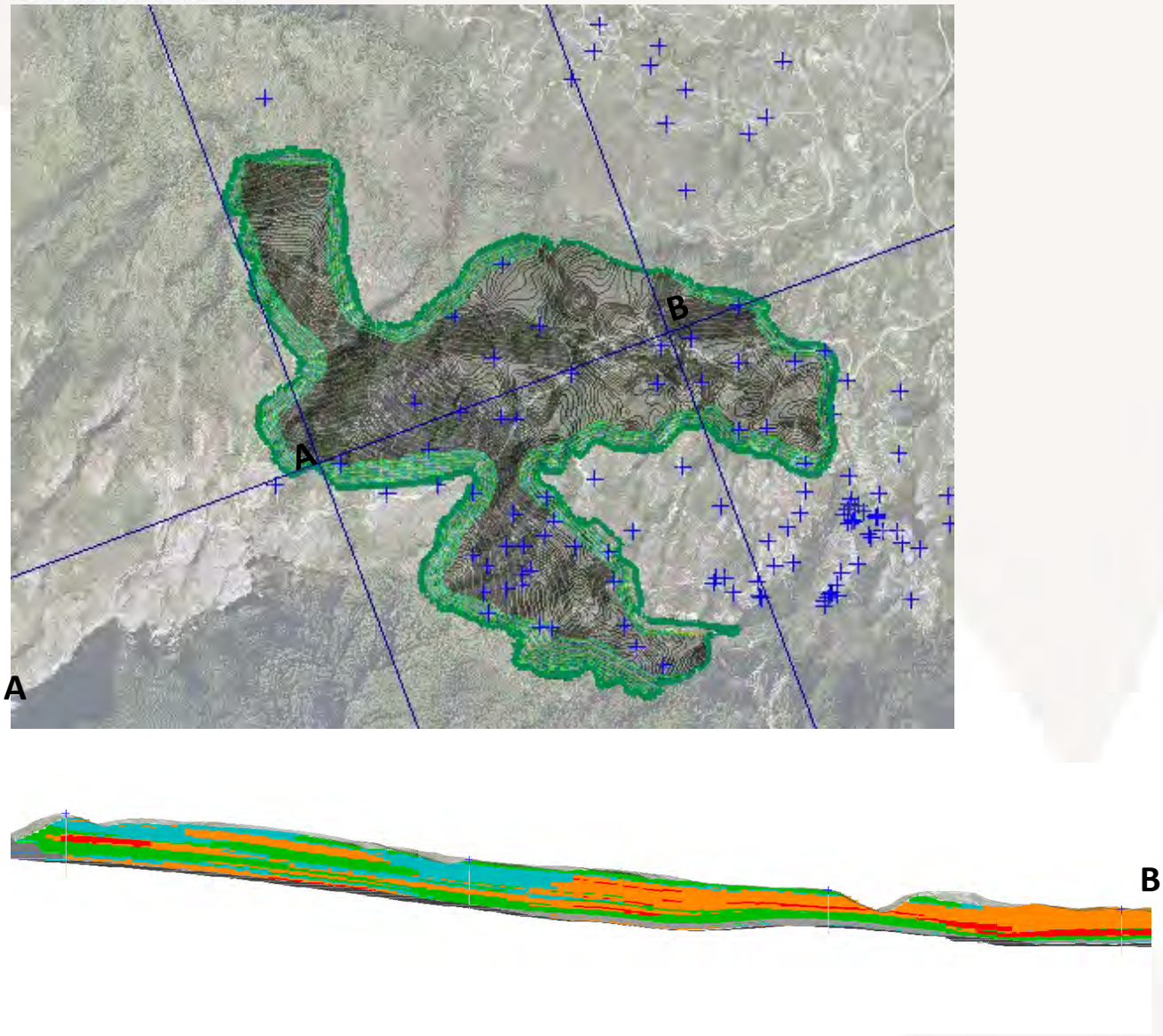


Figure 18 Cross-section view of the Denniston ABA model coloured by PFC Classification (A-B shown on plan). Green = NAF, Cyan=Low Risk, Orange = PAF, Red = HAF. Pit Design ESE-096 shown. Only blocks within the Pit Design are shown.

The ABA Block model can be used to report the global ABA risk from within the pit shell. Figure 19 below shows the relative tonnages of overburden rock expected from the pit design ESE-096 used for the project. The block model can be used by reporting waste materials classification and ABA data by dividing up the pit shell design into small blocks and used for scheduling. Waste volumes and classification can therefore be provided from source to scheduled placement into engineered landforms (ELFs) to ensure higher risk PAF and HAF materials are segregated and stored within the core of the ELFs as required by management plans.

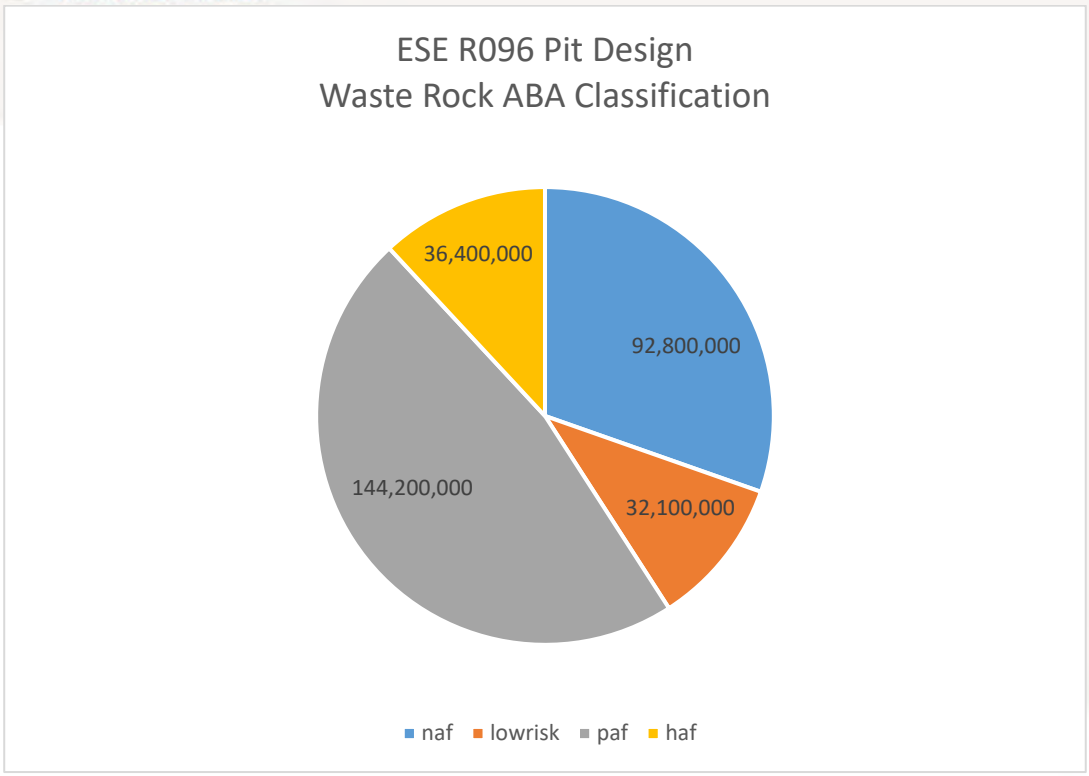


Figure 19 Relative tonnages of waste rock classified by the PFC. Labels show total rock tonnages.

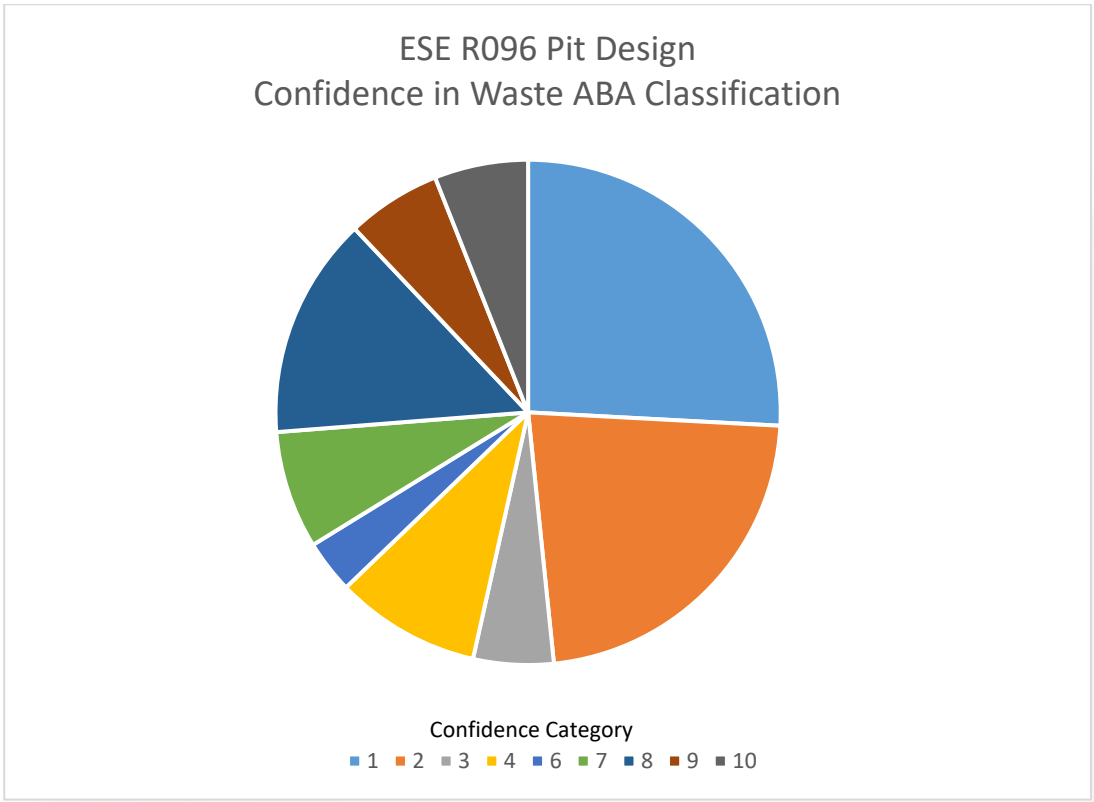


Figure 20 Confidence in the estimation of ABA parameters and subsequent ABA classification. The lower the confidence value, the higher the confidence with the classification.

10 Recommendations

As mining progresses at the EEP, it is recommended that further refinement of the ABA model is undertaken particularly where confidence levels are in the higher categories.

Further refinement of the model and modelling processes is recommended including:

- Continue to review and update geostatistical relationships between samples for each stratigraphic domain. Feed these into grade estimation search ellipse radii specifications.
- Review whether surface weathering profiles are prevalent and quantifiable. Assess whether addition of a surface weathering profile should be added to the model
- Review whether a basement weathering profile are prevalent and quantifiable. Assess whether addition of a basement weathering profile is required.
- Ensure that when further ABA analysis is carried out that a sampling specific process flow is used to ensure additional ANC and NAG pH data is available to be used in model estimation processes instead of using the PFC.

Further data acquisition and QA/QC is recommended as mining commences such as:

- ABA sampling of stored drill core for remaining holes that were within the project area
- Infill and step out drilling >12 months prior to mining at spacings that ensure grade estimation of blocks can be achieved.
- Full sampling of selected blast holes to compare ABA results against and feed into the ABA block model. Spot sampling from field outcrop is not recommended due to representativeness issues.
- On going QA/QC including field duplicates, lab duplicates, repeats, standards and blanks.

11 References

Olds, W.E., Bird, B., Pearce, J.I., Sinclair, E., Orr, M. and Weber, P.A., 2015. Geochemical classification of waste rock using process flow diagrams. In The Proceedings of the 2015 AusIMM New Zealand Branch Annual Conference (pp. 307-308).

O'Kane Consultants (NZ) Limited, 2015. Escarpment Mine - Improved waste rock geochemistry classification. Technical Memorandum (895/13) to Bathurst Resources Limited. Dated 18 September 2015.

Kaplan, I.R. et al., 1963. The distribution and isotopic abundance of sulphur in recent marine sediments off southern California. Geochimica et Cosmochimica Acta, Volume 27, Issue 4 (pp 297-312, IN1 313-331)

Berner, R. A, 1970. Sedimentary Pyrite Formation. American Journal of Science Volume 268, (pp 1-23)

Berner, R. A, 1983. Sedimentary Pyrite Formation: An update. Geochimica et Cosmochimica Acta, Volume 48, Issue 4 (pp 605-615)

ATTACHMENT E: MOUNT FREDERICK SOUTH OVERBURDEN QUANTITIES

[redacted]

Memo

To: [redacted] Mine Waste Management

From: [redacted], Bathurst Resources Limited

cc: [redacted]

Date: 03 March 2025

Re: MFS ABA Block Model - Buller Plateaux Continuation Project

---

1 Executive Summary

This memo provides:

- An overview of the spatial coverage of Acid Base Accounting (ABA) data across the Mt Fred South (MFS) ABA 3D Block Model area.
- A summary of the stratigraphic and geological domains identified.
- A breakdown of how the ABA block model is constructed and ABA parameters estimated.
- A summary of the ABA classification process for overburden materials and confidence in that classification within the MFS pit design.
- Recommendations for further work to control and improve the effectiveness of the ABA model to predict acid and metalliferous drainage (AMD) source hazards.

2 Introduction

This memo provides a summary of the geochemical ABA Model for MFS. MFS forms part of the wider Buller Plateaux Continuation Project (BPCP) and is shown on Figure 1 below.

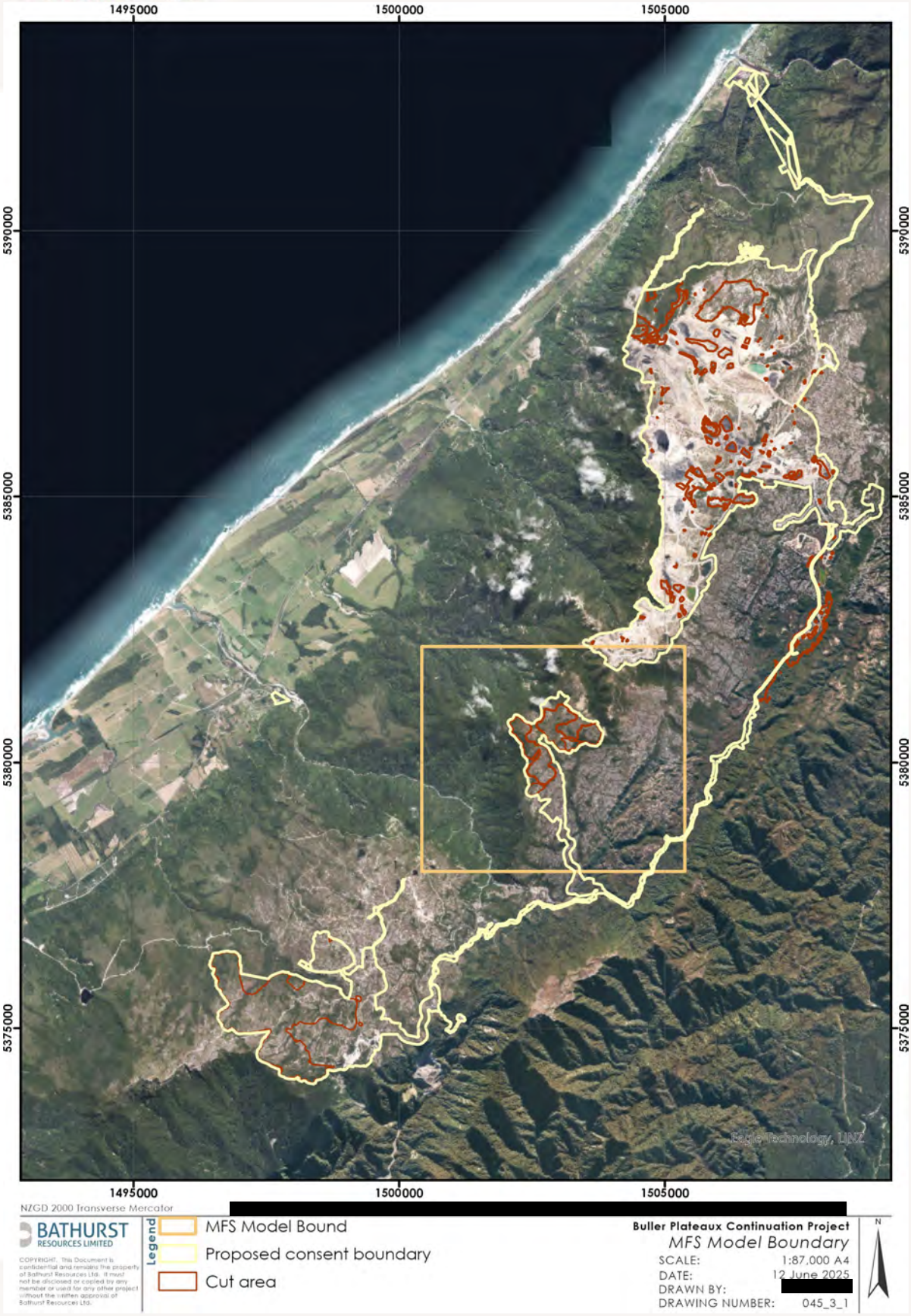


Figure 1. The MFS ABA 3D Block Model Boundary in relation to the Buller Plateaux Continuation Project

3 MFS ABA Dataset

The MFS ABA dataset is summarised and discussed in MWM (2025a). Further information is available in that report.

3.1 Spatial Distribution

Samples are distributed spatially across the project area and down hole.

ABA sampling process for the MFS area have sampled all drill core available from the drill hole. This results in high representativity of the overburden, and lower risk of bias and error than spot/selective sampling methods. Sampling recommendations were provided by MWM (2025a). Sampling was carried out to target a downhole sample length of 1-2 m or where changes to lithology dictate smaller or sometimes larger samples. Mean downhole thickness of samples is 1.56 m.

It is noted that, with particular regard to sulphur, the analysis results can be quite nuggety across and through the overburden sequence. The smaller the sample, the higher the variability of result.

The sample database population is relatively evenly spaced surrounding the MFS pit. The difference in spatial coverage of total sulphur vs Acid Neutralising Capacity (ANC) or Net Acid Generating (NAG) pH results is due to the analysing laboratory following the MFS process flow classification scheme when analysing a subset of ABA samples (MWM, 2025a). When total sulphur was enough to classify the sample then the remaining analysis was not carried out. Spatial distribution is shown in Figure 2 to Figure 4 below.

3.1.1 Total Sulphur Sample Distribution

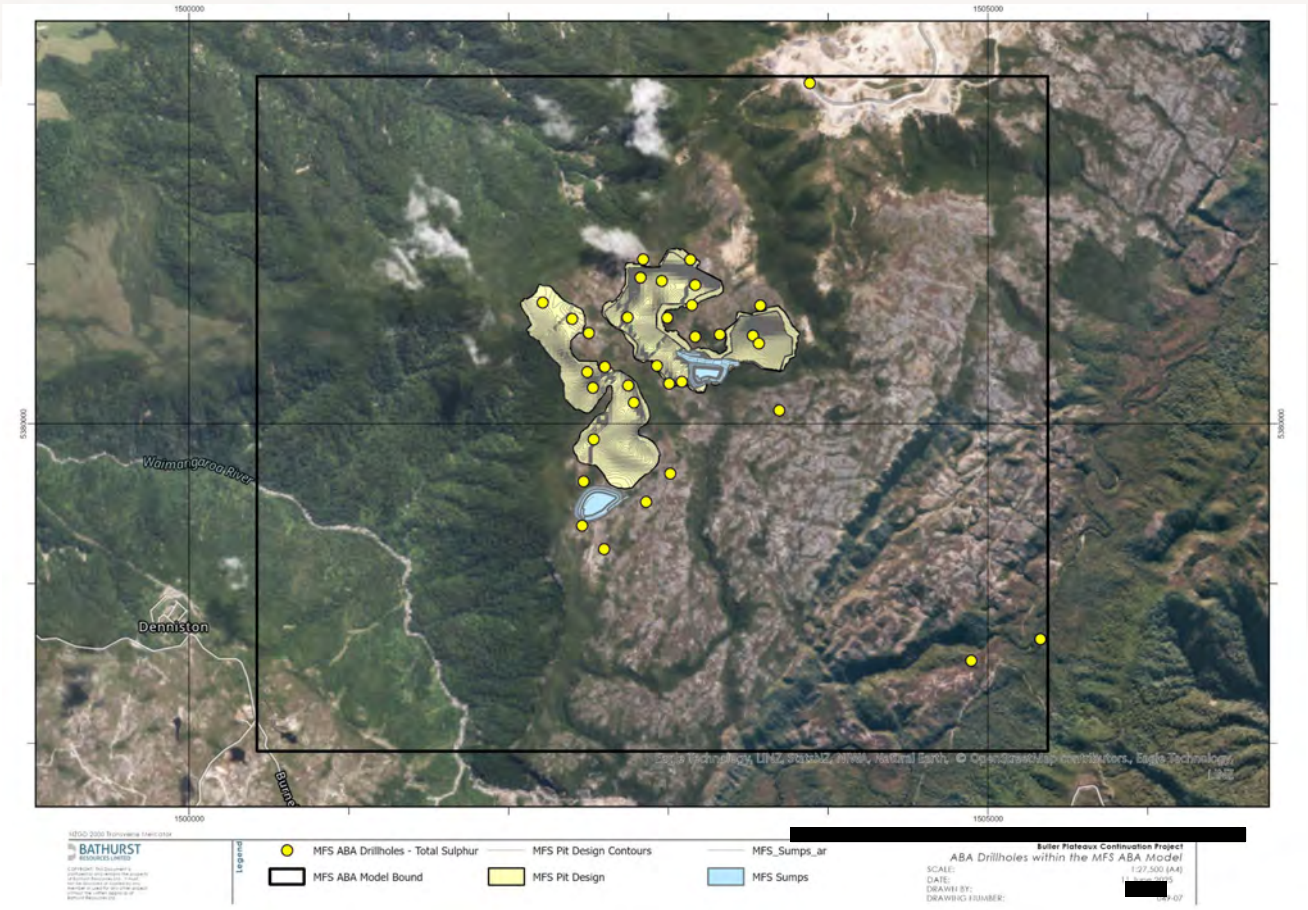


Figure 2. Sample spatial distribution for total sulphur results

3.1.2 ANC Sample Distribution

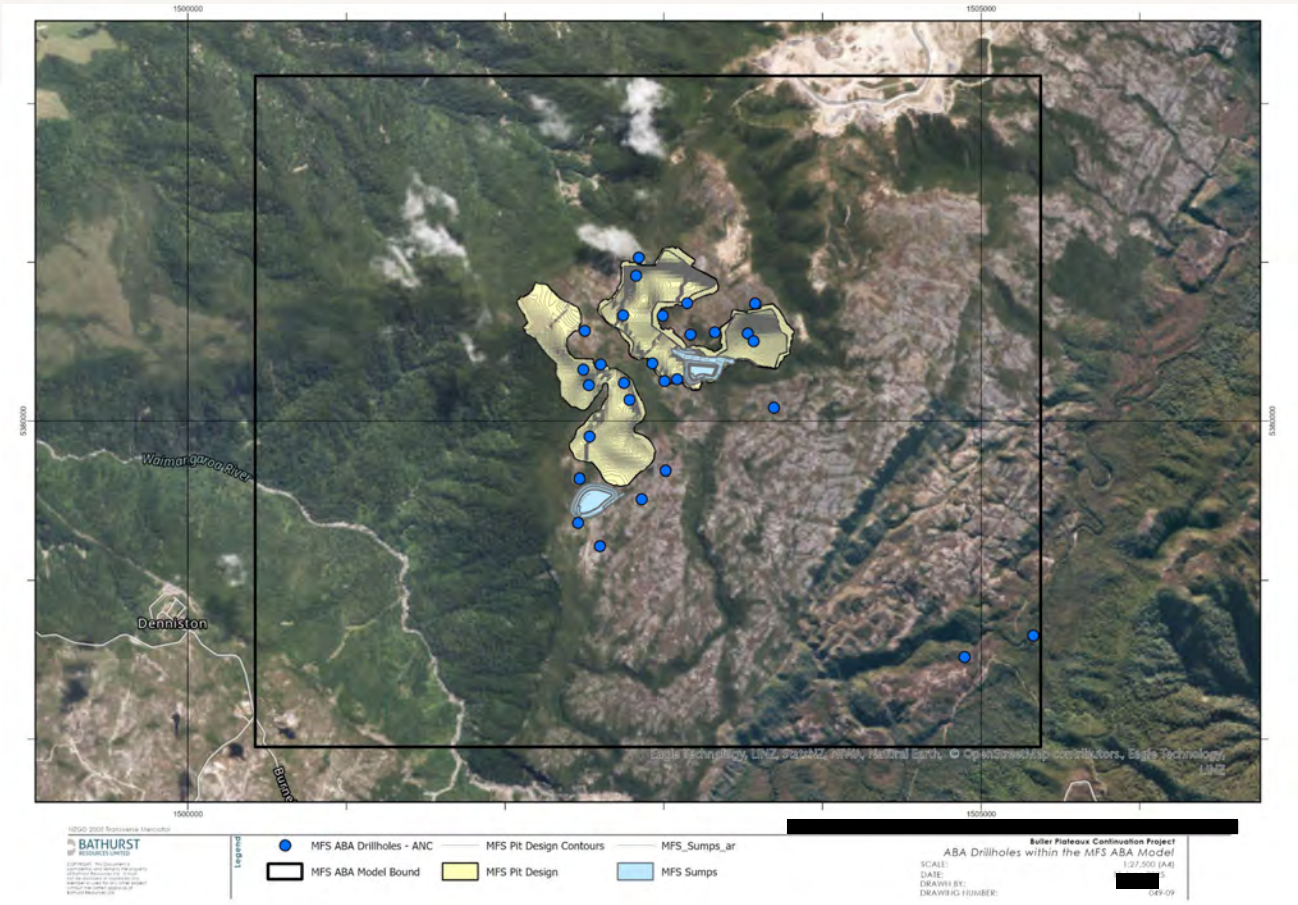


Figure 3. Sample spatial distribution for ANC results

3.1.3 NAG pH Sample Distribution

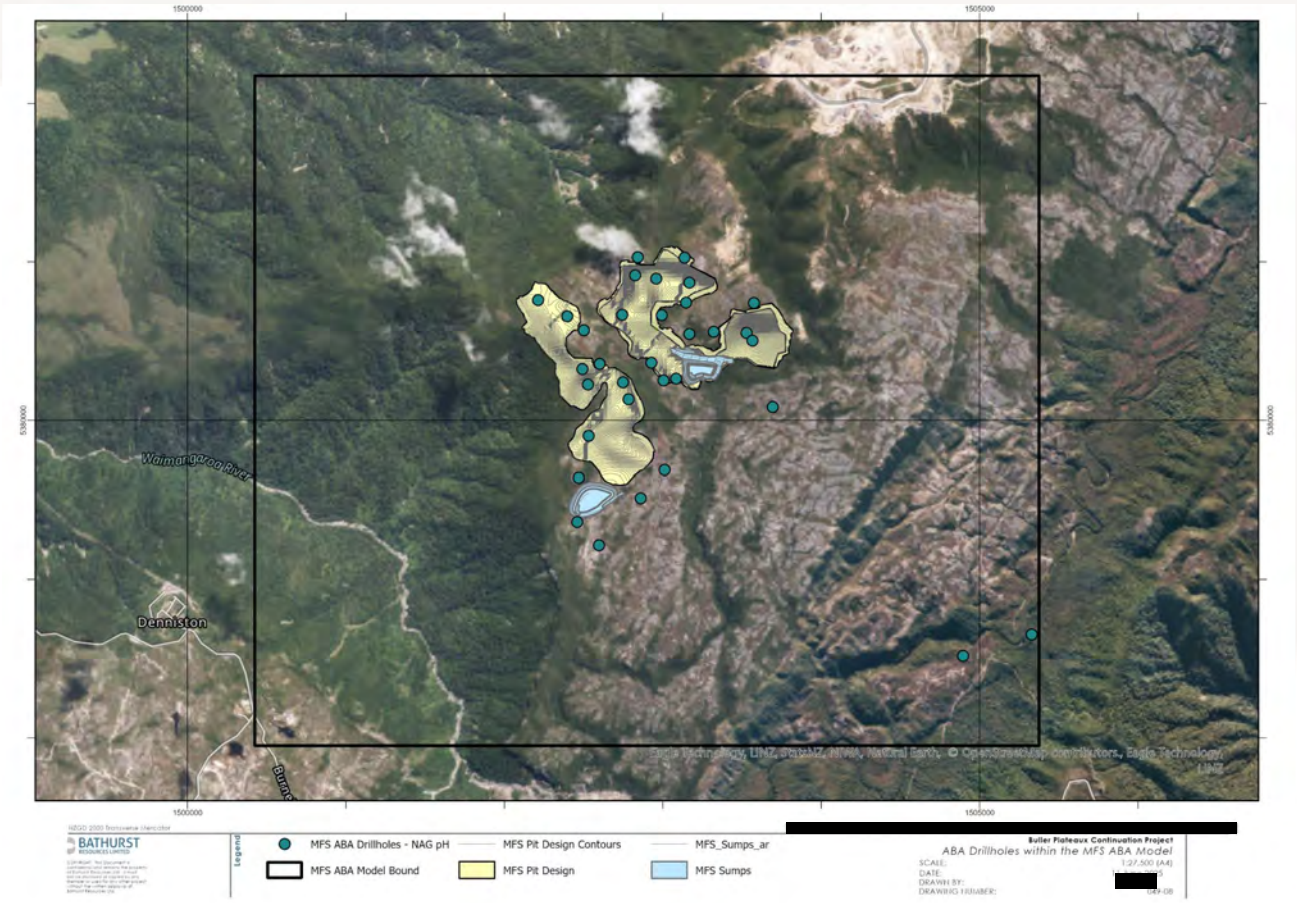


Figure 4. Sample spatial distribution for NAG pH results

4 ABA Classification

The MFS ABA Model uses a site-specific Process Flow Classification (PFC) scheme, which is summarised by MWM (2025a). Further information is available in that report. The PFC divides materials into:

- NAF – Non-acid forming
- LR – Low risk for acid generation
- PAF – Potentially acid forming
- HAF – High acid forming

5 MFS Stratigraphic Model

The geological model for the MFS Project area utilises stratigraphic modelling tools provided in Maptek Vulcan 3D software.

The stratigraphic sequence was deposited in layers that are well defined across the MFS Project area, and as with most stratigraphic deposits, relational features of the rock mass are more related on a horizontal horizon than through the sequence (down hole).

This predominately horizontal relationship within the overburden enables the structure of the coal resources model to be utilized for ABA characterisation of the overburden materials.

The major drivers of ABA classification are sulphur and ANC.

The ANC content of the rock is a function of the minerals within the sedimentary rocks of the overburden. Therefore, estimation of ANC of the rock mass can utilise stratigraphic domaining to select sample results during grade estimation. Secondary carbonate mineralisation is not prevalent at the MFS Project area within the Brunner Coal Measures (BCM).

Metal sulfide precipitation can occur during several stages of diagenesis and burial of sedimentary rocks. Total sulphur content of a siliciclastic sedimentary rock at the BPCP can be primarily attributed to sedimentary controls. During early stages of diagenesis, anaerobic sulphate-reducing bacteria consume organic carbon and sulphate and produce hydrogen sulfide and bicarbonate. Pyrite (FeS_2) is formed by the reaction of this biogenic sulfide with reactive, detrital iron-bearing minerals near the sediment–water interface (Kaplan et al., 1963; Berner, 1970, 1984). Secondary sulphur mineralisation processes predominantly require fluid flow through the host rock with porosity and connectivity of the formation driven by primary sedimentary processes. Therefore, using stratigraphic domains for sulphur estimation is acceptable for the project area. Fault derived fluid flow and subsequent sulphur deposition has not shown to be prevalent at the BPCP project.

Due to this depositional controlled relationship, different layers within the stratigraphic deposit can be used to domain datasets and control estimation of the rock mass from the ABA datasets. Five domains have been used as described 6.3.

6 Geostatistical Relationships

6.1 Sample Normalisation / Compositing

The ABA drillhole database is normalised into 1.0 m thick intervals using the Maptek Vulcan sample compositing tool. Normalised datasets are required to determine geostatistical and geospatial relationships between samples.

Compositing of sample sets for each analysis type is completed independently. This avoids issues relating to compositing null values where analysis is not completed for some samples (e.g., ANC or NAG pH data missing due to total sulphur values allowing classification using the PFC without the need to analyse additional parameters).

Log based parameters such as NAG pH and Paste pH have been converted to the hydrogen ion concentration [H^+] prior to sample compositing to allow the proton activity mean to be calculated when compositing samples. The use of log values would create significant bias, and this is avoided by using concentration.

6.2 Sample Domaining

During sample compositing, samples have been domained into their respective stratigraphic domain (where in the stratigraphic sequence that sample lies).

6.3 Stratigraphic Domaining

6.3.1 Basement

Basement rocks throughout the project area are predominantly Greenland Group metasediments (GG), ranging from low rank greenschist facies up to highly metamorphic gneiss. Other rock types within the basement formation are fine-grained quartz porphyry rocks from the intrusive Berlins Quartz Porphyry formation (BQP). This formation does not exhibit the strong stratigraphic relationships as the overlying sedimentary sequences above and therefore search ellipses used in grade estimations have been set as spherical rather than elliptical.

A paleo weathering profile has been observed within the basement lithologies, with some elevated sulphur concentrations also observed near the contact with the overlying BCM.

6.3.2 Basal Brunner Coal Measures

Basal BCM are characterised by coarse grits and conglomerates. Basal grits and conglomerates are a distinct layer modelled above basement within the MFS stratigraphic model. The Basal domain for the purposes of the ABA model covers the Basal stratigraphic unit plus the coal measure rocks lying above the Basal conglomerates and below the floor of the first coal seam (M1).

6.3.3 Interburden Rocks within Main Coal Seam (M1-M2)

This is a generally a very thin or non-existent domain that consists of any non-coal material present as partings within the main coal bearing M1 and M2 seams, which usually make up one single seam but in some areas of the deposit, the parting between the upper and lower split can reach above 10 m thick.

6.3.4 Overburden Rocks (M2 -M3)

This domain consists of all overburden rocks between the main coal seam (M1-M2) and first rider seam (M3). This domain is the largest domain by volume within the MFS pit design.

6.3.5 Overburden Rocks (above M3 seam)

This domain consists of all overburden rocks above the M3 rider seam.

Of note, the Kaiata Formation (KMS), a marine mudstone unit that conformably overlies the BCM is located in the southeast corner of the MFS ABA 3D Block Model area but well outside of the MFS project footprint. The stratigraphic model used to build the MFS ABA and coal block models does not differentiate the KMS from the upper portions of the BCM, and the stratigraphic sequence is poorly modelled in this area. The ABA characteristics of the KMS are significantly different to that of the BCM. ABA results from the KMS should be excluded from estimation of BCM blocks in future models, and this unit should be modelled separately using an appropriate classification such as the classification system proposed for the KMS (McLachlan, 2022) that is used at the Cypress Mine.

6.3.6 Coal Seams

Coal seams are retained within the ABA model but are excluded from the ABA classification and estimation process due to the expectation that coal would be extracted and removed and not represent an AMD source hazard. Coal Composite analysis data for MFS coal shows that sulphur contained within coal seams

is predominately organic sulfur (i.e., non-acid forming) and does not represent a large source hazard for acid generation. Figure 5 provides the distribution of sulfur between organic, sulfide, and sulfate sulfur forms for coal composite results. Table 1 provides the mean and median proportions of each form of sulfur.

Coal will be transported to Stockton for processing and sold off site. Rejects from washing contaminated coal will be disposed at Stockton Coal Mine and are expected to be made up of BCM contamination from material collapsed into historic workings. Coal lost to waste during mining and extraction such as during roof or floor preparation are negligible when compared to total overburden volumes.

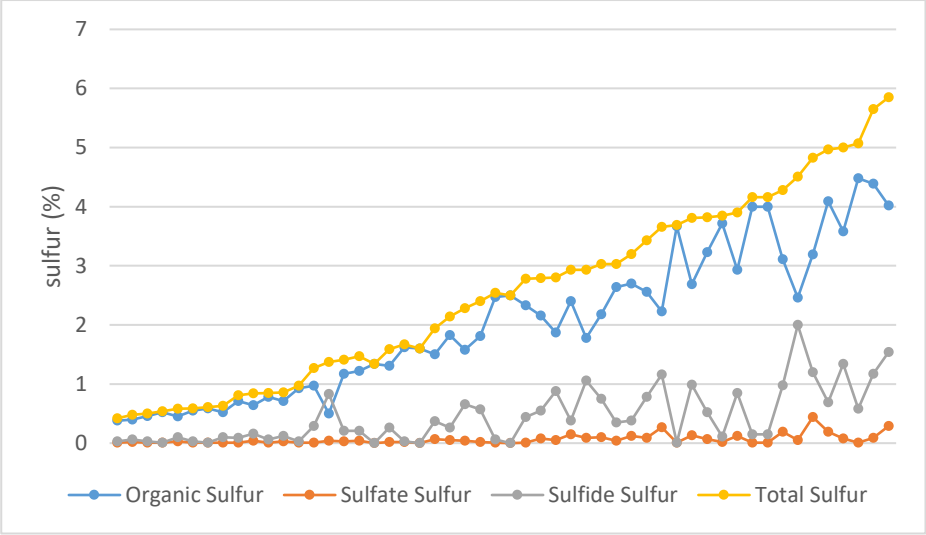


Figure 5. Forms of sulfur from coal composite analysis at MFS.

Table 1. Summary forms of sulfur data from 52 coal composite analysis carried out at MFS.

	Organic Sulfur	Sulfate Sulfur	Sulfide Sulfur
Mean	79%	3%	18%
Median	85%	2%	13%

6.4 Fault Block Domaining

No fault domaining has been utilised within the MFS ABA Block Model. Although the area is crossed by numerous faults, some with significant offsets, it has been assumed that horizontal movement along these faults is minimal and that ABA properties of the rock mass are comparable and extend across these fault zones. Unfolding techniques are used during grade estimation, which takes into account the vertical offset across these fault zones (see Section 8).

6.5 Sample Summary by Domain

ABA sample data is summarised and presented in Table 2 to Table 4 below. Both a numeric mean and a length weighted mean of the samples are provided, however only length weighted means are used in the modelling process. pH values have been converted to hydrogen ion concentration [H^+] before calculating the length weighted proton activity mean.

Table 2. Total sulphur data for MFS

Stratigraphic Domain	Sul_T sample mean (%)	Length (m)	Sul_T weighted average (%)
m3_ob	0.075	142.0	**0.068**
m_ob	0.143	393.5	**0.137**
m_ib	0.250	136.1	**0.253**
basal	0.198	164.8	**0.197**
base	0.485	172.7	**0.499**

Table 3. NAG pH Data for MFS

Stratigraphic Domain	NAG pH arithmetic mean	Length (m)	NAG pH weighted arithmetic mean	[H^+]	NAG pH weighted average – based on [H^+]
m3_ob	5.6	90.3	5.6	0.0000334	**4.5**
m_ob	5.3	317.3	5.3	0.0000804	**4.1**
m_ib	4.8	136.1	4.8	0.0001428	**3.8**
basal	5.4	164.8	5.4	0.0000800	**4.1**
base	4.8	162.3	4.8	0.0002483	**3.6**

Table 4. ANC data for MFS

Stratigraphic Domain	ANC sample mean (kg H_2SO_4/t)	Length (m)	ANC weighted average (kg H_2SO_4/t)
m3_ob	1.4	71.3	**1.4**
m_ob	1.2	289.5	**1.2**
m_ib	1.6	123.9	**1.7**
basal	1.6	160.5	**1.4**
base	4.2	155.09	**4.3**

6.6 Geostatistics

No geostatistical analysis has been completed on the MFS dataset to date. It has been assumed the geostatistical relationships identified and reported for the Denniston ABA Block model in BRL (2025) hold true for the stratigraphic domains at MFS.

Further geostatistical investigation should be made on the MFS dataset to ensure this assumption is suitable, and if not, update the search criteria for grade estimation of blocks within each stratigraphic domain.

7 MFS ABA Block Model

The MFS ABA Block Model has been built using Maptek Vulcan's regularise tri-blocking functions from the MFS Coal Resource model to apply sub-blocks to overburden, interburden, and basement blocks. Coal blocks are retained. The resultant model is structurally identical to the Coal Resource Model, however the data carried by each block is not retained, with a new set of variables applied to capture the ABA specific datasets.

The latest MFS ABA model is named ***mfs_2024_reso_v7_aba250212.bmf.*** Blocks are 25 m x 25 m and minimum block height of 0.5 m. Maximum block heights are:

- 0.5 m for coal blocks
- a maximum of 2.0 m for interburden and overburden
- a maximum block height for basal coal measures and basement of 2.0 m

2.0 m maximum thickness of interburden and overburden materials aligns with mining bench depth at MFS and the average sample thickness within the dataset. 34 variables are carried through the model for each block. These variables are listed below in Table 5.

Table 5, MFS ABA Block Model List of Variables

Variables	Default	Type	Description
weath_zone	def	name	zone of surface weathering
seam	def	name	seam code
fault	nothing	name	fault block
sgroup	def	name	seam modelled below 50% for estimation
sdomain	def	name	Parent seams
estimation	def	name	estimated or calculated (assigned) value
permit	def	name	Crown minerals permit or licence
density_ps	-99	float	Apparent relative density insitu (after preston saunders)
original_t	-99	float	Original Tonnes in ground before any mining
s_d_sult	-99	integer	sample distance - total sulphur
n_p_sult	-99	integer	current pass number - total sulphur
n_s_sult	-99	integer	number of samples used in estimate - total sulphur
n_h_sult	-99	integer	number of holes used in the estimate - total sulphur
s_d_anc	-99	integer	sample distance - anc
n_p_anc	-99	integer	current pass number - anc
n_s_anc	-99	integer	number of samples used in estimate - anc
n_h_anc	-99	integer	number of holes used in the estimate - anc
s_d_nagph	-99	integer	sample distance - nagph
n_p_nagph	-99	integer	current pass number - nagph
n_s_nagph	-99	integer	number of samples used in estimate - nagph
n_h_nagph	-99	integer	number of holes used in the estimate - nagph

Variables	Default	Type	Description
s_d_pstph	-99	integer	sample distance - pasteph
n_p_pstph	-99	integer	current pass number - pasteph
n_s_pstph	-99	integer	number of samples used in estimate - pasteph
n_h_pstph	-99	integer	number of holes used in the estimate - pasteph
aba_anc	-99	float	Acid Neutralizing capacity (kg H2S04)
aba_nagph	-99	float	net acid generating PH.
aba_nagph_l	-99	double	net acid generating PH (inverse log10 used for grade estimation).
aba_pstph	-99	float	paste PH. required for original classification
aba_pstph_l	-99	double	paste PH (inverse log10 used for grade estimation).
aba_sul_t	-99	float	Total sulphur from ABA data.
aba_class_n	def	name	Classification using BRL site specific PFC
aba_class_d	def	name	Old classification using scheme as described in original ESC AMD management plan (flawed)
aba_confidence	-99	integer	indication of confidence in the classification (based on underlying estimation of parameters driving it). 202411

This version of the model does not provide for a weathering profile within the rock mass and all samples are grade estimated assuming no weathering effects (beyond those inherent within the ABA samples).

There is a clear paleo weathering profile exhibited in basement rocks underlying the contact with the BCM. Samples taken from within this zone show generally higher total sulphur values than unweathered samples taken from deeper down hole. Due to very limited sample spacing from unweathered basement rocks, this model has not separated the weathered and unweathered zones during grade estimation processes, with all basement blocks estimated using the same search ellipse settings.

8 ABA Grade estimation

ABA variables are grade estimated from the composited database separately for each parameter and for each domain.

Sedimentary domains (domains other than the Basement domain) are grade estimation utilising Maptek Vulcans unfolding projection process. This process utilises a top and bottom surface (tetra) to unfold/normalise the stratigraphic trend to allow grade estimation using a search ellipse with a variable minor axis (the minor axis is set as a proportion of the thickness of the tetra. This method allows the sample selection and sample weighting used to grade estimate a block to apply higher weightings to samples that lie at the same vertical position within the horizon being estimated.

Log based parameters such as NAG pH have been converted to the hydrogen ion concentration [H^+] prior to sample compositing and grade estimation. The H^+ concentrations can then be averaged numerically to normalise the data and estimate blocks within the ABA model. After grade estimation, the H^+ concentrations are then converted back to pH using the formula pH = -log(H^+). Paste pH, and rinse pH have not been estimated for the MFS ABA model as these data are not used for classification purposes.

Search radius set for each parameter were determined by relative geostatistical relationships derived for the Escarpment project on the nearby Denniston Plateau in 2015 (BRL, 2025). Search distances have been limited to where distance exceeds those identified spatial relationship for each stratigraphic domain.

Maximum number of samples allowed for a single drill hole is set to 3 samples for every pass. Due to sample database being normalised into 1.0 m lengths, and maximum block heights set to 2.0 m, this may result in some smoothing of the downhole trends.

Table 6. Summary of grade estimation settings for total sulphur for each stratigraphic domain

Sul_t												
	Pass 1				Pass 2				Pass 3			
	search radius	minor axis (m, or ratio)	min # samples	max # samples	search radius	minor axis (m, or ratio)	min # samples	max # samples	search radius	minor axis (m, or ratio)	min # samples	max # samples
base	100 m	50 m	1	10	400 m	100 m	1	16	N/A	N/A	N/A	N/A
basal	100 m	0.2	1	12	500 m	0.5	1	16	N/A	N/A	N/A	N/A
m_ib	150 m	0.2	1	12	400 m	0.5	1	16	N/A	N/A	N/A	N/A
m_ob	150 m	0.25	1	12	400 m	0.25	1	16	950 m	0.5	1	16
m3_ob	150 m	0.2	1	12	300 m	0.5	1	16	N/A	N/A	N/A	N/A

Table 7. Summary of grade estimation settings for ANC for each stratigraphic domain

ANC												
	Pass 1				Pass 2				Pass 3			
	search radius	minor axis (m, or ratio)	min # samples	max # samples	search radius	minor axis (m, or ratio)	min # samples	max # samples	search radius	minor axis (m, or ratio)	min # samples	max # samples
base	100 m	50 m	1	10	400 m	100 m	1	16	N/A	N/A	N/A	N/A
basal	100 m	0.2	1	12	500 m	0.5	1	16	N/A	N/A	N/A	N/A
m_ib	150 m	0.2	1	12	400 m	0.5	1	16	N/A	N/A	N/A	N/A
m_ob	350 m	0.2	1	16	600 m	0.3	1	16	1200 m	0.5	1	20
m3_ob	150 m	0.15	1	12	400 m	0.25	1	16	950 m	0.5	1	20

Table 8. Summary of grade estimation settings for NAG pH for each stratigraphic domain

NAG pH												
	Pass 1				Pass 2				Pass 3			
	search radius	minor axis (m, or ratio)	min # samples	max # samples	search radius	minor axis	min # samples	max # samples	search radius	minor axis (m, or ratio)	min # samples	max # samples
base	100 m	50 m	1	10	400 m	100 m	1	16	N/A	N/A	N/A	N/A
basal	100 m	0.2	1	12	500 m	0.5	1	16	N/A	N/A	N/A	N/A
m_ib	150 m	0.2	1	12	400 m	0.5	1	16	N/A	N/A	N/A	N/A
m_ob	300 m	0.15	1	16	750 m	0.5	1	20	N/A	N/A	N/A	N/A
m3_ob	150 m	0.2	1	12	300 m	0.5	1	16	N/A	N/A	N/A	N/A

8.1 Confidence in the ABA Estimation

The MFS ABA model includes a confidence field (aba_confidence). This is assigned via a script after grade estimation is completed.

The confidence parameter is an integer from 1 – 9 and should be used as a qualitative measure to indicate the reliability of the overall ABA classification depending on the underlying reliability of the input parameters used to classify the block.

The ABA data is grade estimated in multiple passes for each parameter depending on the geostatistical relationships for each parameter/domain. The pass number is tracked in block variables for each parameter.

If a parameter was not grade estimated (no sample near enough to the block being estimated) the pass number is set to 7 and the parameters are assigned to default values derived from the length weighted sample averages for that stratigraphic domain/fault block (see section 6.5).

The confidence is calculated by multiplying the 'pass numbers' for each parameter used in the classification. The resultant multiple is clipped to a maximum of 7. For any parameter that has pass number equal to 7, 1 is added to the confidence (hence, the minimum confidence level for a block that has one parameter as default is 8).

The MFS PFC only requires total sulphur and NAG pH parameters, with no requirement to include ANC or NAPP in determining the classification. This simplifies the confidence qualification relative to the Denniston PFC.

Table 9. Summary of how the ABA Confidence variable is determined from search pass number for the MFS ABA model.

Estimation Pass Number			
Sul_t	NAGpH	multiplied	ABA Confidence
1	1	1	1
1	2	2	2
1	3	3	3
2	1	2	2
2	2	4	4
2	3	6	6
3	1	3	3
3	2	6	6
3	3	9	7
default=7	x	>=7	8
x	**default=7**	>=7	8
default=7	**default=7**	>=7	9

Note. If only one parameter is used in the classification (eg Sul_t > 0.7 and Class = HAF) then confidence is set to the pass number of that parameter. If only two parameters are used in the classification the confidence is set by multiplying only those two pass numbers together.

Figure 18 shows the relative confidence in the PFC for the MFS Pit Design. Approximately 76% of the blocks have been classified with ABA parameters estimated in the first pass during grade estimation (confidence value of 1). Only 1% of blocks are classified with at least one parameter that is used to classify the block following the MFS PFC being too far away from the nearest sample to be estimated and hence default values for that stratigraphic domain being used (confidence values of 8 or 9). Infill data collection should be undertaken to improve confidence in the classification of these blocks prior to mining.

9 Source Hazard – Constituents of Potential Concern

Detailed geochemical analysis of overburden materials has been undertaken at MFS where the pulp retention samples from 472 ABA samples were scanned using portable X-ray Fluorescence (pXRF) to understand metal concentrations in the project materials.

Gazley and Fisher (2014) provide a review of the reliability of pXRF data. For MFS it was assumed that the pXRF data is reliable to identify relatively elevated concentrations in marker horizons of geological domains.

A total of 453 ABA samples from 23 drill holes at MFS were scanned by RSC Consulting Limited (RSC) by pXRF. The following sample preparations were used.

- Pulp split
- Pressed into tabs
- Scanned with average reported
- 3 Beam scan, Instrument # 846836
- 22 duplicates (one for each hole)
- Data not corrected to known standards
- Element suite provided includes

As (ppm)	Ba (ppm)	Ca (ppm)	Ce (ppm)	Co (ppm)	Cr (ppm)	Cu (ppm)	Fe (ppm)	K (ppm)
Mg (ppm)	Mn (ppm)	Mo (ppm)	Nb (ppm)	Ni (ppm)	P (ppm)	Pb (ppm)	Rb (ppm)	S (ppm)
Sb (ppm)	Si (ppm)	Sr (ppm)	Th (ppm)	Ti (ppm)	V (ppm)	Y (ppm)	Zn (ppm)	Zr (ppm)

A total of 19 samples from one drill hole were scanned by BT utilising their own pXRF. The following sample preparations were used

- Pulp split
- 7 to 10 mm layer into a Petrie dish
- Scanned using 4 scans (2 initially, plus 2 after tipping dish into other half) with average reported
- 2 Beam scan, Instrument # 805869
- 5 Standards scanned before and after samples analysed, blanks scanned before, during and after
- 10 second scans
- Data not corrected
- Element suite provided includes:

Al (ppm)	Si (ppm)	P (ppm)	S (ppm)	K (ppm)	Ca (ppm)	Ti (ppm)	V (ppm)	Cr (ppm)
Mn (ppm)	Fe (ppm)	Co (ppm)	Ni (ppm)	Cu (ppm)	Zn (ppm)	As (ppm)	Se (ppm)	Rb (ppm)

Sr (ppm)	Y (ppm)	Zr (ppm)	Nb (ppm)	Mo (ppm)	Ag (ppm)	Cd (ppm)	Sn (ppm)	Sb (ppm)
Ba (ppm)	W (ppm)	Hg (ppm)	Pb (ppm)	Bi (ppm)	Th (ppm)	U (ppm)		

A comparison of the sulfur data provided from the pXRF data vs the total sulfur determined by LECO method obtained from the ABA analysis is shown in Figure 6 below. The relationship indicates that pXRF sulfur concentrations provide a good representation of total sulfur however the resultant concentrations are ~ 10-15% lower than the LECO ABA analysis method.

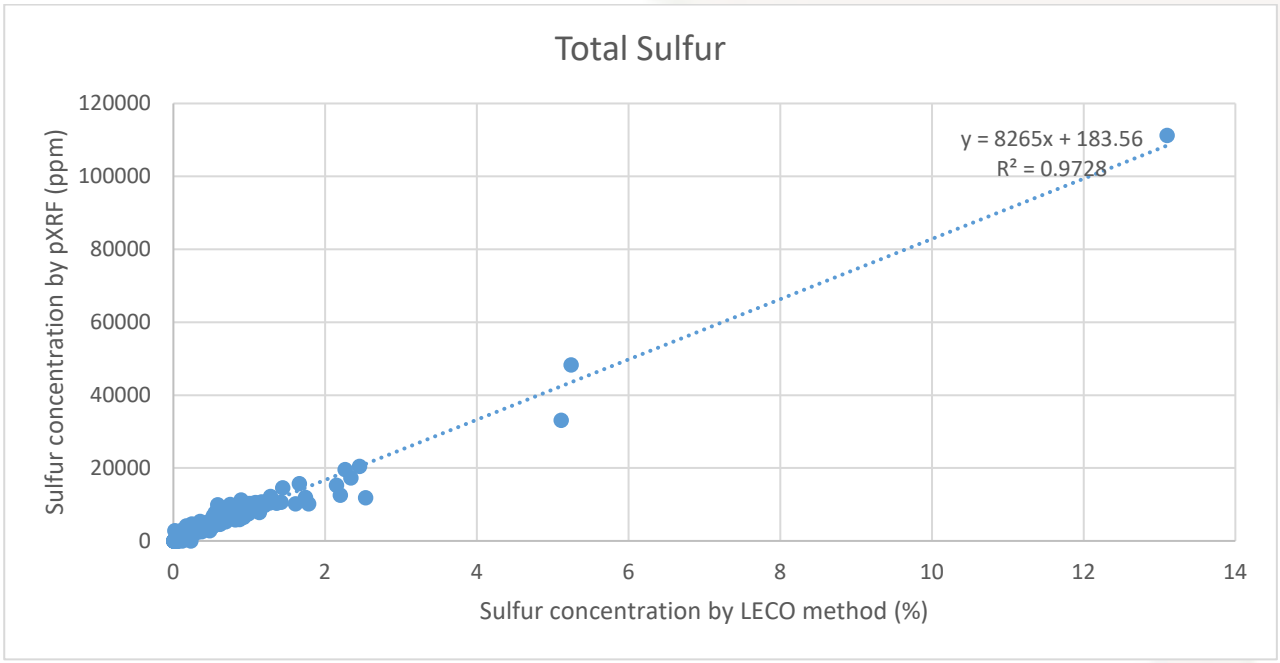


Figure 6. Comparison of sulfur concentrations analysed by the LECO method (SGS) vs pXRF analysis.

ABA Sample pulps scanned using pXRF were taken from 24 drill holes across the MRS area and are spatially distributed as shown in Figure 7 below.

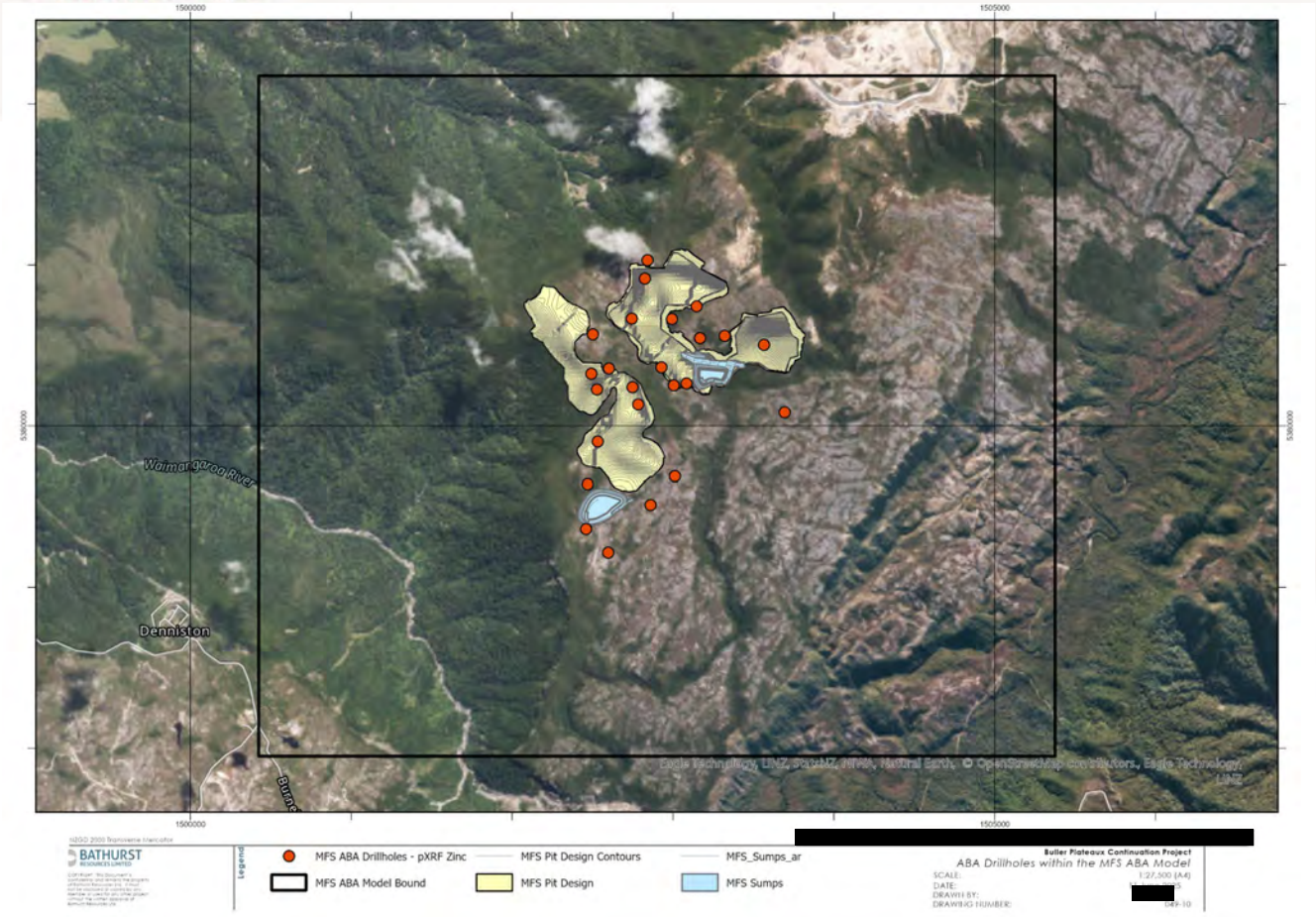


Figure 7. Plan showing drill hole locations with pXRF data.

Constituents of potential concern (COPC) for the MFS project were identified by MWM (2025c) as Al, Cu, Ni, and Zn. The pXRF data has been graphed by lithology type where lithologies are ordered by increasing grainsize for BCM materials (Figure 8 to Figure 12). Basement samples are provided in the 3 columns on the right for each figure and have been coded as argillite, greywacke, or Greenland Group. Cu, Ni, and Zn all show a clear increase in concentration in basement samples, and a similar trend of lower concentrations in fine and very coarse grain sizes, with moderate concentrations in midrange grainsized lithologies. Due to Al being a common element in rock building minerals such as feldspar and some clays it is difficult to determine source hazard from total element concentrations alone without further analysis on leachability of Al such as SPLP analysis. Further analysis of Al concentrations have not been investigated.

Note where pXRF analysis did not detect an element these are considered zero values in these graphs.

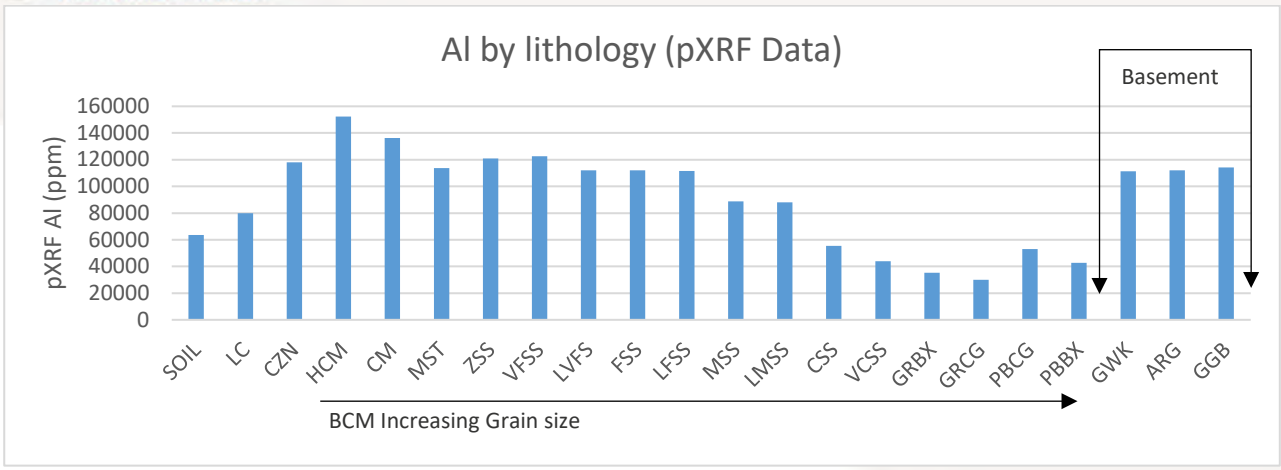


Figure 8. Aluminium concentration by logged sample lithology.

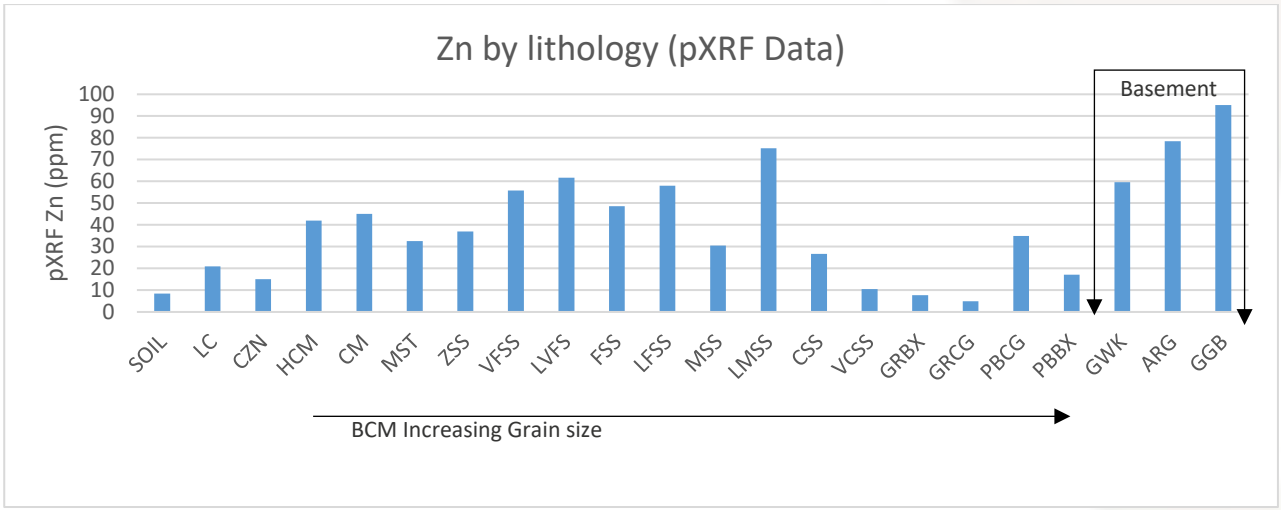


Figure 9. Zinc concentration by logged sample lithology.

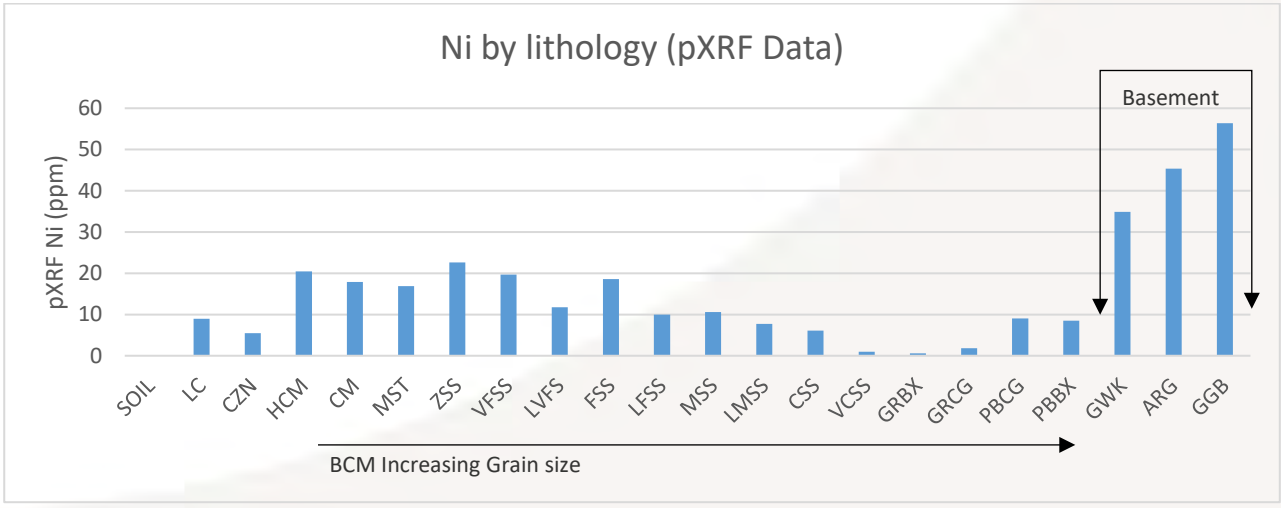


Figure 10. Nickel concentration by logged sample lithology.

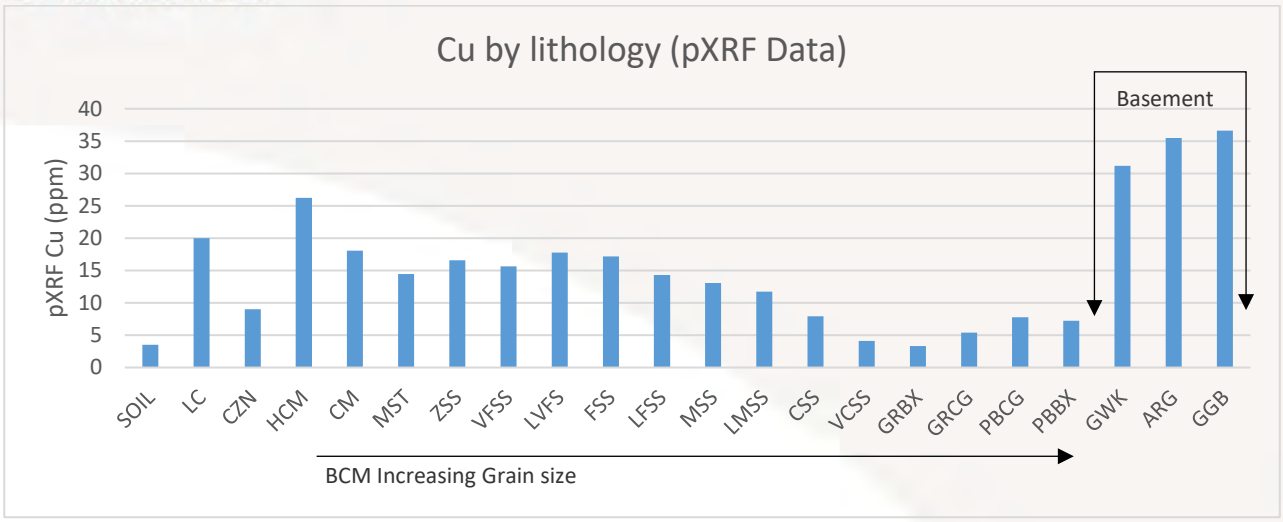


Figure 11. Copper concentration by logged sample lithology.

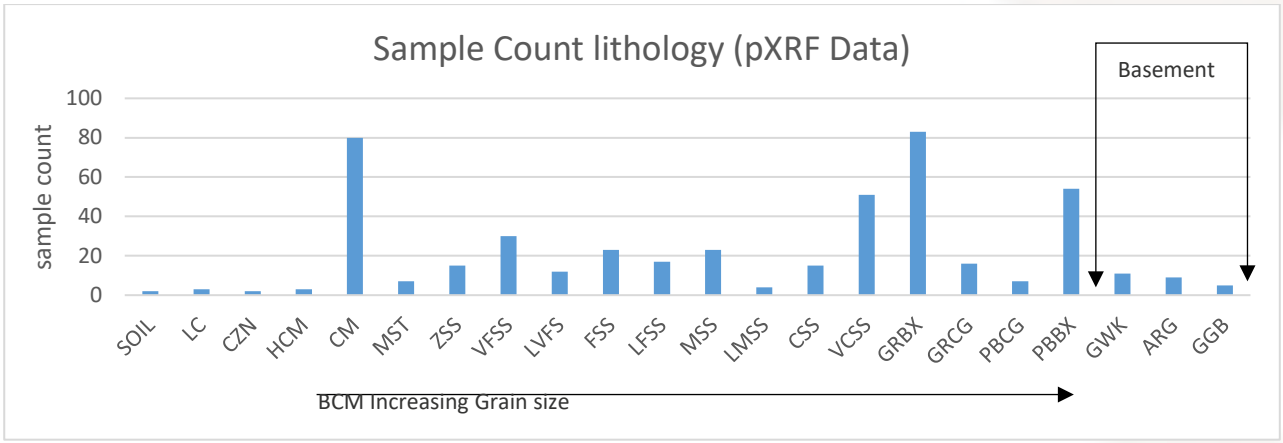


Figure 12. Sample counts for each lithology for pXRF analysis.

pXRF data is summarised and presented in Table 10. Results from stratigraphic domaining of the data provides the following mean and length weighted mean concentrations for each domain. As indicated in Figure 8 to Figure 12, basement lithologies show higher average concentrations of COPC's in the domained data. Note, where pXRF data for an element was below the lower limit of quantification (LOQ), the lower limit was used to compute the average (LOQ were Cu=7 ppm, Ni=9 ppm, Zn=5 ppm).

Table 10. Average concentrations of COPC's Zn, Ni, and Cu from pXRF data.

Stratigraphic Domain	count	Zn (ppm) sample mean	Cu (ppm) sample mean	Ni (ppm) sample mean	Total sample Length (m)	Zn (ppm) weighted average	Cu (ppm) weighted average	Ni (ppm) weighted average
m3_ob	83	18	10	10	71	**16**	**10**	**10**
m_ob	307	18	10	10	289	**18**	**10**	**10**
m_ib	139	34	14	17	121	**35**	**14**	**17**
basal	179	29	13	18	161	**27**	**12**	**17**
base	95	55	25	31	82	**53**	**25**	**31**

Selected element concentrations from the pXRF data are grade estimated from the composited database simultaneously. Selected elements that are grade estimated into the ABA block model are Al, As, Ba, Ca, Cu, K, Mg, Mn, Mo, Ni, S, Si, Ti, Y, and Zr.

Table 11. Summary of grade estimation settings for pXRF data.

pXRF data												
	Pass 1				Pass 2				Pass 3			
	search radius	minor axis (m, or ratio)	min # samples	max # samples	search radius	minor axis (m, or ratio)	min # samples	max # samples	search radius	minor axis (m, or ratio)	min # samples	max # samples
base	50 m	25 m	1	10	100 m	50 m	1	16	N/A	N/A	N/A	N/A
basal	100 m	0.2	1	12	500 m	0.5	1	16	N/A	N/A	N/A	N/A
m_ib	150 m	0.2	1	12	400 m	0.5	1	16	N/A	N/A	N/A	N/A
m_ob	150 m	0.25	1	12	400 m	0.25	1	16	950 m	0.5	1	16
m3_ob	150 m	0.2	1	12	300 m	0.5	1	16	N/A	N/A	N/A	N/A

9.1 Discussion

The data indicates that basement lithologies represent the highest source hazard for the 3 COPC's investigated, particularly Zn, however generally basement lithologies are rarely mined as part of the mine plan with exception for the proposed water treatment sumps.

The bulk of the overburden to be moved lies in the M_ob and M3_ob stratigraphic domains. Generally, the HAF and PAF classified blocks also contain higher concentrations of COPC's, particularly Zn.

Table 12. ABA model outputs for the planned pit design showing Cu, Ni, and Zn concentrations by ABA classification for the M_ob and M3_ob stratigraphic domains.

M_ob	Cu mean (ppm)	Ni mean (ppm)	Zn mean (ppm)	Tonnes of rock
haf	12	12	34	566,361
paf	13	13	46	4,224,377
lowrisk	12	12	30	3,756,064
naf	12	11	24	16,835,327
	12	12	33	25,382,129

M3_ob				
haf	18	14	76	7,028
paf	10	11	24	330,564
lowrisk	8	7	16	656,469
naf	9	8	18	5,832,013
total	9	8	19	6,826,074

10 Results

The MFS ABA Block Model provides a robust estimate of ABA parameters and classification, assisting BRL to select, plan, and schedule overburden materials to manage and reduce potential AMD effects at the source. Figure 14 to Figure 16 show the results of the MFS ABA model displayed in plan and section.

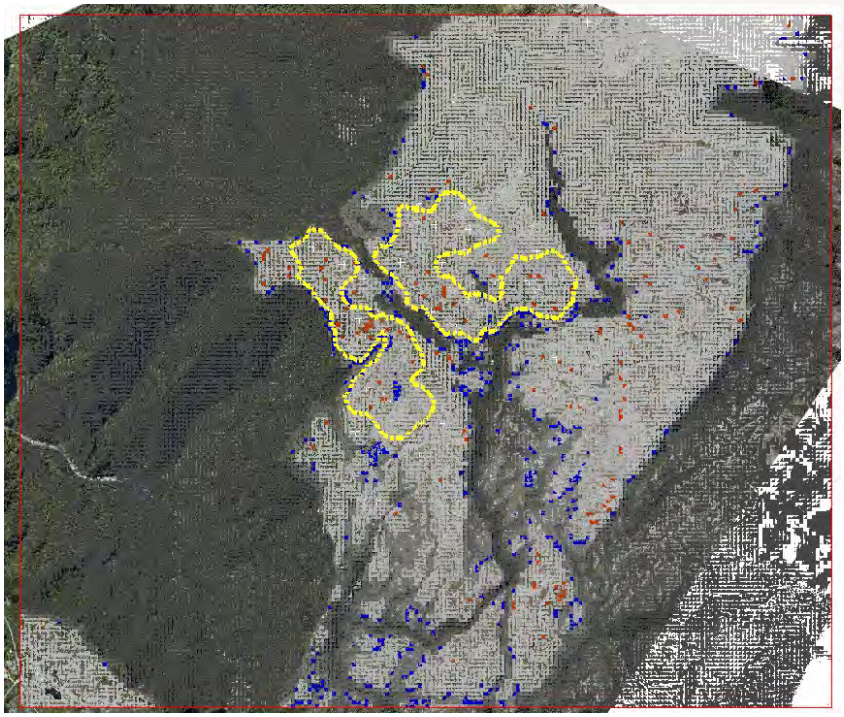


Figure 13. The MFS ABA model coloured by stratigraphic sequence (increasingly darker grey with depth, blue dots are M1/M2 outcrop, red dots are M3 outcrop). Pit Shell design shown in yellow. ABA drill holes shown (white '+').

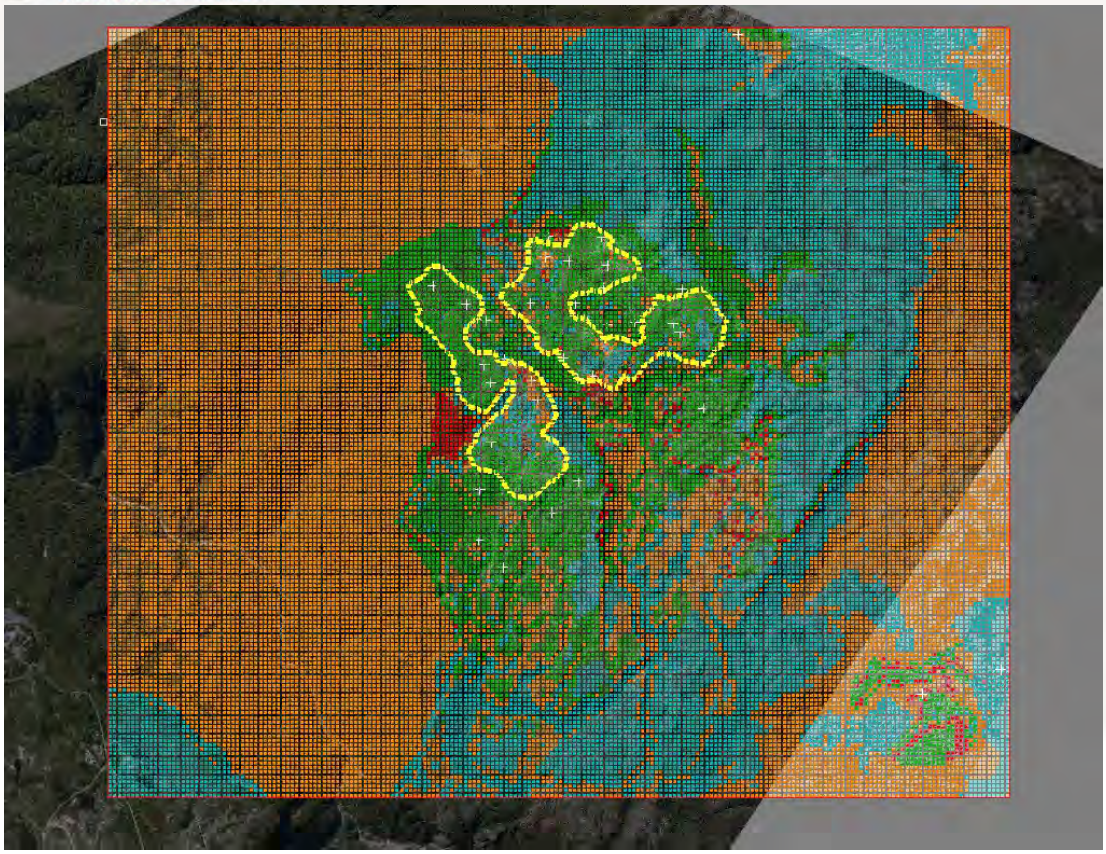
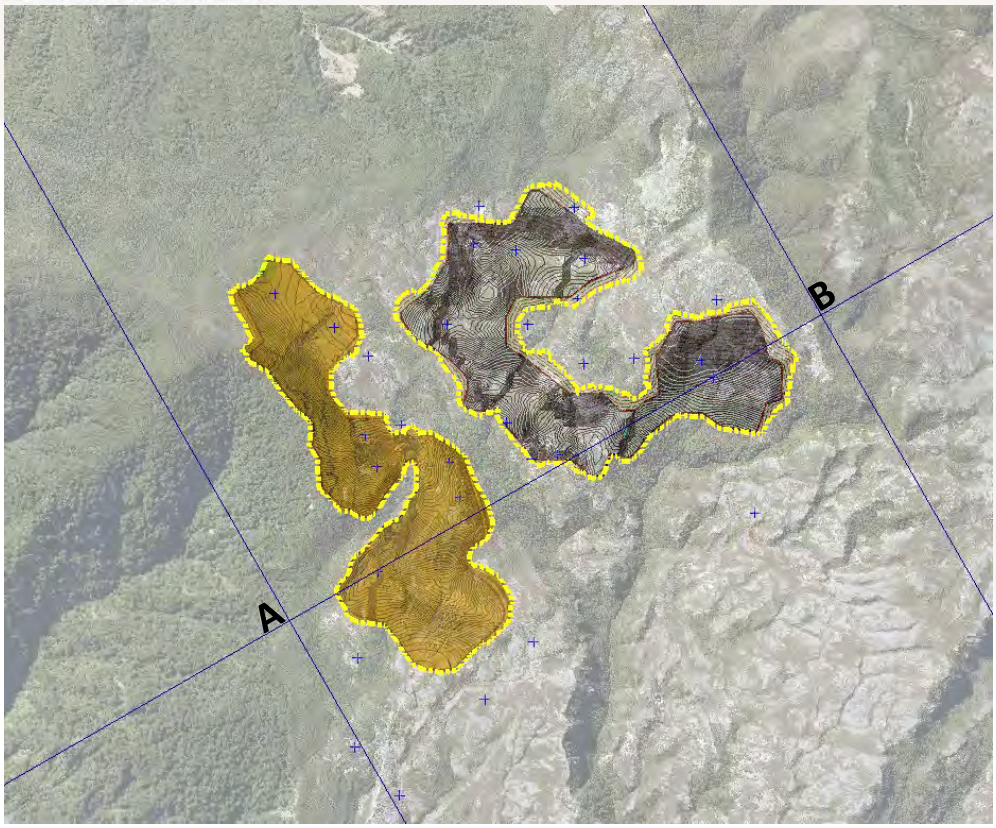


Figure 14. The MFS ABA Model coloured by the MFS PFC (only surface blocks shown: 0.5 m – 2.0 m below surface). Green = NAF, Cyan=Low Risk, Orange = PAF, Red = HAF. MFS Pit Shell design shown (dashed yellow).



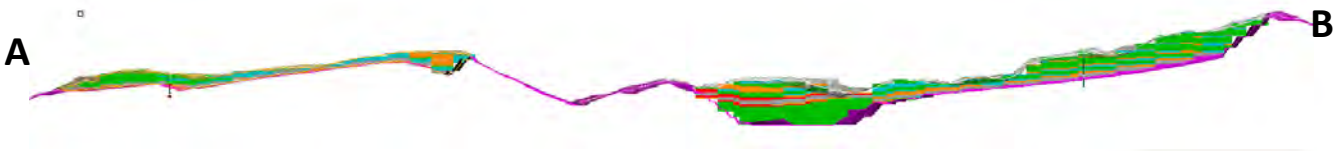


Figure 15. Cross-section view of the MFS ABA model coloured by MFS PFC (A-B shown on plan). Green = NAF, Cyan=Low Risk, Orange = PAF, Red = HAF, Grey = Coal. MFS Pit Design shown. Only blocks within the Pit Design and sumps are shown on the section.

The MFS ABA Block model enables reporting of the global ABA risk from within the MFS pit shell. Figure 17 below shows the relative tonnes of overburden rock expected from the MFS ultimate pit design used for the project. The block model can be used by reporting waste material classifications and ABA data by dividing up the pit shell design into small blocks for scheduling. Waste volumes and classification can therefore be provided from source to scheduled placement into engineered landforms (ELFs) to ensure higher risk PAF and HAF materials are segregated and stored within the core of the ELFs.

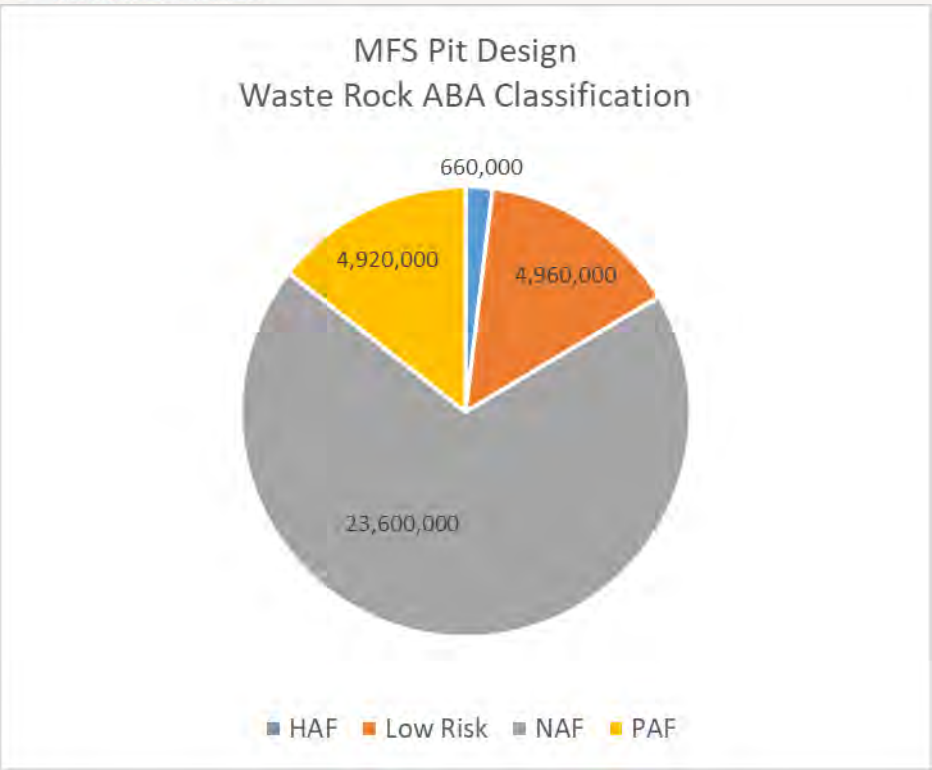


Figure 16. Relative tonnages of waste rock classified by the PFC. Labels show total rock tonnages.

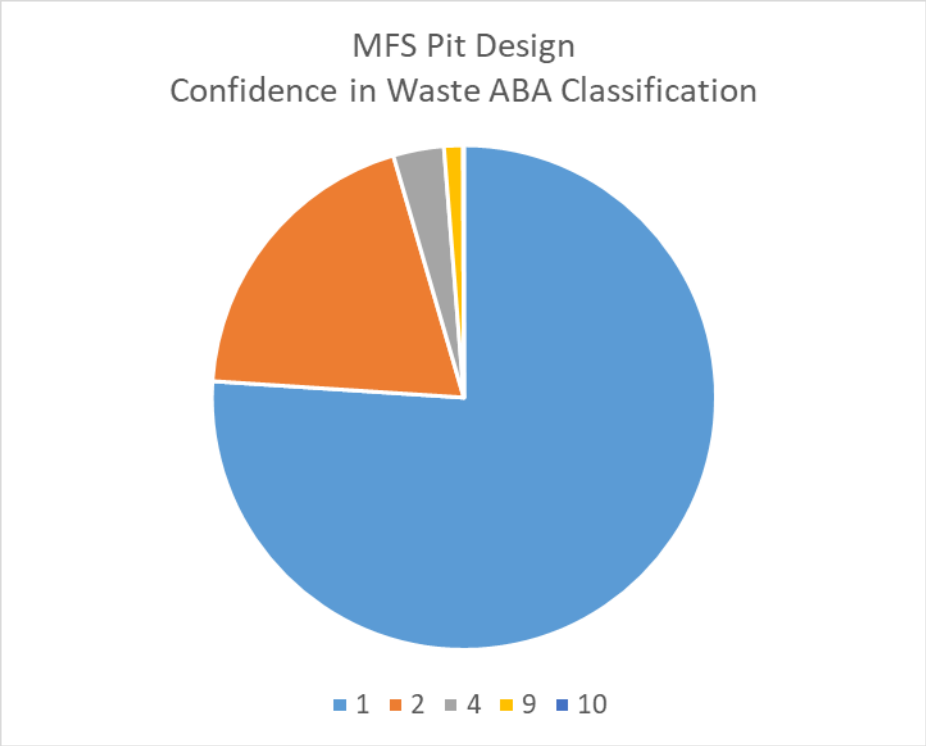


Figure 17. Confidence in the estimation of ABA parameters and subsequent ABA classification. The lower the confidence value, the higher the confidence with the classification.

11 Recommendations

Prior to mining beginning at MFS, it is recommended that further refinement of the ABA model is undertaken to improve structural interpretation and seam correlations to refine estimations of sedimentary/stratigraphic domains.

Further refinement of the Block Model and modelling processes is recommended at the next level of study including:

- Review and update structure model including fault model, and seam correlations.
- Reduce the block X and Y dimensions to increase resolution of the Block Model.
- Add Kaiata Mudstone to the stratigraphic sequence within the ABA Model and estimate separately using a suitable classification system such as the Cypress Mine classification system (McLachlan, 2022).
- Review and update geostatistical relationships between samples for each stratigraphic domain. Feed these into grade estimation search ellipse radii specifications.
- Review whether surface weathering profiles are prevalent and quantifiable in waste rock. Assess whether the addition of a surface weathering profile should be added to the model.
- Review whether a basement weathering profile is prevalent and quantifiable. Assess whether the addition of a basement weathering profile is required.
- Ensure that when further ABA analysis is undertaken, that a sampling specific process flow is used to ensure additional ANC and NAG pH data is available to be used in model estimation processes instead of using the PFC.

At commencement and during mining operations, further data acquisition and QA/QC[1] is recommended such as:

- Infill and step out drilling >12 months prior to mining at spacings that ensure grade estimation of blocks can be achieved.
- Full sampling of selected blast holes to compare ABA results against the existing Block Model, and then update the ABA Block Model. Spot sampling from field outcrop is not recommended due to representativeness issues.
- On going QA/QC including field duplicates, lab duplicates, repeats, standards and blanks to ensure laboratory data are reliable. Further discussion on QA/QC is provided by MWM (2025b).

12 References

Bathurst Resources Limited, 2025. Denniston ABA Block Model As part of the Escarpment Extension Project. Technical Memorandum to Mine Waste Management. Dated 04 February 2025.

[1] Quality Assurance / Quality Control

Berner, R. A, 1970. Sedimentary Pyrite Formation. American Journal of Science Volume 268, (pp 1-23)

Berner, R. A, 1983. Sedimentary Pyrite Formation: An update. Geochimica et Cosmochimica Acta, Volume 48, Issue 4 (pp 605-615)

M F Gazley & L A Fisher, 2014. A Review of the Reliability and Validity of Portable X-ray Fluorescence Spectrometry (pXRF) Data.

Kaplan, I.R. et al., 1963. The distribution and isotopic abundance of sulphur in recent marine sediments off southern California. Geochimica et Cosmochimica Acta, Volume 27, Issue 4 (pp 297-312, IN1 313-331)

McLachlan, C., 2022. Determination of Acid Producing Potential Using pXRF: A Case Study from Cypress Mine, Stockton Plateau. In IMWA 2022 Proceedings, Pope, J.; Wolkersdorfer, C.; Rait, R.; Trumm, D.; Christenson, H.; Wolkersdorfer, K. (Editors), pp 253 - 258.

Mine Waste Management, 2025. Factual Report: Geoenvironmental Hazards, Mt Fred South Project. Mine Waste Management Report J-NZ0377-001-R-Rev1.

Mine Waste Management, 2025. BPCP AMD Hazard Classification. Technical Memorandum to Bathurst Resources Limited. J-NZ0453-003-M-RevA, Dated 16 December 2024

Mine Waste Management, 2025. Column Leach Testing, Mt Fred South Project. Factual Report to Bathurst Resources Limited. J-NZ0377-005-R-RevA, Dated 03 February 2025

APPENDIX G CYPRESS PXRF SUMMARY

MINE WASTE MANAGEMENT
GREENROAD GROUP

[redacted]

MEMORANDUM

Recipient:	[redacted] – Bathurst Resources Limited
From:	[redacted] – Mine Waste Management Limited
Date:	21 July 2026
Cc:	[redacted] – MWM
Document Number:	J-NZ0453-010-M-FINAL
Document Title:	Cypress pXRF Summary

Mine Waste Management Limited (MWM) has provided this memorandum to Bathurst Resources Limited (BRL) to present the Cypress pXRF[1] data that supports the acid and metalliferous drainage (AMD) classification system for Kaiata Mudstone (KMS) that was developed by McLachlan (2022). AMD classification of KMS is important for the northern areas of the Upper Waimangaroa Haul Road (UWHR) as these lithologies will be intersected during the development of the transport corridor for the Buller Plateaux Continuation Project (BPCP or Project).

A reverse circulation (RC) drilling programme comprising 50 holes was completed in late 2021 across Stages 3 and 4 of the Mt William push-back at the Cypress Mine to define the NAPP[2] = 0 (kg H_2SO_4/t) surface. This surface is approximately 30 m above the Brunner Coal Measures (BCM):KMS contact is the cut-off between potentially acid forming (PAF) materials and overlying non-acid forming (NAF) materials.

The RC drilling programme also led to the identification of a second NAPP = 0 surface, located ~5–10 m below the ground surface. It is assumed this NAPP = 0 surface has developed due to leaching of NAF KMS by net infiltration of rainfall/organic acids over geological timeframes, which has leached out carbonate minerals yet preserved sulfides due to low oxygen ingress (McLachlan, 2022).

Hence, AMD classification of the KMS will be required for the UWHR, particularly at:

- ~30 m above the BCM/KMS contact; and
- Within ~5–10 m of the current ground surface.

RC drilling across Stages 3 and 4 of the Mount William push-back at the Cypress Mine produced dry, homogenised drill-chips suitable for direct analysis using pXRF. A total of 1,019 m was drilled, with hole depths ranging from 9 to 48 m. One-metre intervals were riffle split to obtain ~2–5 kg sub-samples, each analysed four times by pXRF (McLachlan, 2022).

[1] *Portable x-ray fluorescence*
[2] *Net Acid Production Potential*

A total of 318 samples were selected for laboratory analysis to determine total sulfur (wt%) and acid neutralising capacity (ANC) for the NAPP calculation. Laboratory testing by SGS Westport was used to validate pXRF results (McLachlan, 2022).

These results and pXRF data are provided in this memorandum as supporting data for the AMD classification scheme for KMS.

RESULTS

This section summarises the key results of this analysis programme. Full results are presented in Attachment A.

Table 1: Summary of key parameters

	pXRF Ca (ppm)	pXRF S (ppm)	ANC (pXRF Calc)	SGS ANC (kg H_2SO_4/t)	SGS S wt%
Average	17,969	11,915	57	60	2
Min	1,899	2,382	17	-5	0.39
Max	50,686	23,554	140	174	2
Median	18,339	11,778	58	61	2

Data from the RC drilling programme are plotted in Figure 1 and Figure 2 indicating that:

- There is a strong relationship between the measured ANC and pXRF Ca content (hence pXRF Ca content is a suitable substitute for ANC).
- There is a strong relationship between NAPP and pXRF Ca content (hence pXRF Ca content is a suitable method to determine NAPP).
- The pXRF-Ca value identified by McLachlan (2022) of 14,000 mg Ca/kg for use in field classification of Kaiata Mudstone is appropriate.

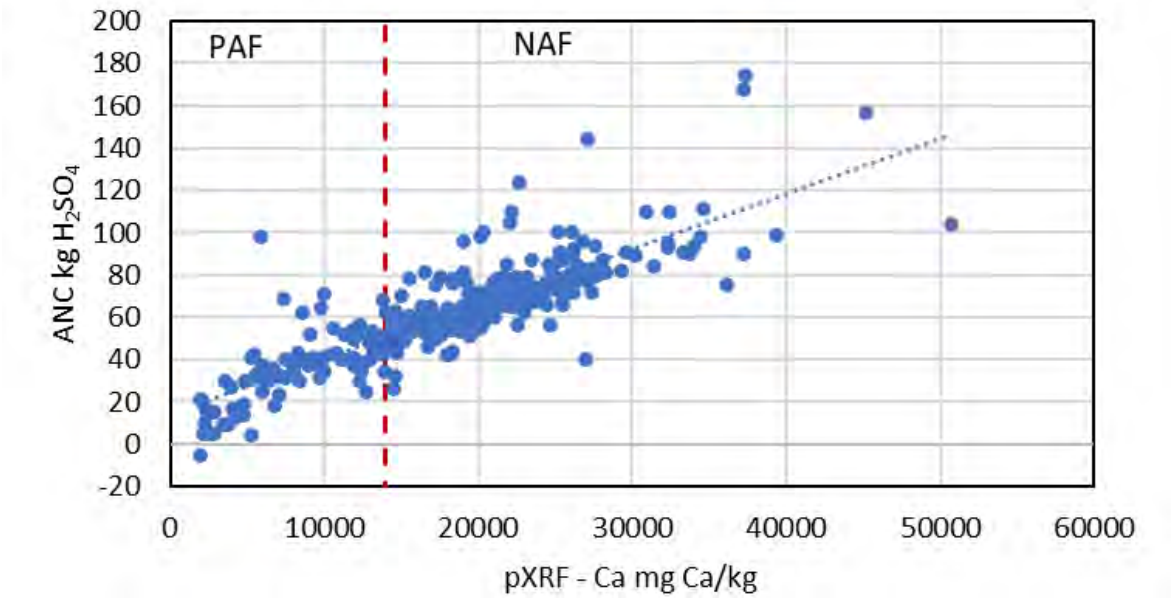


Figure 1: Correlation between pXRF-Ca and laboratory ANC

Red dash line = classification value of 14,000 mg Ca/kg

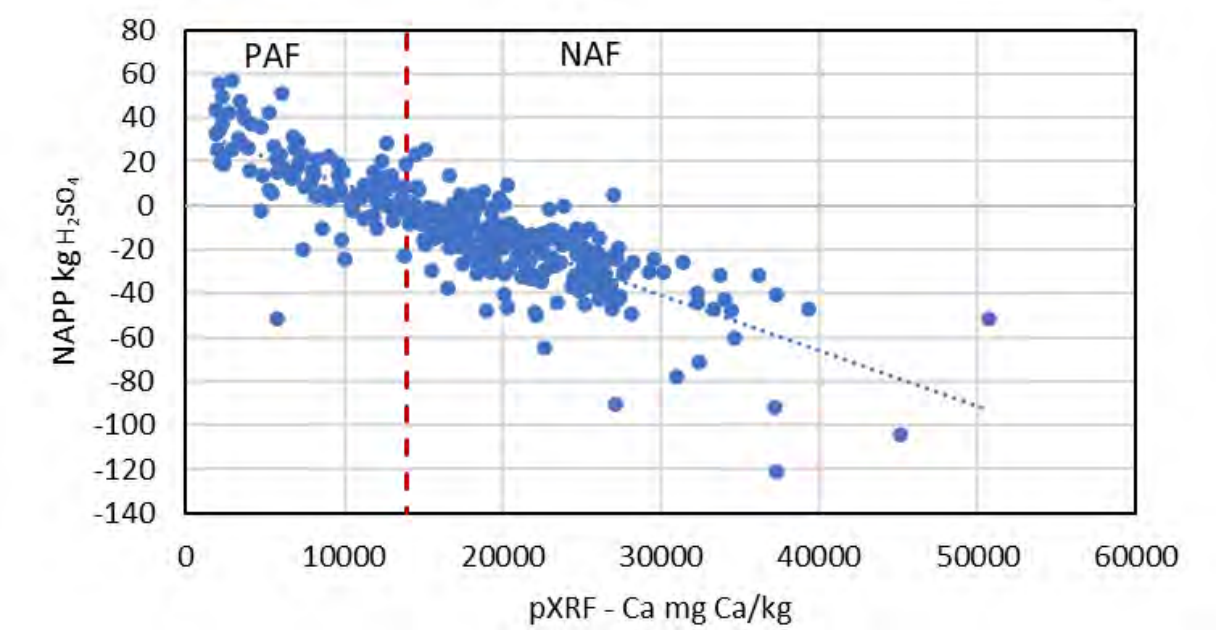


Figure 2: Correlation between pXRF-Ca and NAPP.

Red dash line = classification value of 14,000 mg Ca/kg

The results presented in Figure 1 and Figure 2 confirmed that the NAPP = 0 kg H_2SO_4/t corresponds to pXRF Ca range of ~14,000 and hence this provides:

- A suitable tool for the classification of KMS as either PAF or NAF; and
- A rapid field AMD classification of RC samples to accurately assess the NAPP = 0 surface within the KMS.

CLOSING REMARKS

Please do not hesitate to contact Paul Weber at +64 3 241 0221 or paul.weber@minewaste.com.au should you wish to discuss this matter in greater detail.

Attachments: Attachment A – pXRF and ABA Results

REFERENCES

McLachlan, C., 2022. Determination of Acid Producing Potential Using pXRF: A Case Study from Cypress Mine, Stockton Plateau. In IMWA 2022 Proceedings, Pope, J.; Wolkersdorfer, C.; Rait, R.; Trumm, D.; Christenson, H.; Wolkersdorfer, K. (Editors), pp 253 - 258.

ATTACHMENT A – DATA TABULATION

Date	SGS Lab Report Lunber	Info	m from	m to	pXRF Ca (ppm)	pXRF S (ppm)	ANC pulp eqn (pXRF calc)	SGS ANC (kg H2SO4/t)	SGS Total S % (LECO)	MWM NAPP Calculation
9/11/2021	WP21-09138	cpo3539	6.00	7.00	2361	8942	17.86	6	1.53	40.818
9/11/2021	WP21-09138	cpo3539	7.00	8.00	4133	9858	22.36	12	1.6	36.96
9/11/2021	WP21-09138	cpo3539	8.00	9.00	16284	9690	53.18	62	1.58	-13.652
9/11/2021	WP21-09138	cpo3539	9.00	10.00	9848	8784	36.85	41	1.5	4.9
9/11/2021	WP21-09138	cpo3539	10.00	11.00	21430	12421	66.24	65	1.26	-26.444
9/11/2021	WP21-09138	cpo3539	11.00	12.00	24860	14238	74.94	77	1.25	-38.75
9/11/2021	WP21-09138	cpo3539	22.00	23.00	17684	16505	56.73	54	1.55	-6.57
9/11/2021	WP21-09138	cpo3539	23.00	24.00	26255	11874	78.48	77	1.59	-28.346
9/11/2021	WP21-09138	cpo3539	24.00	25.00	33983	12331	98.09	94	1.68	-42.592
9/11/2021	WP21-09138	cpo3539	25.00	26.00	6007	16178	27.11	25	1.57	23.042
9/11/2021	WP21-09138	cpo3539	26.00	27.00	6730	14906	28.94	33	1.55	14.43
9/11/2021	WP21-09138	cpo3539	27.00	28.00	7052	13706	29.76	23	1.71	29.326
20/09/2021	WP21-09138	cpo3876	4.00	5.00	29587	10119	86.93	91	2.18	-24.292
20/09/2021	WP21-08677	cpo3876	5.00	6.00	23660	12316	71.89	67	1.78	-12.532
20/09/2021	WP21-08677	cpo3876	6.00	7.00	23861	11773	72.40	70	2.27	-0.538
20/09/2021	WP21-08677	cpo3876	7.00	8.00	37201	9688	106.25	168	2.49	-91.806
2/11/2021	WP21-09139	cpo3878r	0.00	1.00	3666	10658	21.17	9	1.66	41.796
2/11/2021	WP21-09139	cpo3878r	1.00	2.00	6795	7252	29.11	18	1.62	31.572
2/11/2021	WP21-09139	cpo3878r	2.00	3.00	3711	8345	21.28	9	1.58	39.348
2/11/2021	WP21-09139	cpo3878r	3.00	4.00	3444	7512	20.61	9	1.85	47.61
2/11/2021	WP21-09139	cpo3878r	4.00	5.00	2891	8245	19.20	5	2.02	56.812
2/11/2021	WP21-09139	cpo3878r	5.00	6.00	2112	9230	17.23	5	1.98	55.588
2/11/2021	WP21-09139	cpo3878r	6.00	7.00	2295	7347	17.69	5	1.79	49.774
2/11/2021	WP21-09139	cpo3878r	7.00	8.00	4743	7683	23.90	19	1.8	36.08
2/11/2021	WP21-09139	cpo3878r	8.00	9.00	2413	10887	17.99	16	1.24	21.944
2/11/2021	WP21-09139	cpo3878r	9.00	10.00	19344	12526	60.95	60	1.2	-23.28
2/11/2021	WP21-09139	cpo3878r	10.00	11.00	26914	12624	80.15	83	1.18	-46.892
2/11/2021	WP21-09139	cpo3878r	11.00	12.00	34467	12132	99.31	98	1.65	-47.51
2/11/2021	WP21-09139	cpo3878r	12.00	13.00	33748	10989	97.49	90	1.9	-31.86
1/11/2021	WP21-09139	cpo3878r	29.00	30.00	27113	7601	80.65	77	1.72	-24.368
1/11/2021	WP21-09139	cpo3878r	30.00	31.00	13034	8498	44.94	40	1.76	13.856
1/11/2021	WP21-09139	cpo3878r	31.00	32.00	16408	9144	53.50	54	1.65	-3.51
1/11/2021	WP21-09139	cpo3878r	32.00	33.00	17529	8687	56.34	59	1.54	-11.876
1/11/2021	WP21-09139	cpo3878r	33.00	34.00	17194	10099	55.49	50	1.5	-4.1
1/11/2021	WP21-09139	cpo3878r	34.00	35.00	17943	9608	57.39	63	1.53	-16.182
1/11/2021	WP21-09139	cpo3878r	35.00	36.00	13825	7194	46.94	47	1.58	1.348
1/11/2021	WP21-09139	cpo3878r	36.00	37.00	19266	9307	60.75	53	1.64	-2.816
1/11/2021	WP24-13565	cpo3878r	43.00	44.00	24647	8047	74.40	56	1.48	-10.712
1/11/2021	WP24-13565	cpo3878r	44.00	45.00	22579	12817	69.15	56	1.42	-12.548
1/11/2021	WP24-13565	cpo3878r	45.00	46.00	25495	14766	76.55	66	1.82	-10.308
1/11/2021	WP21-09139	cpo3878r	46.00	47.00	18916	10875	59.86	65	1.4	-22.16
1/11/2021	WP21-09139	cpo3878r	47.00	48.00	13208	10221	45.38	49	1.6	-0.04
29/09/2021		cpo3907	4.00	5.00	21847	7366	67.30	85	1.69	-33.286
29/09/2021		cpo3907	5.00	6.00	19406	9542	61.10	70	1.53	-23.182
29/09/2021		cpo3907	6.00	7.00	17371	9049	55.94	58	1.7	-5.98
29/09/2021		cpo3907	7.00	8.00	15841	9557	52.06	54	1.62	-4.428
29/09/2021		cpo3907	8.00	9.00	18334	8930	58.38	76	1.63	-26.122
29/09/2021		cpo3907	9.00	10.00	15354	8754	50.82	56	1.79	-1.226
29/09/2021		cpo3907	10.00	11.00	16698	11405	54.23	62	1.39	-19.466
29/09/2021		cpo3907	11.00	12.00	17845	10080	57.14	57	1.62	-7.428
29/09/2021		cpo3907	12.00	13.00	14393	7504	48.38	56	1.6	-7.04
29/09/2021		cpo3907	13.00	14.00	18103	10506	57.80	54	1.71	-1.674

Date	SGS Lab Report Lunber	Info	m from	m to	pXRF Ca (ppm)	pXRF S (ppm)	ANC pulp eqn (pXRF calc)	SGS ANC (kg H2SO4/t)	SGS Total S % (LECO)	MWM NAPP Calculation
29/09/2021		cpo3907	14.00	15.00	15494	8451	51.18	55	1.63	-5.122
29/09/2021		cpo3907	15.00	16.00	21979	10550	67.63	77	1.48	-31.712
29/09/2021		cpo3907	16.00	17.00	19386	11542	61.05	66	1.27	-27.138
29/09/2021		cpo3907	17.00	18.00	24351	12963	73.65	76	1.27	-37.138
29/09/2021		cpo3907	18.00	19.00	28120	18245	83.21	87	1.24	-49.056
29/09/2021		cpo3907	19.00	20.00	22845	13695	69.83	68	1.74	-14.756
29/09/2021		cpo3907	20.00	21.00	25999	12913	77.83	78	1.84	-21.696
29/09/2021		cpo3907	21.00	22.00	25037	13382	75.39	75	1.56	-27.264
29/09/2021		cpo3907	22.00	23.00	24505	13437	74.04	76	1.39	-33.466
29/09/2021		cpo3907	23.00	24.00	20128	13411	62.93	61	1.37	-19.078
29/09/2021		cpo3907	24.00	25.00	18284	12811	58.26	63	1.38	-20.772
28/09/2021	WP21-08729	cpo3909	19.00	20.00	26352	10834	78.72	80	1.75	-26.45
28/09/2021	WP21-08729	cpo3909	20.00	21.00	18866	13159	59.73	62	1.69	-10.286
28/09/2021	WP21-08729	cpo3909	21.00	22.00	17080	14239	55.20	61	1.62	-11.428
28/09/2021	WP21-08729	cpo3909	22.00	23.00	33318	13358	96.40	91	1.43	-47.242
28/09/2021	WP21-08729	cpo3909	23.00	24.00	32349	11920	93.94	95	1.81	-39.614
28/09/2021	WP21-08729	cpo3909	24.00	25.00	18795	12476	59.55	53	1.93	6.058
28/09/2021	WP21-08729	cpo3909	25.00	26.00	22110	8284	67.96	110	1.96	-50.024
28/09/2021	WP21-08729	cpo3909	26.00	27.00	21429	12269	66.24	76	1.84	-19.696
29/09/2021	WP21-08729	cpo3909	27.00	28.00	9055	15020	34.84	52	1.78	2.468
29/09/2021	WP21-08729	cpo3909	28.00	29.00	8054	13238	32.30	37	1.74	16.244
3/11/2021	WP21-09047	cpo3918	17.00	18.00	15078	15462	50.12	59	1.34	-17.996
3/11/2021	WP21-09047	cpo3918	18.00	19.00	12168	15040	42.74	52	1.72	0.632
3/11/2021	WP21-09047	cpo3918	19.00	20.00	27001	13037	80.37	40	1.46	4.676
3/11/2021	WP21-09047	cpo3918	20.00	21.00	10007	12532	37.26	71	1.52	-24.488
3/11/2021	WP21-09047	cpo3918	21.00	22.00	12633	14310	43.92	39	1.51	7.206
3/11/2021	WP21-09047	cpo3918	22.00	23.00	12133	15606	42.65	39	1.59	9.654
3/11/2021	WP21-09047	cpo3918	23.00	24.00	9239	13982	35.31	41	1.48	4.288
3/11/2021	WP21-09047	cpo3918	24.00	25.00	8120	16934	32.47	33	1.56	14.736
3/11/2021	WP21-09047	cpo3918	25.00	26.00	9643	19600	36.33	31	1.62	18.572
17/09/2021	WP21-08749	cpo3973	2.00	3.00	2737	9121	18.81	15	1.88	42.528
17/09/2021	WP21-08749	cpo3973	3.00	4.00	3905	8193	21.78	27	1.75	26.55
17/09/2021	WP21-08749	cpo3973	4.00	5.00	18779	10151	59.51	61	1.52	-14.488
17/09/2021	WP21-08749	cpo3973	5.00	6.00	32369	16048	93.99	110	1.27	-71.138
17/09/2021	WP21-08749	cpo3973	6.00	7.00	26110	18496	78.11	81	1.38	-38.772
17/09/2021	WP21-08749	cpo3973	7.00	8.00	20600	14228	64.13	67	1.64	-16.816
17/09/2021	WP21-08749	cpo3973	8.00	9.00	22866	12328	69.88	68	1.78	-13.532
17/09/2021	WP21-08749	cpo3973	9.00	10.00	24246	11040	73.38	71	1.86	-14.084
17/09/2021	WP21-08749	cpo3973	10.00	11.00	29299	10787	86.20	82	1.7	-29.98
17/09/2021	WP21-08749	cpo3973	11.00	12.00	39358	10604	111.72	99	1.69	-47.286
17/09/2021	WP21-08749	cpo3973	12.00	13.00	19428	11535	61.16	62	1.77	-7.838
17/09/2021	WP21-08749	cpo3973	13.00	14.00	18189	12179	58.02	61	1.87	-3.778
17/09/2021	WP21-08749	cpo3973	14.00	15.00	20909	14553	64.92	70	1.83	-14.002
17/09/2021	WP21-08749	cpo3973	15.00	16.00	23255	16369	70.87	69	1.89	-11.166
17/09/2021	WP21-08749	cpo3973	16.00	17.00	25155	18372	75.69	75	1.81	-19.614
17/09/2021	WP21-08749	cpo3973	17.00	18.00	17884	15046	57.24	57	1.97	3.282
17/09/2021	WP21-08749	cpo3973	18.00	19.00	25617	12343	76.86	76	1.78	-21.532
17/09/2021	WP21-08749	cpo3973	19.00	20.00	28239	12609	83.51	81	1.79	-26.226
17/09/2021	WP21-08749	cpo3973	20.00	21.00	25941	12076	77.68	76	1.78	-21.532
17/09/2021	WP21-08749	cpo3973	21.00	22.00	27116	12692	80.66	144	1.75	-90.45
17/09/2021	WP21-08749	cpo3973	22.00	23.00	27141	14852	80.73	77	1.8	-21.92
17/09/2021	WP21-08749	cpo3973	23.00	24.00	9974	18858	37.17	34	1.6	14.96

Date	SGS Lab Report Lunber	Info	m from	m to	pXRF Ca (ppm)	pXRF S (ppm)	ANC pulp eqn (pXRF calc)	SGS ANC (kg H2SO4/t)	SGS Total S % (LECO)	MWM NAPP Calculation
17/09/2021	WP21-08749	cpo3973	24.00	25.00	11773	19848	41.74	53	1.57	-4.958
17/09/2021	WP21-08749	cpo3973	25.00	26.00	6401	23554	28.11	30	1.51	16.206
17/09/2021	WP21-08679	cpo3977	1.00	2.00	9767	6869	36.65	37	1.47	7.982
17/09/2021	WP21-08679	cpo3977	2.00	3.00	19274	10250	60.77	59	1.56	-11.264
17/09/2021	WP21-08679	cpo3977	3.00	4.00	27340	10185	81.23	72	1.73	-19.062
17/09/2021	WP21-08679	cpo3977	4.00	5.00	22562	10113	69.11	71	1.73	-18.062
17/09/2021	WP21-08679	cpo3977	5.00	6.00	22425	11936	68.76	79	1.48	-33.712
17/09/2021	WP21-08679	cpo3977	6.00	7.00	26034	17572	77.92	79	1.47	-34.018
17/09/2021	WP21-08679	cpo3977	7.00	8.00	21057	12716	65.29	66	1.77	-11.838
17/09/2021	WP21-08679	cpo3977	8.00	9.00	23725	13284	72.06	73	1.81	-17.614
17/09/2021	WP21-08679	cpo3977	9.00	10.00	25260	13522	75.95	76	1.84	-19.696
17/09/2021	WP21-08679	cpo3977	10.00	11.00	25846	14797	77.44	77	1.49	-31.406
17/09/2021	WP21-08679	cpo3977	11.00	12.00	26811	15326	79.89	80	1.4	-37.16
17/09/2021	WP21-08679	cpo3977	12.00	13.00	25547	16000	76.68	71	1.43	-27.242
17/09/2021	WP21-08679	cpo3977	13.00	14.00	25434	18931	76.39	69	1.43	-25.242
17/09/2021	WP21-08679	cpo3977	14.00	15.00	22968	16309	70.14	72	1.43	-28.242
17/09/2021	WP21-08679	cpo3977	15.00	16.00	24787	19556	74.76	81	1.44	-36.936
17/09/2021	WP21-08679	cpo3977	16.00	17.00	50686	12070	140.46	104	1.72	-51.368
17/09/2021	WP21-08679	cpo3977	17.00	18.00	8566	17002	33.60	62	1.68	-10.592
17/09/2021	WP21-08679	cpo3977	18.00	19.00	6880	19566	29.32	32	1.9	26.14
17/09/2021	WP21-08679	cpo3977	19.00	20.00	15520	19204	51.24	78	1.59	-29.346
11/10/2021	WP22-10652	cpo3981	1.00	2.00	14788	7996	49.39	52	1.42	-8.548
11/10/2021	WP22-10652	cpo3981	2.00	3.00	1899	6699	16.69	-5	1.26	43.556
11/10/2021	WP22-10652	cpo3981	3.00	4.00	2874	5935	19.16	15	1.32	25.392
11/10/2021	WP22-10652	cpo3981	4.00	5.00	14386	6660	48.37	56	1.85	0.61
11/10/2021	WP22-10652	cpo3981	5.00	6.00	37310	5725	106.52	174	1.73	-121.062
11/10/2021	WP22-10652	cpo3981	6.00	7.00	24528	6826	74.10	85	1.74	-31.756
11/10/2021	WP22-10652	cpo3981	7.00	8.00	20343	5633	63.48	100	1.76	-46.144
11/10/2021	WP22-10652	cpo3981	8.00	9.00	22024	7908	67.74	105	1.85	-48.39
11/10/2021	WP22-10652	cpo3981	9.00	10.00	26757	6932	79.75	96	1.77	-41.838
11/10/2021	WP22-10652	cpo3981	10.00	11.00	18364	8748	58.46	78	1.54	-30.876
11/10/2021	WP22-10652	cpo3981	11.00	12.00	15007	10973	49.94	70	1.77	-15.838
11/10/2021	WP22-10652	cpo3981	12.00	13.00	19082	8240	60.28	81	1.74	-27.756
11/10/2021	WP22-10652	cpo3981	13.00	14.00	25307	6363	76.07	91	1.76	-37.144
11/10/2021	WP22-10652	cpo3981	14.00	15.00	17253	6497	55.64	75	1.84	-18.696
11/10/2021	WP22-10652	cpo3981	15.00	16.00	16353	8041	53.36	65	1.91	-6.554
11/10/2021	WP22-10652	cpo3981	16.00	17.00	14567	9006	48.83	63	1.98	-2.412
11/10/2021	WP22-10652	cpo3981	17.00	18.00	14033	10377	47.47	62	2.09	1.954
11/10/2021	WP22-10652	cpo3981	18.00	19.00	30937	9546	90.36	110	1.04	-78.176
11/10/2021	WP22-10652	cpo3981	19.00	20.00	5233	13651	25.15	41	1.57	7.042
11/10/2021	WP22-10652	cpo3981	20.00	21.00	5483	10856	25.78	42	1.56	5.736
11/10/2021	WP22-10652	cpo3981	21.00	22.00	18999	9505	60.07	96	1.57	-47.958
11/10/2021	WP22-10652	cpo3981	22.00	23.00	5970	9806	27.02	37	1.78	17.468
11/10/2021	WP22-10652	cpo3981	23.00	24.00	5532	9703	25.91	33	1.97	27.282
16/09/2021	WP21-08671	4011	2.00	3.00	2208	4625	17.47	10	0.968	19.6208
16/09/2021	WP21-08671	4011	3.00	4.00	3585	7365	20.97	30	1.92	28.752
16/09/2021	WP21-08671	4011	5.00	6.00	8240	10485	32.77	43	1.54	4.124
16/09/2021	WP21-08671	4011	6.00	7.00	14753	8780	49.30	55	1.67	-3.898
16/09/2021	WP21-08671	4011	7.00	8.00	11914	12160	42.10	50	1.77	4.162
16/09/2021	WP21-08671	4011	8.00	9.00	15207	13992	50.45	49	1.48	-3.712
16/09/2021	WP21-08671	4011	9.00	10.00	13945	12270	47.25	49	1.56	-1.264
16/09/2021	WP21-08671	4011	10.00	11.00	18344	10969	58.41	44	1.52	2.512

Date	SGS Lab Report Lunber	Info	m from	m to	pXRF Ca (ppm)	pXRF S (ppm)	ANC pulp eqn (pXRF calc)	SGS ANC (kg H2SO4/t)	SGS Total S % (LECO)	MWM NAPP Calculation
16/09/2021	WP21-08671	4011	11.00	12.00	17481	10657	56.22	79	1.72	-26.368
16/09/2021	WP21-08671	4011	12.00	13.00	23914	10191	72.54	68	1.64	-17.816
16/09/2021	WP21-08671	4011	13.00	14.00	17828	13823	57.10	61	1.29	-21.526
16/09/2021	WP21-08671	4011	14.00	15.00	22455	16126	68.84	65	1.43	-21.242
16/09/2021	WP21-08671	4011	15.00	16.00	26183	12422	78.30	92	1.84	-35.696
16/09/2021	WP21-08671	4011	16.00	17.00	27415	15141	81.42	83	1.36	-41.384
16/09/2021	WP21-08671	4011	17.00	18.00	22922	14192	70.02	62	1.96	-2.024
16/09/2021	WP21-08671	4011	18.00	19.00	17504	10029	56.28	58	1.79	-3.226
16/09/2021	WP21-08671	4011	19.00	20.00	19793	12201	62.08	57	1.98	3.588
16/09/2021	WP21-08671	4011	20.00	21.00	22638	12396	69.30	124	1.94	-64.636
16/09/2021	WP21-08671	4011	21.00	22.00	20492	10726	63.86	68	1.96	-8.024
16/09/2021	WP21-08671	4011	22.00	23.00	25113	13237	75.58	75	2.03	-12.882
16/09/2021	WP21-08671	4011	23.00	24.00	16639	16786	54.08	52	2.16	14.096
16/09/2021	WP21-08671	4011	24.00	25.00	12081	10402	42.52	53	1.4	-10.16
16/09/2021	WP21-08671	4011	25.00	26.00	7909	13086	31.93	38	1.6	10.96
16/09/2021	WP21-08671	4011	26.00	27.00	16716	15345	54.28	52	1.42	-8.548
16/09/2021	WP21-08671	4011	27.00	28.00	10792	17697	39.25	43	1.57	5.042
23/09/2021	WP21-08751	cpo4012	0.00	1.00	4058	8032	22.16	17	1.08	16.048
23/09/2021	WP21-08751	cpo4012	1.00	2.00	9636	14435	36.32	37	1.66	13.796
23/09/2021	WP21-08751	cpo4012	2.00	3.00	21710	13589	66.95	75	1.62	-25.428
23/09/2021	WP21-08751	cpo4012	3.00	4.00	23037	12300	70.31	68	1.74	-14.756
23/09/2021	WP21-08751	cpo4012	4.00	5.00	24705	8943	74.55	75	1.73	-22.062
23/09/2021	WP21-08751	cpo4012	5.00	6.00	21796	10014	67.17	71	1.8	-15.92
23/09/2021	WP21-08751	cpo4012	6.00	7.00	16829	12929	54.56	54	1.79	0.774
29/09/2021	WP21-08751	cpo4012	7.00	8.00	45136	12135	126.38	157	1.71	-104.674
29/09/2021	WP21-08751	cpo4012	8.00	9.00	14166	16620	47.81	51	1.67	0.102
16/09/2021	WP21-08680	4014	0.00	1.00	4780	2382.25	24.00	14	0.386	-2.1884
16/09/2021	WP21-08680	4014	1.00	2.00	2004	5868.00	16.95	20	1.48	25.288
16/09/2021	WP21-08680	4014	2.00	3.00	2296	4316.25	17.69	16	1.75	37.55
16/09/2021	WP21-08680	4014	3.00	4.00	7170	9348.25	30.06	32	1.71	20.326
16/09/2021	WP21-08680	4014	4.00	5.00	14060	10316.25	47.54	48	1.31	-7.914
16/09/2021	WP21-08680	4014	5.00	6.00	13766	9855.50	46.79	48	1.5	-2.1
16/09/2021	WP21-08680	4014	6.00	7.00	11861	5926.25	41.96	54	1.58	-5.652
16/09/2021	WP21-08680	4014	7.00	8.00	25763	5648.50	77.23	79	1.58	-30.652
16/09/2021	WP21-08680	4014	8.00	9.00	27706	8509.25	82.16	80	1.65	-29.51
16/09/2021	WP21-08680	4014	9.00	10.00	22049	9036.00	67.81	65	1.54	-17.876
16/09/2021	WP21-08680	4014	10.00	11.00	25116	10674.75	75.59	73	1.33	-32.302
16/09/2021	WP21-08680	4014	11.00	12.00	27318	13374.00	81.18	82	1.28	-42.832
16/09/2021	WP21-08680	4014	12.00	13.00	21697	11726.50	66.91	79	1.49	-33.406
16/09/2021	WP21-08680	4014	13.00	14.00	21095	12015.75	65.39	68	1.64	-17.816
16/09/2021	WP21-08680	4014	14.00	15.00	21830	10731.25	67.25	70	1.72	-17.368
16/09/2021	WP21-08680	4014	15.00	16.00	21821	11844.00	67.23	66	1.73	-13.062
16/09/2021	WP21-08680	4014	16.00	17.00	22082	13455.25	67.89	69	1.71	-16.674
16/09/2021	WP21-08680	4014	17.00	18.00	25128	10162.75	75.62	86	1.73	-33.062
16/09/2021	WP21-08680	4014	18.00	19.00	23028	9126.75	70.29	65	1.75	-11.45
16/09/2021	WP21-08680	4014	19.00	20.00	18529	13186.50	58.88	56	1.84	0.304
16/09/2021	WP21-08680	4014	22.00	23.00	20117	19536.75	62.91	98	1.89	-40.166
16/09/2021	WP21-08680	4014	21.00	22.00	23120	21357.50	70.53	68	1.46	-23.324
16/09/2021	WP21-08680	4014	23.00	24.00	9813	18732.75	36.76	64	1.58	-15.652
16/09/2021	WP21-08680	4014	24.00	25.00	7368	14182.50	30.56	69	1.59	-20.346
16/09/2021	WP21-08680	4014	26.00	27.00	6452	20746.75	28.24	35	1.63	14.878
16/09/2021	WP21-08680	4014	25.00	26.00	6767	18325.00	29.04	33	1.5	12.9

Date	SGS Lab Report Lunber	Info	m from	m to	pXRF Ca (ppm)	pXRF S (ppm)	ANC pulp eqn (pXRF calc)	SGS ANC (kg H2SO4/t)	SGS Total S % (LECO)	MWM NAPP Calculation
16/09/2021	WP21-08680	4014	27.00	28.00	8356	17719.00	33.07	30	1.66	20.796
16/09/2021	WP21-08680	4014	28.00	29.00	14487	17067.00	48.62	26	1.61	23.266
16/09/2021	WP21-08680	4014	29.00	30.00	5816	15646.50	26.63	98	1.52	-51.488
16/09/2021	WP21-08680	4014	30.00	31.00	5742	14645.50	26.44	34	1.79	20.774
6/10/2021	WP21-08752	cpo4015	8.00	9.00	25476	9919	76.50	87	1.75	-33.45
6/10/2021	WP21-08752	cpo4015	9.00	10.00	18102	9757	57.79	56	1.56	-8.264
6/10/2021	WP21-08752	cpo4015	10.00	11.00	16828	11324	54.56	55	1.35	-13.69
6/10/2021	WP21-08752	cpo4015	11.00	12.00	18716	12641	59.35	62	1.35	-20.69
6/10/2021	WP21-08752	cpo4015	12.00	13.00	19805	11949	62.12	69	1.76	-15.144
6/10/2021	WP21-08752	cpo4015	13.00	14.00	20958	12607	65.04	66	1.35	-24.69
6/10/2021	WP21-08752	cpo4015	14.00	15.00	18214	11352	58.08	56	1.54	-8.876
6/10/2021	WP21-08752	cpo4015	15.00	16.00	20800	10659	64.64	66	1.68	-14.592
6/10/2021	WP21-08752	cpo4015	16.00	17.00	21255	9840	65.79	69	1.58	-20.652
6/10/2021	WP21-08752	cpo4015	17.00	18.00	17595	11915	56.51	57	1.39	-14.466
6/10/2021	WP21-08752	cpo4015	18.00	19.00	20368	11358	63.54	70	1.38	-27.772
6/10/2021	WP21-08752	cpo4015	19.00	20.00	26782	12502	79.81	78	1.38	-35.772
6/10/2021	WP21-08752	cpo4015	20.00	21.00	20088	11520	62.83	64	1.49	-18.406
6/10/2021	WP21-08752	cpo4015	21.00	22.00	19168	11949	60.50	65	1.42	-21.548
6/10/2021	WP21-08752	cpo4015	22.00	23.00	19786	13373	62.07	62	1.73	-9.062
6/10/2021	WP21-08752	cpo4015	23.00	24.00	17790	15053	57.00	54	1.76	-0.144
6/10/2021	WP21-08752	cpo4015	24.00	25.00	20542	16256	63.99	61	1.64	-10.816
20/09/2021	WP21-08676	cpo4047	9.00	10.00	15759.25	14137.75	51.85	57	1.37	-15.078
20/09/2021	WP21-08676	cpo4047	10.00	11.00	22439.00	14791.50	68.80	75	1.32	-34.608
20/09/2021	WP21-08676	cpo4047	11.00	12.00	20376.25	15776.75	63.56	72	1.4	-29.16
20/09/2021	WP21-08676	cpo4047	12.00	13.00	23396.75	17521.50	71.23	75	1.56	-27.264
14/09/2021	WP21-08610	4048	2.00	3.00	2368	3991	17.88	16	1.13	18.578
14/09/2021	WP21-08610	4048	3.00	4.00	1907	7267	16.71	21	1.75	32.55
14/09/2021	WP21-08610	4048	4.00	5.00	2087	12715	17.17	21	1.8	34.08
14/09/2021	WP21-08610	4048	5.00	6.00	10447	15019	38.37	42	1.37	-0.078
14/09/2021	WP21-08610	4048	6.00	7.00	13140	12852	45.21	53	1.5	-7.1
14/09/2021	WP21-08610	4048	7.00	8.00	16209	11220	52.99	59	1.64	-8.816
14/09/2021	WP21-08610	4048	8.00	9.00	16923	9647	54.80	57	1.6	-8.04
14/09/2021	WP21-08610	4048	9.00	10.00	18006	8420	57.55	64	1.77	-9.838
14/09/2021	WP21-08610	4048	10.00	11.00	27607	11509	81.91	94	2.07	-30.658
14/09/2021	WP21-08610	4048	11.00	12.00	16901	8692	54.75	65	1.88	-7.472
14/09/2021	WP21-08610	4048	12.00	13.00	18374	10916	58.49	54	1.77	0.162
14/09/2021	WP21-08610	4048	13.00	14.00	32300	11295	93.82	93	1.59	-44.346
14/09/2021	WP21-08610	4048	14.00	15.00	23008	18869	70.24	68	1.4	-25.16
14/09/2021	WP21-08610	4048	15.00	16.00	26457	14582	78.99	78	1.53	-31.182
14/09/2021	WP21-08610	4048	16.00	17.00	31410	9749	91.56	84	1.91	-25.554
14/09/2021	WP21-08610	4048	17.00	18.00	27248	11369	81.00	81	1.87	-23.778
15/09/2021	WP21-08610	4048	18.00	19.00	26077	10972	78.03	100	1.88	-42.472
15/09/2021	WP21-08610	4048	19.00	20.00	17305	13706	55.77	60	1.9	-1.86
16/09/2021	WP21-08610	4048	20.00	21.00	22543	16505	69.06	71	1.88	-13.472
16/09/2021	WP21-08610	4048	21.00	22.00	19543	13573	61.45	72	1.51	-25.794
16/09/2021	WP21-08610	4048	22.00	23.00	24919	18002	75.09	80	1.43	-36.242
16/09/2021	WP21-08610	4048	23.00	24.00	20946	16339	65.01	76	1.71	-23.674
16/09/2021	WP21-08610	4048	24.00	25.00	37259	14842	106.40	90	1.61	-40.734
16/09/2021	WP21-08610	4048	25.00	26.00	17081	17052	55.20	58	1.73	-5.062
16/09/2021	WP21-08610	4048	26.00	27.00	13756	17070	46.77	42	1.65	8.49
16/09/2021	WP21-08610	4048	27.00	28.00	13792	16685	46.86	68	1.47	-23.018
16/09/2021	WP21-08610	4048	28.00	29.00	17043	18347	55.11	49	1.59	-0.346

Date	SGS Lab Report Lunber	Info	m from	m to	pXRF Ca (ppm)	pXRF S (ppm)	ANC pulp eqn (pXRF calc)	SGS ANC (kg H2SO4/t)	SGS Total S % (LECO)	MWM NAPP Calculation
16/09/2021	WP21-08610	4048	29.00	30.00	18146	18293	57.91	42	1.54	5.124
16/09/2021	WP21-08610	4048	30.00	31.00	11229	11787	40.36	40	1.62	9.572
16/09/2021	WP21-08610	4048	31.00	32.00	13622	10330	46.43	51	1.78	3.468
4/10/2021	WP21-08750	cpo4078	9.00	10.00	4830	10376	24.12	30	1.43	13.758
4/10/2021	WP21-08750	cpo4078	10.00	11.00	20084	12416	62.82	72	1.33	-31.302
4/10/2021	WP21-08750	cpo4078	11.00	12.00	34642	10227	99.76	111	1.66	-60.204
4/10/2021	WP21-08750	cpo4078	19.00	20.00	26405	11448	78.86	85	1.74	-31.756
4/10/2021	WP21-08750	cpo4078	20.00	21.00	23202	13828	70.73	79	1.77	-24.838
4/10/2021	WP21-08750	cpo4078	21.00	22.00	9023	12575	34.76	37	1.95	22.67
4/10/2021	WP21-08750	cpo4078	22.00	23.00	6961	16811	29.53	33	1.62	16.572
4/10/2021	WP21-08750	cpo4078	23.00	24.00	19261	14570	60.73	76	1.49	-30.406
4/10/2021	WP21-08750	cpo4078	24.00	25.00	5802	12920	26.59	31	1.52	15.512
9/09/2021	WP21-08558	4079	3.00	4.00	7500	10182	30.90	31	1.74	22.244
9/09/2021	WP21-08558	4079	4.00	5.00	13184	11369	45.32	44	1.74	9.244
9/09/2021	WP21-08558	4079	5.00	6.00	21041	13651	65.30	60	1.57	-11.958
9/09/2021	WP21-08558	4079	6.00	7.00	21608	11937	66.69	66	1.59	-17.346
9/09/2021	WP21-08558	4079	7.00	8.00	15821	9153	52.01	53	1.68	-1.592
9/09/2021	WP21-08558	4079	8.00	9.00	14687	8897	49.13	45	1.7	7.02
10/09/2021	WP21-08558	4079	9.00	10.00	14543	8993	48.76	50	1.63	-0.122
10/09/2021	WP21-08558	4079	10.00	11.00	14939	11532	49.77	48	1.5	-2.1
10/09/2021	WP21-08558	4079	11.00	12.00	24462	11567	73.93	66	1.59	-17.346
10/09/2021	WP21-08558	4079	12.00	13.00	24911	6523	75.07	74	1.68	-22.592
10/09/2021	WP21-08558	4079	13.00	14.00	19370	11002	61.01	71	1.75	-17.45
10/09/2021	WP21-08558	4079	14.00	15.00	19442	8087	61.19	51	1.62	-1.428
10/09/2021	WP21-08558	4079	15.00	16.00	22668	7533	69.38	78	1.59	-29.346
10/09/2021	WP21-08559	4079	16.00	17.00	21877	10649	67.37	66	1.73	-13.062
10/09/2021	WP21-08559	4079	17.00	18.00	23662	10563	71.90	74	1.57	-25.958
10/09/2021	WP21-08559	4079	18.00	19.00	24344	12065	73.63	75	1.91	-16.554
10/09/2021	WP21-08559	4079	19.00	20.00	20419	11016	63.67	67	1.92	-8.248
10/09/2021	WP21-08559	4079	20.00	21.00	26130	8817	78.16	72	1.87	-14.778
10/09/2021	WP21-08559	4079	21.00	22.00	25174	8473	75.74	100	1.81	-44.614
10/09/2021	WP21-08559	4079	22.00	23.00	17325	9634	55.82	54	1.92	4.752
10/09/2021	WP21-08559	4079	23.00	24.00	26640	12510	79.46	78	1.76	-24.144
10/09/2021	WP21-08559	4079	24.00	25.00	8745	14812	34.05	40	1.52	6.512
10/09/2021	WP21-08559	4079	25.00	26.00	11860	14317	41.96	41	1.67	10.102
10/09/2021	WP21-08559	4079	26.00	27.00	12906	17437	44.61	48	1.53	-1.182
9/09/2021	WP21-08559	4079	27.00	28.00	11245	19290	40.40	52	1.49	-6.406
9/09/2021	WP21-08559	4079	28.00	29.00	7491	16964	30.88	40	1.58	8.348
10/09/2021	WP21-08560	4079	29.00	30.00	6668	19987	28.79	36	1.58	12.348
23/09/2021	WP21-08678	cpo4087	8.00	9.00	12247	9743	42.94	56	1.91	2.446
23/09/2021	WP21-08678	cpo4087	9.00	10.00	15490	7688	51.17	61	1.61	-11.734
23/09/2021	WP21-08678	cpo4087	10.00	11.00	26154	6750	78.22	91	1.85	-34.39
23/09/2021	WP21-08678	cpo4087	11.00	12.00	23416	6963	71.28	87	1.4	-44.16
23/09/2021	WP21-08678	cpo4087	12.00	13.00	17692	9349	56.76	61	1.47	-16.018
23/09/2021	WP21-08678	cpo4087	13.00	14.00	21198	8364	65.65	78	1.5	-32.1
23/09/2021	WP21-08678	cpo4087	14.00	15.00	17931	7433	57.36	63	1.73	-10.062
23/09/2021	WP21-08678	cpo4087	15.00	16.00	20196	7204	63.11	67	1.74	-13.756
23/09/2021	WP21-08678	cpo4087	16.00	17.00	20939	7830	64.99	73	1.82	-17.308
23/09/2021	WP21-08678	cpo4087	17.00	18.00	16617	8353	54.03	61	1.7	-8.98
23/09/2021	WP21-08678	cpo4087	18.00	19.00	16688	8179	54.21	61	1.48	-15.712
20/10/2021	WP24-13562	cpo3849	3.00	4.00	3326	9120.25	20		0.991	30.3246
20/10/2021	WP24-13562	cpo3849	4.00	5.00	19345	9308.00	61	62.000	2	-0.8

Date	SGS Lab Report Lunber	Info	m from	m to	pXRF Ca (ppm)	pXRF S (ppm)	ANC pulp eqn (pXRF calc)	SGS ANC (kg H2SO4/t)	SGS Total S % (LECO)	MWM NAPP Calculation
20/10/2021	WP24-13562	cpo3849	5.00	6.00	12655	9946.25	44	25.000	1.74	28.244
20/10/2021	WP24-13562	cpo3849	6.00	7.00	5275	11563.00	25	4.000	1.51	42.206
20/10/2021	WP24-13562	cpo3849	7.00	8.00	14609	12176.00	49	32.000	1.32	8.392
20/10/2021	WP24-13562	cpo3849	8.00	9.00	14723	12454.75	49	43.000	1.35	-1.69
20/09/2021	WP21-08670	cpo3877	5.00	6.00	30217	11731	88.53	89	1.92	-30.248
20/09/2021	WP21-08670	cpo3877	6.00	7.00	20324	13287	63.43	58	2.19	9.014
20/09/2021	WP21-08670	cpo3877	7.00	8.00	15101	12839	50.18	51	2.49	25.194
20/09/2021	WP21-08670	cpo3877	8.00	9.00	20534	10789	63.96	64	1.61	-14.734
	WP24-13566	CPO3873	1.00	2.00				3	1.6	45.96
	WP24-13566	CPO3873	2.00	3.00				7	1.56	40.736
	WP24-13566	CPO3873	3.00	4.00				40	1.29	-0.526
	WP24-13566	CPO3873	4.00	5.00				58	1.49	-12.406
	WP24-13566	CPO3873	5.00	6.00				55	1.36	-13.384
	WP24-13566	CPO3873	6.00	7.00				32	1.58	16.348
	WP24-13566	CPO3873	7.00	8.00				33	1.61	16.266
	WP24-13566	CPO3873	8.00	9.00				57	1.42	-13.548
	WP24-13566	CPO3873	9.00	10.00				25	1.5	20.9
	WP24-13566	CPO3873	10.00	11.00				20	1.56	27.736
	WP24-13566	CPO3873	11.00	12.00				32	1.68	19.408
12/11/2021	WP24-13564	cpo3916	6.00	7.00	6122	10686	27.40		1.68	51.408
12/11/2021	WP24-13564	cpo3916	7.00	8.00	12341	12840	43.18	30	1.65	20.49
12/11/2021	WP24-13564	cpo3916	8.00	9.00	17887	11031	57.25	42	1.37	-0.078
12/11/2021	WP24-13564	cpo3916	9.00	10.00	36161	10357	103.61	75	1.41	-31.854
12/11/2021	WP24-13564	cpo3916	10.00	11.00	16768	12684	54.41	46	1.42	-2.548
12/11/2021	WP24-13564	cpo3916	11.00	12.00	17618	12747	56.57	52	1.36	-10.384
12/11/2021	WP24-13564	cpo3916	12.00	13.00	12446	12771	43.45	34	1.54	13.124
12/11/2021	WP24-13564	cpo3916	13.00	14.00	13928	12543	47.20	34	1.72	18.632
12/11/2021	WP24-13564	cpo3916	14.00	15.00	20132	13447	62.94	55	1.82	0.692
12/11/2021	WP24-13564	cpo3916	15.00	16.00	14381	12988	48.35	46	1.50	-0.1
12/11/2021	WP24-13564	cpo3916	16.00	17.00	16534	11783	53.82	81	1.43	-37.242
12/11/2021	WP24-13564	cpo3916	17.00	18.00	11086	12022	39.99	40	1.43	3.758
12/11/2021	WP24-13564	cpo3916	18.00	19.00	11865	11176	41.97	37	1.70	15.02
12/11/2021	WP24-13564	cpo3916	19.00	20.00	10564	8224	38.67	55	1.73	-2.062

	pXRF Ca (ppm)	pXRF S (ppm)	ANC pulp eqn (pXRF calc)	SGS ANC (kg H2SO4/t)	SGS Total S % (LECO)	MWM NAPP Calculation
Average	18075	11920	57.73	60	1.63	-9.85
Min	1899	2382	16.69	-5	0.39	-121.06
Max	50686	23554	140.46	174	2.49	56.81
Median	18747	11729	59.43	61	1.62	-11.26
# Samples	320	320	320	343	345	345

APPENDIX H ANNUAL OVERBURDEN SCHEDULE

MINE WASTE MANAGEMENT
GREENROAD GROUP

[redacted]

MEMORANDUM

Recipient:	[redacted] – Bathurst Resources Limited
From:	[redacted] – Mine Waste Management; [redacted] – Mine Waste Management
Date:	21 July 2026
Cc:	[redacted] – Mine Waste Management; [redacted] – Bathurst Resources Limited
Document Number:	J-NZ0453-011-M-FINAL
Document Title:	Annual Overburden Schedule: MFS, ESE, UWHR

Mine Waste Management Limited (MWM) was engaged by Bathurst Resources Limited (BRL) to provide a memorandum on the annual waste rock production for the Buller Plateaux Continuation Project (BPCP) (the Project). This memorandum presents a detailed summary, which will be used to support the assessment of environmental effects (AEE) for the Fast-track Approvals Act (FTAA) application.

This memorandum presents key data relating to overburden quantities for the BPCP. It focuses on the Escarpment Extended (ESE), Mount Frederick South (MFS), and the Upper Waimangaroa Haul Road (UWHR). The information is intended to support site establishment planning, environmental and geotechnical assessments, and construction sequencing.

OBJECTIVES

The objectives of this memorandum are as follows:

- Summarise overburden schedules for ESE and MFS by mine stage and indicative financial year.
- Present UWHR bulk fill and overburden quantities (Year 1 and 2).

ESE OVERBURDEN SCHEDULE

A materials schedule for ESE has been provided by BRL for Stage -1 to Stage 14. The dataset is split into potentially acid forming (PAF), non-acid forming (NAF), Low Risk, and High Acid Forming (HAF) material types and estimated extraction volumes are summarised in Table 1. For the purposes of material scheduling, HAF materials are managed under the same risk framework as PAF materials. This scheduling does not include Stockton and/or ESE borrow pit materials (i.e., granite, which is considered NAF).

Table 1: ESE overburden quantities

INDICATIVE YEAR	PROJECT STAGE	NAF	LOW RISK	PAF	HAF	TOTAL OVERBURDEN [1]
[redacted]	Stage -1	83,800	23,000	503,500	48,900	659,200
	Stage 0	258,700	403,800	2,428,700	1,257,100	4,348,200
	Stage 1	820,400	679,500	3,888,400	2,041,700	7,429,800
	Stage 2	610,200	294,000	4,935,700	1,763,300	7,603,100
	Stage 3	1,591,700	694,800	5,957,300	1,560,500	9,804,100
	Stage 4	2,421,200	482,500	4,202,500	2,819,600	9,925,600
	Stage 5	3,779,500	378,400	2,958,200	2,822,500	9,938,500
	Stage 6	3,536,300	481,300	5,185,700	636,600	9,839,800
	Stage 7	3,123,300	1,798,600	3,105,600	1,886,100	9,913,400
	Stage 8	2,670,100	2,446,800	3,882,200	803,700	9,802,600
	Stage 9	3,862,300	1,615,500	3,250,200	1,195,200	9,923,000
	Stage 10	4,403,500	1,131,400	3,013,400	983,700	9,531,900
	Stage 11	3,126,900	514,100	4,659,400	1,146,900	9,447,200
	Stage 12	1,862,300	432,800	5,672,800	1,062,500	9,030,200
	Stage 13	3,260,800	540,200	4,040,300	962,600	8,803,800
	Stage 14	1,418,800	27,600	720,200	19,400	2,185,800
Grand Total [1]		36,828,900	11,943,600	58,403,500	21,009,600	128,185,500

All results in bcm (bank cubic meters)

[1] Total overburden and grand totals are calculated and rounded from source data; therefore, may not equal the sum of the rounded figures shown.

[2] Green cells represent the Construction Phase.

Overburden materials are predominantly comprised of PAF (46%) with moderate quantities of HAF (16%), NAF (29%), and Low Risk materials (9%). Variability is evident over the reporting period with:

- Low Risk and NAF projected to be most abundant in Stages 5–14 (> 40%), except for Stages 11 and 12 where high-risk materials (PAF & HAF) increase to > 60% of total mined volumes (Figure 1B).
- The largest volume and highest projected proportion of Low Risk materials is forecasted for Stage 8 (25%).
- From Stages -1 to 7 high-risk materials (HAF & PAF) are projected to comprise > 50% of extracted materials.
- The highest ratio of high-risk to low-risk materials is projected for Stage 2 and the lowest in Stage 14.

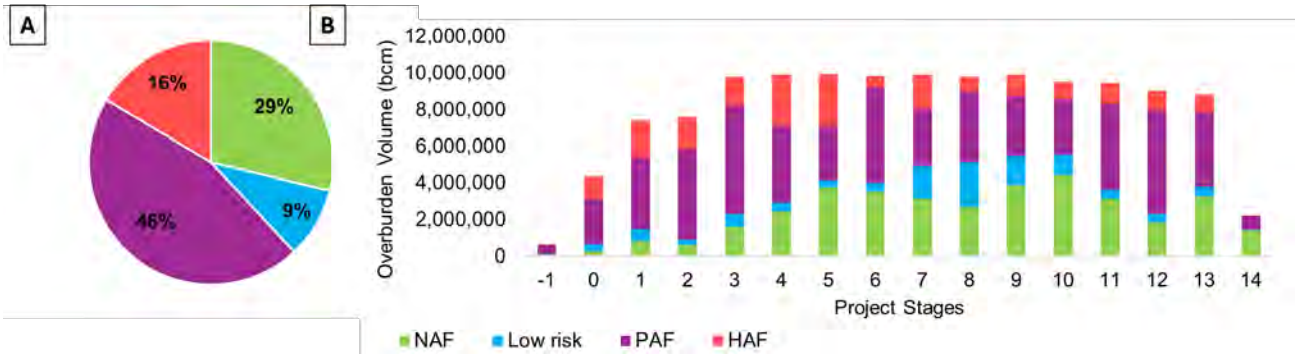


Figure 1: ESE overburden summary based on AMD classification

(A) Summary of ESE overburden volume by classification (Stage -1 – Stage 14).
(B) Total forecasted ESE overburden volumes and proportional composition by mine development stage.

The distribution of overburden types over the 16-year project period suggests that scheduling of PAF and NAF placement will be necessary to optimise encapsulation.

MFS OVERBURDEN SCHEDULE

A materials schedule for MFS has been provided by BRL for Stage -1 to Stage 14. The dataset is split into potentially acid forming (PAF), non-acid forming (NAF), Low Risk, and High Acid Forming (HAF) material types and estimated extraction volumes are summarised in Table 2. For the purposes of material scheduling, HAF materials are managed under the same risk framework as PAF materials. This scheduling does not include Stockton and/or ESE borrow pit materials (i.e., granite, which is considered NAF).

Table 2: MFS overburden quantities

INDICATIVE YEAR	PROJECT STAGE	NAF	LOW RISK	PAF	HAF	TOTAL OVERBURDEN [1]
	Stage -1	-	365,500	30,100	-	395,600
	Stage 0	599,300	210,800	414,100	169,900	1,394,100
	Stage 1	724,100	87,000	38,100	1,700	850,700
	Stage 2	529,300	80,200	17,000	300	626,600
	Stage 3	149,100	154,700	150,300	5,700	459,700
	Stage 4	413,400	107,800	39,800	500	561,400
	Stage 5	130,800	64,100	61,700	-	256,600
	Stage 6	1,023,500	55,600	25,200	5,700	1,109,800
	Stage 7	1,108,300	143,500	198,800	9,300	1,459,700
	Stage 8	771,900	239,200	499,900	1,500	1,512,400
	Stage 9	1,845,900	108,200	154,700	4,500	2,113,100
	Stage 10	980,000	216,100	181,400	44,900	1,422,200
	Stage 11	367,700	125,100	227,800	151,300	871,900
	Stage 12	1,809,000	255,300	202,700	66,800	2,333,600

INDICATIVE YEAR	PROJECT STAGE	NAF	LOW RISK	PAF	HAF	TOTAL OVERBURDEN [1]
[redacted]	Stage 13	405,000	170,000	200,200	2,300	777,300
	Stage 14	8,300	14,400	41,300	1,500	65,400
Grand Total [1]		10,865,600	2,397,500	2,483,100	465,900	16,212,100

All results measured in bcm (bank cubic meters), - indicates no volume to be extracted during this Stage.

[1]Total overburden and grand total are calculated and rounded from source data; therefore, may not equal the sum of the rounded figures shown.

[2]Green cells represent the Construction Phase.

Overall, forecasted overburden consist of 82% low-risk material (NAF and Low Risk) and 18% high-risk material (PAF and HAF, Figure 2). Variability is evident with:

- Low Risk and NAF materials exceeding 80% of forecasted overburden in Stage -1, Stage 1, Stage 2, Stage 4, Stage 6, Stage 7, Stage 9, Stage 10, and Stage 12.
- Periods of increased proportions of high-risk material (PAF & HAF) (> 40%), are forecasted for Stage 0, Stage 11, and Stage 14. In Stage 14, despite lower total extraction volumes, high-risk material (PAF & HAF) is expected to comprise approximately 65% of total overburden. Mitigation measures such as temporary stockpiles, rehandling, or limestone addition may be required during these phases.

HAF is projected to account for 17% of extracted materials in Stage 11,

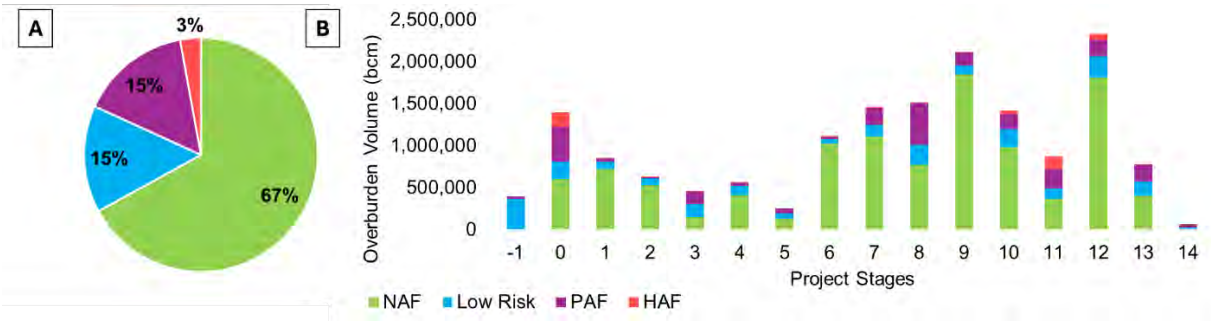


Figure 2: MFS overburden summary based on AMD classification

(A) Summary of MFS overburden volume by classification (Stage -1 – Stage 14).

(B) Total forecasted MFS overburden volumes and proportional composition by mine development stage.

UWHR CONSTRUCTION QUANTITIES & ROCK TYPES

UWHR bulk fill requirements have been determined by BRL and summarised in this section.

The bulk fill strategy for the construction of the UWHR relies exclusively on competent rock sources recovered from cut operations within Brunner Coal Measures (BCM) and imported granite from the Stockton borrow pits, which is classified as NAF.

No Kaiata mudstone (KMS) or colluvial materials are used in the construction of the haul road due to their poor geotechnical performance. The total excavated BCM volumes available for reuse have been quantified by road section (Table 3). Likewise, the total volume of BCM unsuitable for placement, due to geochemical or lithological constraints, are also provided (Table 3).

Table 3: UWHR material balances (8.6 m pavement go forward case)

			UNSUTABLE FOR CONSTRUCTION*			
ROAD SEC	**CATCHMENT**	**BCM DESIGN CUT TO FILL**	**ESE PAF ELF**	**ESE NAF ELF**	**CYP PAF ELF**	**CYP NAF ELF**
		(m^3)	(m^3)	(m^3)	(m^3)	(m^3)
E2C	Burnett's	14,049	-	-	-	-
C2B	Burnett's	26,455	-	-	-	-
B2B	Burnett's	3,528	-	-	-	-
B2B	Gomorrah Ck	7,928	3,374	-	-	-
B2B	Upper Waimangaroa	-	322	932	-	-
B2F	Upper Waimangaroa	24,368	-	7,358	-	-
F2C	Upper Waimangaroa	-	-	-	3,266	4,894
Total	-	76,327	3,696	8,290	3,266	4,894

**Fill north of ford and south of Cypress Mine, a mixture of colluvium and basement, which may include Kaiata Mudstone (NAF or PAF) – percentage uncertain.*

BCM = Brunner Coal Measures, ESE = Escarpment Extended, CYP = Cypress

The fill volumes for the UWHR are provided in Table 4, which are concentrated in a small number of locations, particularly in the F2C and C2B sections. This localised placement of BCM rather than granite requires planning to mitigate potential AMD effects.

Table 4: Bulk fill summary by road section

ROAD SEC	CATCHMENT	VOLUME (m^3)	BULK FILL TYPE*
E2C	Burnett's	17,944	BCM
C2B	Burnett's	56,464	BCM
B2B	Burnett's	1,150	BCM
B2B	Gomorrah Ck	10,683	BCM
B2B	Upper Waimangaroa	3,094	BCM
B2F	Upper Waimangaroa	19,241	BCM
F2C	Upper Waimangaroa	91,169	Granite
Total	-	199,745	-

**Does not include road base and surfacing which is inert borrow-pit-sourced granite*

Material balances need to be reviewed to ensure sufficient NAF and BCM-PAF materials are available. Where these are insufficient, granite will be used from the Stockton and/or ESE borrow pits.

SUMMARY

The following summary is provided:

- ESE volumes indicate that PAF material accounts for approximately 46% of total projected overburden. From Stages -1 to 7 high-risk materials (HAF & PAF) are projected to comprise > 50% of extracted materials, , which requires consideration for mine planning. There is a relative increase in low-risk materials (NAF and Low Risk) for Stage 7 – Stage 14.
- MFS waste schedule indicates overburden is predominantly low-risk (82% NAF and Low Risk); however, variability is evident throughout the reporting timeframe, including periods of increased proportions of higher risk (PAF & HAF) materials (> 40%) across Stage 0, Stage 11 and Stage 14.
- UWHR bulk fill demand is primarily met by granite and BCM material, with major fills concentrated at a limited number of locations.

CLOSING REMARKS

Please do not hesitate to contact Paul Weber at [redacted] should you wish to discuss this matter in greater detail.

APPENDIX I ESCARPMENT MINE - BARREN VALLEY ELF WATER QUALITY MODEL

Escarpment Mine

Barren Valley ELF Water Quality Model

20 July 2026

J-NZ0349-008-R-FINAL

MINE WASTE MANAGEMENT
GREENROAD GROUP

BATHURST RESOURCES LIMITED

Escarpment Mine

Barren Valley ELF Water Quality Model

Document Number: J-NZ0349-008-R-FINAL

Document Date: 20 July 2026

Prepared for:

Bathurst Resources Limited

Bathurst Resources Limited
[redacted]

Prepared by:

Mine Waste Management Limited

[redacted]
www.minewaste.com.au

REVISION	DATE	AUTHOR	RECORD OF REVIEW
J-NZ0349-008-R-FINAL	20/07/2026	CH/SH/PW	PW

EXECUTIVE SUMMARY

Bathurst Resources Limited (BRL) is seeking to obtain authorisation through the Fast-track Approvals Act (FTAA) to progress development and mining of the coal resources across the wider Buller Plateaux. This project is referred to as the Buller Plateaux Continuation Project (BPCP or Project).

The purpose of the BPCP is to reconsent the existing infrastructure and mining operations associated with the existing Stockton Mine and provide access to additional coal mining areas across the Buller Plateaux, as the coal resource in the current Stockton Mine is close to depletion, and further coal resources for blending are required. There are five key project sub-areas:

- Stockton mining area (Stockton)
- Mount Frederick South (MFS)
- Escarpment Extended (ESE)
- Upper Waimangaroa Haul Road (UWHR)
- Cypress mining area (Cypress)

Background

Mine Waste Management Limited (MWM) has developed this report to support BRL with the assessment of environmental effects (AEE) for the BPCP. This report relates to the development of a water quality model for the Barren Valley Engineered Landform (BV ELF), located at the existing Escarpment Mine, which is currently under care and maintenance.

The objectives of this report are:

- Update the BV ELF water quality model using new data to understand flow, water quality, and potential constituents of concern (PCOC).
- Develop a load model, based on empirical data from the BV ELF, to estimate seepage water quality for ELFs associated with ESE and MFS sub-areas of the Project.

BV ELF Water Quality Load Model

The BV ELF has been monitored and studied since 2014, when construction commenced and provides a full-scale landform to understand geochemical trends. The empirical data from this site (flow and quality) provides a strong analogue dataset to construct water quality models for other ELFs that are proposed as part of the BPCP. However, unlike the proposed BPCP ELFs there are some minor variances that need to be considered. For instance:

- The BV ELF has been covered with non-acid forming (NAF) overburden but is not rehabilitated or revegetated. Therefore, the net percolation and oxygen flux rates are likely to be higher in the BV ELF compared to BPCP ELFs as determined by cover system studies (MWM, 2026c).
- Performance monitoring data for the BV ELF demonstrates that the ELF construction technique has, in places, limited oxygen ingress to diffusion, however parts of the ELF are affected by

advective ingress of oxygen. This means that oxidation processes and acid generation rates are likely to be higher in the BV ELF than an ELF that limits advective oxygen flux.

Hence, the BV ELF provides a unique opportunity to confidently model and scale water quality results from an ELF that is analogous to those that are proposed at ESE and MFS.

The BV ELF water quality model involved the development of a conceptual site model (CSM) to support the derivation of flow rates and PCOC loads based on measured water quantity and quality. Components of the model include:

- Run-on seepage (the Pluto Bund, Red Shed Adit, Red Shed Pit Pond).
- AMD generated within the BV ELF that reports to the BV ELF underdrain.

The purpose of understanding the acid and metalliferous drainage (AMD) sources is to understand the acidity loads discharging from the BV ELF, and by difference, determine the acidity load mobilised by net percolation (NP) of rainfall, through the ELF materials.

Results indicate the following:

- The average flow rate was 3.35 L/s based on sonde data (May 2023 to July 2024). This is assumed to fairly represent the flow derived from NP after consideration of run-on water and water loss due to seepage from the ELF.
- A peak acidity from the BV ELF of 183 mg $CaCO_3$/L.
- The peak sulfate (SO_4) concentration was 386 mg/L, which corresponds to a peak acidity load of 42.5 t $CaCO_3$/yr (assuming all sulfate is derived from pyrite oxidation). Results indicate that the sulfate:measured acidity ratio is 2.1 indicating significant neutralisation (i.e., ~50%) within the ELF, relating to minor ANC and the addition of limestone (1.16 kg/t) during construction (~962 t). This is supported by empirical data that indicates from March 2017 to April 2024:
    - that ANC/limestone (based on dissolved Ca) contributed to the neutralisation of 75 mg $CaCO_3$/L.
    - that acidity derived from sulfate (i.e., pyrite) was 185 mg $CaCO_3$/L.
    - that measured acidity (pH 8.3) was 117 mg $CaCO_3$/L.

This indicates that measured acidity is within ~5% of calculated acidity (based on SO_4 acidity minus Ca alkalinity). Data indicates that ANC and limestone provide significant neutralisation and is of benefit to the Project to mitigate the effects of sulfide mineral oxidation.

BV ELF Seepage Quality

Three distinct water quality phases were identified for the BV ELF:

<u>Phase 1: Construction Phase</u>

- August 2014 – April 2016.

- Low PCOC concentrations that increase with an increasing amount of waste rock placement within the ELF and gradual wetting up of the materials.
- Generally, peak concentration of PCOC coincide with maximum material placement.

Phase 2: Stabilisation Phase

- May 2016 – December 2017 (20 months).
- Flow rates are generally stable as the ELF wets up and then flushes stored oxidation products from the waste rock. For the BPCP, it is assumed the duration of the Stabilisation Phase for final rehabilitated areas of the ELF also aligns with the duration of the draindown phase (created by the installation of a lower permeability cover system).
- Concentrations of PCOC remain stable.
- The majority of stored oxidation products are flushed by the end of the Stabilisation Phase.

Phase 3: Decay Phase

- January 2018 – onwards.
- Phase 3 relates to the decrease in PCOC concentrations from peak concentrations observed in the Stabilisation Phase.
- During this phase, water infiltration rates remain steady, but the rate of solute generation declines (lesser oxidation of sulfides and minor flushing out of stored oxidation products).

ELF Seepage Water Quality Model

Two ELF load models were developed including the stored oxidation product (SOP) load model and the sulfide oxidation (SOX) load model, which were developed using empirical data from the BV ELF and other supplementary data sources to derive:

- Sulfate concentration over the three water quality phases considering two processes:
    - Dissolution of stored oxidation products: This relates to the release of solutes in the short term due to flushing of readily available soluble minerals by net percolation through the ELF. This was assessed using the SOP load model.
    - Oxidation of sulfides: This relates to ongoing generation of sulfate and associated solutes over the long term due to oxygen ingress and the oxidation of sulfide minerals. This was assessed using the SOX load model.
- PCOC concentrations were derived from sulfate relationships, observed in the BV ELF Drainage and other empirical datasets (e.g., Stockton Mine AMD and column leach tests).
- The duration of the Stabilisation Phase is based on the average height of the ELF and aligns with previous studies of the draindown phase duration for the original Escarpment ELF (e.g., Okane Consultants (2015)).
- The Decay Phase is due to:

- Natural decay of acidity loads due to flushing out of stored oxidation products and decreasing oxidation rates of reactive sulfides.
- ELF design where rocks > 10 m depth are within a sub-oxic zone and are not generally generating further acidity.
- The load model uses a 9.6% annual decrease per year to align with BV-ELF empirical data before transitioning to a long-term acidity load decay 0.62% per year.

Sensitivity Modelling

Sensitivity modelling was undertaken during the development of the ELF seepage water quality model. This included:

- Application of the calculated total SOP load produced by the BV ELF to varying BV ELF volumes. A 15 m shell was selected as a conservative approach where all load was assigned to the 15 m shell. This is considered conservative as there are parts of the ELF, at depth > 15 m horizontal that are oxidising, contributing to load, hence incorporating this load generates a higher load which is assigned to the rocks in the shell
- Estimation of SOP load through investigation of a range of sulfate water quality data from the Stabilisation Phase from the BV ELF.
- Assessment of the wt% sulfur and sulfate decay rates from column leach testing of MFS and the existing Escarpment Mine material to estimate stored oxidation load.
- Estimation of SOP load from the difference between sulfate water quality data from the Stabilisation Phase and one year post stabilisation from the BV ELF.

One model scenario was chosen to represent BV ELF seepage, which was fitted to empirical data, and this was used to forecast the water quality from the six engineered landforms at the proposed ESE sub-area and the fourteen engineered landforms at the proposed MFS sub-area. This provided a deterministic estimate for water quality, based on empirical data and trends that was adjusted for varying ELF sulfur content. Given the reliance on these deterministic model values, the water and load balance models that were undertaken for ESE and MFS (MWM, 2026f,g) were stress tested with metal loads in ELF seepage being run at ±30% of the Base Case scenario.

Nitrogenous Compounds

The risks associated with the uses of ammonium-nitrate fuel oil (ANFO) explosives was assessed. Water quality data from Stockton and Escarpment mines indicates that nitrate nitrogen and ammoniacal nitrogen are low in recently blasted pit water, seepage to pits from backfill, and from seepage from ELFs.

The development of a model, based on empirical data from the BV ELF and the ELF Seepage Water Quality Model suggested that nitrogenous compounds will be low in BPCP ELF seepage. Performance monitoring is recommended to confirm this assumption.

TABLE OF CONTENTS

1 Introduction 1
1.1 Objectives 1
2 Waste Rock Storage Hydrogeochemical Processes 2
2.1 Lateral Flow within ELFs 2
2.1.1 Management Implications 2
2.1.2 Field Trial Data 3
2.2 Flow Rate and Constant Concentration Model 3
2.3 Advective Oxygen Flux 4
2.4 Sulfur Adjustment Factor 6
2.5 Zinc 6
2.6 AMD Decay 10
2.6.1 Underground Coal Mines 10
2.6.2 Stockton Coal Mine 10
2.6.3 Mangatini Catchment – Stockton Coal Mine 11
2.6.4 Summary 12
2.7 Summary 12
3 BV ELF Conceptual Site Model 13
3.1 Escarpment Mine Overview 13
3.2 BV ELF: As-Built Design 14
3.3 Barren Valley ELF Conceptual Site Model 14
4 BV ELF Flow Rates 16
4.1 Rainfall 16
4.2 Pluto Bund Seepage 16
4.3 Red Shed Adit 16
4.4 Red Shed Pit Highwall Catchment 17
4.5 Red Shed Pit Pond 18
4.6 BV ELF Weir 18
4.7 Water Balance and Summary 21
5 BV ELF Water quality 22
5.1 Pluto Bund Water Quality 22
5.2 Red Shed Adit Water Quality 23
5.3 BV ELF Seepage Water Quality 24
5.4 BV ELF Seepage Water Quality 25
5.4.1 BV ELF Timeseries Data Plots 25
5.4.2 BV ELF Sulfate: PCOC Analysis 30
5.4.3 BV ELF Data 33
5.5 Column Leach Test Data 34
5.6 S23 Water Quality Data 35
5.7 Arsenic 36

5.7.1 Column Leach Test Data 36
5.7.2 Mangatini Catchment 37
5.7.3 MSR Passive Treatment 39
5.7.4 Summary 39
6 BV ELF Geochemical Model 40
6.1 Introduction 40
6.2 Stabilisation Phase Duration 41
6.3 Phase 3 – Decay Phase 42
7 ELF Load Model 44
7.1 Load Models 44
7.2 Sulfide Oxidation (SOX) Load Model 44
7.3 Stored oxidation Product (SOP) Load Model 45
7.4 Load Model Application to the BV ELF 47
7.5 ELF Load Model Approach 49
7.5.1 Flow 49
7.5.2 SOX 50
7.5.3 SOP 50
7.5.4 Sulfur 50
7.5.5 Decay 50
7.6 Water Quality Model 50
7.6.1 pH Estimation 51
7.7 BPCP ELF basal sub-catchments 52
7.8 Empirical Dataset Model Development 53
8 Limestone Dosing 55
8.1.1 Background 55
8.1.2 Analysis 55
8.1.3 Review 57
9 Nitrogenous Compounds 58
9.1 Stockton ANFO Usage 58
9.2 Data Review 58
9.3 Nitrate Reduction due to Pyrite 60
9.4 Geochemical Modelling 60
9.4.1 Data Review 60
9.4.2 Nitrate Concentration Model Development 62
9.4.3 BPCP ELF Nitrate Concentrations 62
9.4.4 Brunner Coal Measures Baseline Nitrate Concentrations 63
9.5 Summary 64
9.6 Performance Monitoring 64
9.7 Adaptive Management 64
10 Summary and Recommendations 66
10.1 Water Quality Model 66

10.2 ELF Seepage Water Quality Model 66
10.3 Sensitivity Modelling 67
10.4 Key Components for ELF Seepage Water Quality Forecasting 68
10.5 Risk Management 68
10.6 Recommendations 69
11 References 70
12 Limitations 74
Appendix A Abbreviations 75
Appendix B Limitations 78

LIST OF TABLES

Table 1: SN3 Dump lysimeter results: 5m lift versus end-dumped infiltration rates. 3
Table 2: Escarpment Mine - domain summary 13
Table 3: BV ELF parameters 14
Table 4: BV ELF CSM components. 15
Table 5: RSPP water balance model. 18
Table 6: BV ELF water balance. 21
Table 7: Pluto Bund seepage water quality data (April 2022 – November 2023). 22
Table 8: Red Shed water quality data (February 2015 – October 2015). 23
Table 9: BV ELF water quality (May 2016 to April 2024). 33
Table 10. Stabilisation Phase duration. 41
Table 11. BV ELF data applied to load models 48
Table 12. Water quality estimates as a function of sulfate. 51
Table 13. BPCP ELF basal sub-catchments 52
Table 14. Nitrate and ammoniacal-N data for various mine domains (Stockton and Escarpment) 59
Table 15. Estimated maximum nitrate concentration of BPCP basal ELF sub catchments. 63
Table 16. Sensitivity modelling 67

LIST OF FIGURES

Figure 1: Cypress North ELF lateral drainage along running surfaces 2
Figure 2: Fanny Creek Side Cast, Island Block Mine, West Coast. 4
Figure 3: Globe Progress Mine, West Coast. 4
Figure 4: BV ELF: Oxygen probe results – Probe Set 2. 5
Figure 5: BV ELF: Oxygen probe results – Probe Set 1. 5
Figure 6: Ni and Zn concentration heat maps for framboidal pyrite (Stockton Mine). 6
Figure 7: Ni and Zn concentration heat maps for euhedral pyrite (Stockton Mine). 7
Figure 8: pXRF results for Zn versus total sulfur wt% (MFS Project sub-area) 7
Figure 9: pXRF results for Zn versus total sulfur % showing lower sulfur materials (MFS Project sub-area). 8
Figure 10: Sulfate versus Zn content for Mount Frederick South column leach test data. 8
Figure 11: Zn versus trace element concentrations (Brunner Coal Measures). 9
Figure 12: Relationship between Zn release and acidity for wall wash samples 9
Figure 13: Egypt control trial pad data: sulfate 11
Figure 14: Mangatini catchment acidity load forecast. 12
Figure 15: Escarpment Coal Mine overview. 14
Figure 16: BV ELF CSM. 15

Figure 17: Pluto Pond / Bund and potential seepage to the BV ELF. 16
Figure 18: Red Shed Adit sonde data. 17
Figure 19: Highwall Catchment and RSPP area. 17
Figure 20: Manual flow measurements vs calculated flow with stage height. 19
Figure 21: BV ELF water level and rainfall. 20
Figure 22: BV ELF acidity concentration. 25
Figure 23: BV ELF pH and acidity concentrations (February 2015 – April 2024). 26
Figure 24: BV ELF Al and Fe concentrations (February 2015 – April 2024). 27
Figure 25: BV ELF Mn and Ni concentrations (February 2015 – April 2024). 28
Figure 26. BV ELF Zn and SO_4 concentrations (February 2015 – April 2024). 29
Figure 27: BV ELF Ca concentration (February 2015 – April 2024). 29
Figure 28: Sulfate versus PCOC: Acidity, Al, Ni, Fe. 30
Figure 29: Sulfate versus PCOC: Zn, Mn, Mg, Ca, pH, and DOC. 31
Figure 30: Sulfate versus PCOC: Cr, Co, Cd, Cu. 32
Figure 31: Sulfate versus PCOC: K, Tl, Na, and Pb. 32
Figure 32: ESE (Columns 1-7) and MFS (samples DC16) Column Leach test data. 34
Figure 33: Column leach test sulfate versus PCOC: Tl, Pb, Na, and K. 35
Figure 34: S23 Sulfate versus PCOC: Cd, Cr, Co, Cu. 36
Figure 35: Arsenic and sulfate relationship for column leach tests. 37
Figure 36: Arsenic and sulfate relationship for Mangatini water quality monitoring sites. 38
Figure 37: Arsenic and sulfate relationship for AMD affected water quality monitoring sites. 38
Figure 38: As extraction profile for Manchester Street MSR, Stockton 39
Figure 39. Sensitivity analysis evaluating draindown for a 50 m high ELF. 42
Figure 40. BV ELF sulfate generation rates. 43
Figure 41. Derivation of SOX load from BV ELF sulfate data. 45
Figure 42. Derivation of SOP load model from BV ELF sulfate data. 46
Figure 43. Calculated BV ELF load models and BV ELF sulfate data. 49
Figure 44: Correlation of the Acidity to pH 5 and pH in the Millerton Catchment and at NR 52
Figure 45. Limestone dosing of the BV ELF. 55
Figure 46. Ratio between acidity calculated from H_2SO_4 and the $CaCO_3$ neutralisation 56
Figure 47. Cypress Pit showing the location of water samples to assess ANFO effects. 59
Figure 48. Time series plot of nitrate-N and sulfate data for the BV ELF. 61
Figure 49. Relationship between nitrate-N and sulfate data for the BV ELF. 61
Figure 50. BV ELF nitrate-N model. 62

1 INTRODUCTION

Bathurst Resources Limited (BRL) is seeking to obtain authorisation through the Fast-track Approvals Act (FTAA) to progress development and mining of the coal resources across the wider Buller Plateaux. This project is referred to as the Buller Plateaux Continuation Project (BPCP or Project).

The purpose of the BPCP is to reconsent the existing infrastructure and mining operations associated with the existing Stockton Mine and provide access to additional coal mining areas across the Buller Plateaux, as the coal resource in the current Stockton Mine is close to depletion, and further coal resources for blending are required. There are five key project sub-areas:

- Stockton mining area (Stockton)
- Mount Frederick South (MFS)
- Escarpment Extended (ESE)
- Upper Waimangaroa Haul Road (UWHR)
- Cypress mining area (Cypress)

Mine Waste Management Ltd (MWM) has developed this report to support Bathurst Resources Limited (BRL) with the assessment of environmental effects (AEE) for its proposed mining activities. This report relates to the development of a water quality model for the Barren Valley Engineered Landform (BV ELF) located at the Escarpment Mine.

1.1 Objectives

The objectives of this report are:

- Update the BV ELF water quality model using new data to understand flow, water quality, and potential constituents of concern (PCOC).
- Develop a load model, based on empirical data from the BV ELF, to estimate seepage water quality for ELFs associated with the ESE and MFS sub-areas of the Project.

2 WASTE ROCK STORAGE HYDROGEOCHEMICAL PROCESSES

The following section provides an explanation of the hydrogeochemical processes associated with waste rock storage facilities such as an engineered landform (ELF).

2.1 Lateral Flow within ELFs

Lateral flow can occur within engineered landforms along compacted running surfaces such that not all net percolation (NP) from rainfall entering the ELF reports as basal toe seepage. Rather some seepage could report to the outer ELF batter slopes. An example of this lateral seepage is presented in Figure 1 for the Cypress North ELF at the existing Cypress Mine, Stockton.

2.1.1 Management Implications

This has several implications for ELF water management:

- Direct basal toe seepage quantities will be lesser than the amount of NP. The assumption that all NP (i.e., flow) reports directly as basal seepage is thus conservative. For modelling this provides confidence that the quality of water requiring management is a maximum.
- Discharge of lateral seepage to batter slopes could impact soils and revegetation efforts. The management of this risk needs to include the placement of a non-acid forming (NAF) layer prior the placement of soils / vegetation to ensue this seepage is captured and reports to the ELF toe for management (i.e., flow needs to be directed along the PAF[1]/NAF[2] boundary and not along the soil contact).

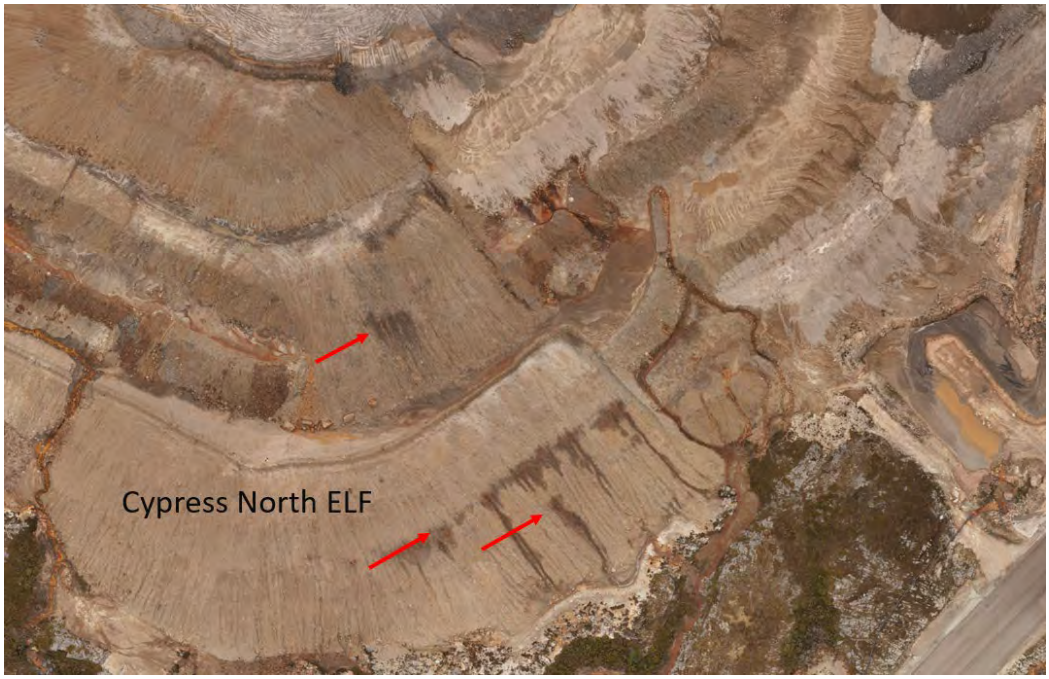


Figure 1: Cypress North ELF lateral drainage along running surfaces

Red arrows indicate seepage along buried running surfaces.

[1] *Potentially acid forming*

[2] *Non-acid forming*

2.1.2 Field Trial Data

Data are available from field trials conducted in 2007 at the Stockton Coal Mine by Solid Energy New Zealand Limited (Table 1). Two 200 L lysimeters, filled with gravel, were installed in the SN3 Dump area where:

- Lysimeter 1 was placed beneath 5 m end-dumped materials
- Lysimeter 2 was placed beneath 5 m compacted lifts

Monitoring was undertaken over four sampling periods with end-dumped materials having a NP rate of 67.5 – 90.3% and 5 m compacted lifts having a NP of 12.2 – 36.5%. Although the results may be compromised by the different permeabilities in the 200 L lysimeter versus in the materials around the lysimeter, the absolute results suggest that compaction might create lateral drainage pathways that could shed ~50% of NP.

Data presented in Table 1 also indicates that the higher rainfall periods might have lower infiltration into the end-dumped material, suggesting greater lateral flow for higher rainfall events.

Table 1: SN3 Dump lysimeter results: 5m lift versus end-dumped infiltration rates.

PERIOD	LYSIMETER VOLUME (END DUMPED 5 m DEPTH)	LYSIMETER VOLUME (COMPACTED 5 m LIFTS)	RAINFALL	INFILTRATION RATE- END DUMPED MATERIAL	INFILTRATION RATE- 5 m COMPACTED MATERIAL
13/4 to 27/4	6.0 litres	1.8 litres	28.8 mm	90.30%	26.60%
27/4 to 11/5	31.7 litres	5.7 litres	205 mm	67.50%	12.20%
11/5 to 18/5	17.2 litres	7.2 litres	111 mm	67.60%	28.50%
18/5 to 27/5	26.7 litres	7.6 litres	91.2 mm	78.20%	36.50%

Source: BRL

2.2 Flow Rate and Constant Concentration Model

Previous work (e.g., Mackenzie, 2010; Weber et al., 2015) has demonstrated that although PCOC concentrations in seepage from a waste rock stack (WRS) can remain approximately constant irrespective of flow rate, with increasing flow the PCOC load increases proportional to flow rate (Figure 2 and Figure 3). This demonstrates that the waste rock has a reservoir of stored oxidation products that are mobilised by increasing water flow through the materials driving an approximate constant concentration.

Any forecast of water quality from ELFs, as part of this study, therefore assumes constant concentration (for the same size ELF with the same sulfur content), on an annual basis where flow is determined by NP modelling. Hence flow drives load and subsequent water treatment requirements.

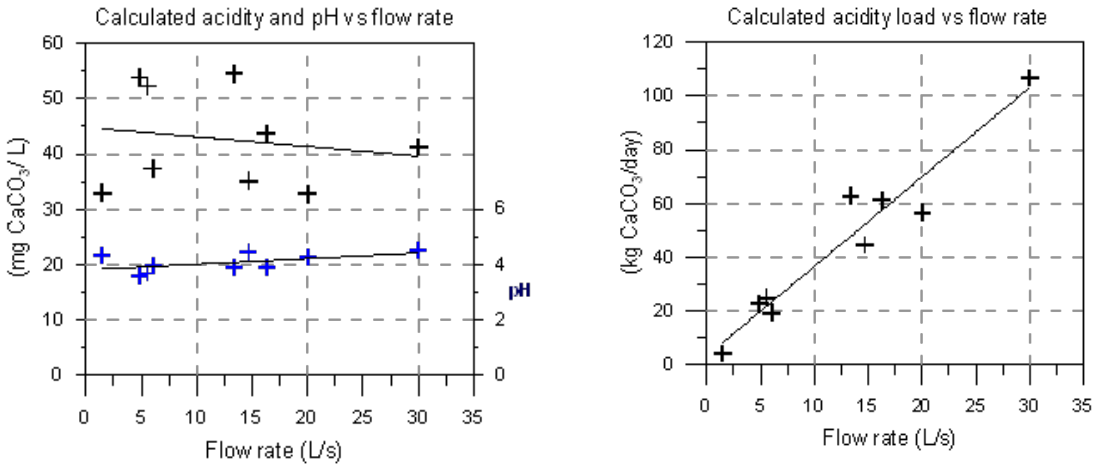


Figure 2: Fanny Creek Side Cast, Island Block Mine, West Coast.

Source: Mackenzie (2010).

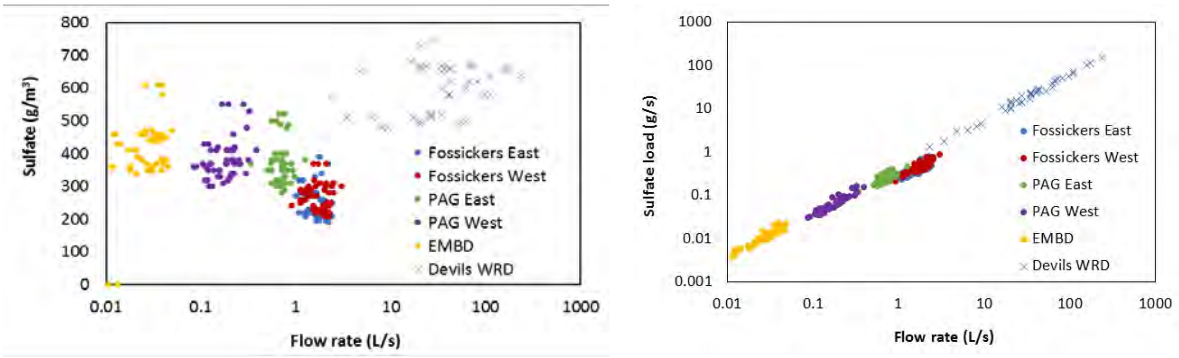


Figure 3: Globe Progress Mine, West Coast.

Source: Weber et al. (2015).

2.3 Advective Oxygen Flux

Although the BV ELF was designed to exclude high air flow (and oxygen) into the core of the ELF, at times poor quality control during construction resulted in areas of advective airflow into the core of the ELF (Figure 4 and Figure 5), which means the BV ELF is behaving more like a traditional WRS rather than an engineered landform in places. However, the fact that parts of the WRS demonstrate control of advective oxygen ingress and a clear diffusion pathway is demonstrated (Figure 5), confirms that the control of advective oxygen ingress can be achieved for the BPCP materials. Such observed decreases in oxygen content with depth into a WRS indicate that oxygen ingress is by diffusion rather than advective ingress of oxygen (Ritchie, 1994). The BV ELF is probably a midpoint between an ELF (no advection) and a WRS (advection the key driver of oxidation) with Figure 5 indicating oxygen ingress is minimal at 15 m distance into the BV ELF. Robust quality control is required for the construction of ELFs at MFS and ESE.

Oxygen probes installed at the Cypress Northern ELF at the Cypress Mine on the Stockton Plateau indicate beyond 6 m into the ELF, oxygen content can be below 1% (Pope et al., 2016). Future ELF construction practices must ensure that design criteria are met, and that oxygen is limited to diffusion. This is a key design requirement to avoid long term management of high acidity loads.

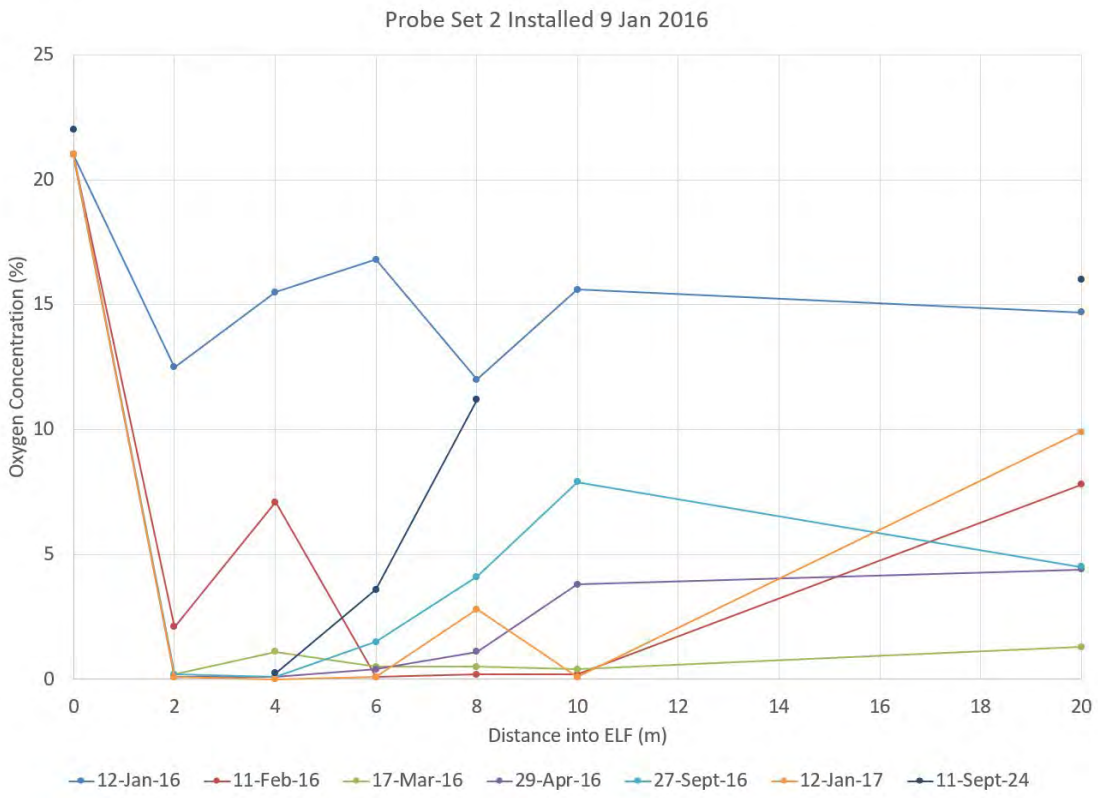


Figure 4: BV ELF: Oxygen probe results – Probe Set 2.

Note: high oxygen content in January 2016 was only a few days after the probes were installed.

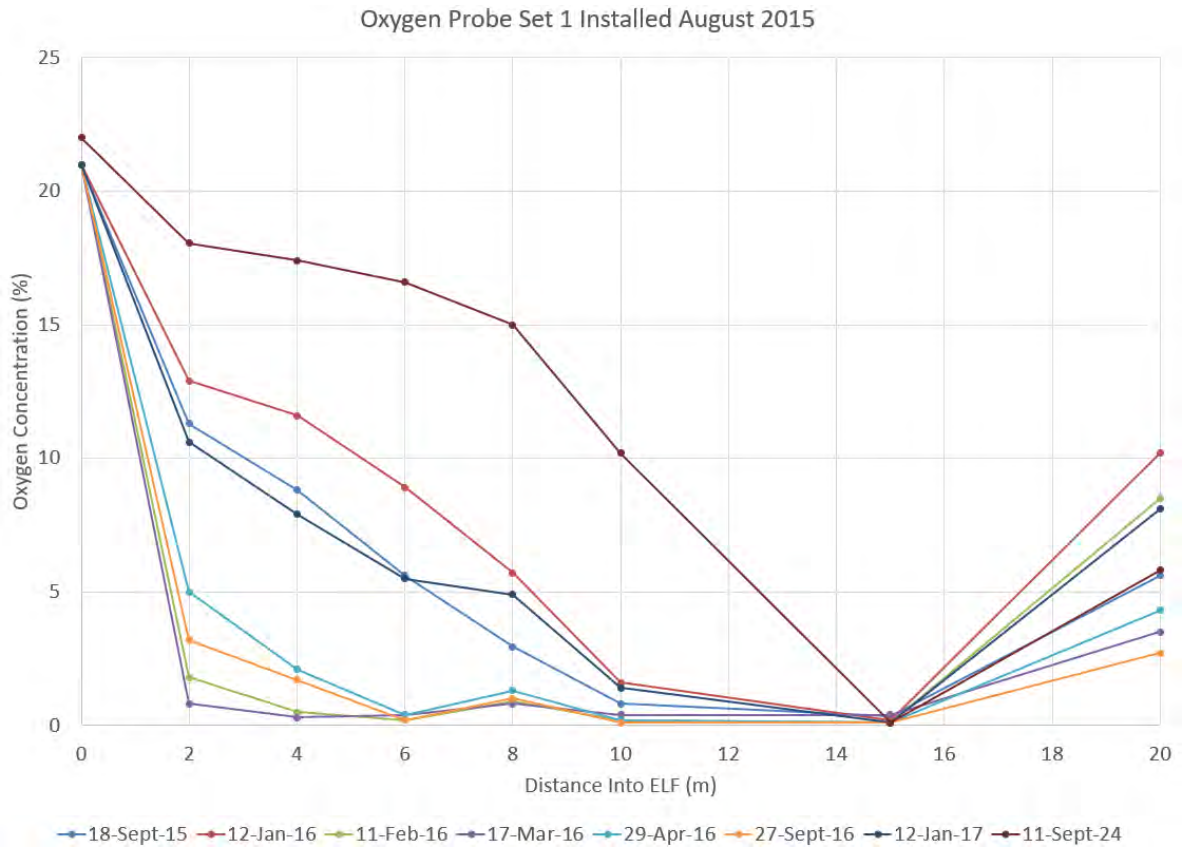


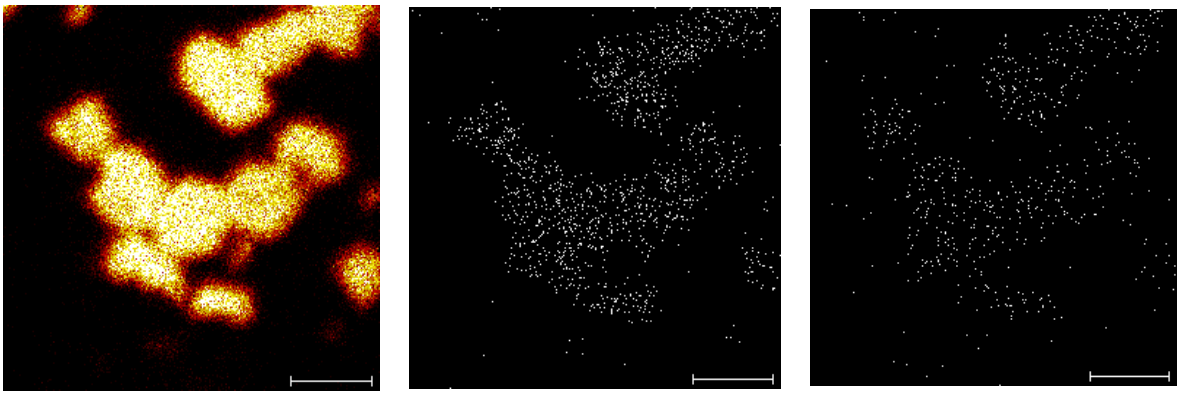
Figure 5: BV ELF: Oxygen probe results – Probe Set 1.

2.4 Sulfur Adjustment Factor

It is assumed that the sulfur content of an ELF can be used as an adjustment factor for solute concentration within an ELF for the following reasons:

- Sulfur content is a key driver of acid and metalliferous drainage (AMD) risk within waste rock. Hence adjustment for sulfur content is important for model development.
- Sulfate in ELF seepage is a key indicator of geochemical reactions such as pyrite oxidation.
- Many PCOC such as trace metals (e.g., Ni, Zn) are associated with sulfide minerals (e.g., Weber et al., 2006), hence the risk of elevated trace metals in ELF seepage water is a function of sulfur / pyrite content (Figure 6).
- Neutralisation reactions are also a function of acidity generation due to sulfide mineral oxidation, hence there is a general relationship between Ca / Mg with sulfate.

Hence, if twice as much sulfide sulfur is present within an ELF, then it is assumed the rate of sulfide oxidation is doubled (assumes no constraint on oxygen supply etc), which means that any related PCOC and reactions products would also be proportionally elevated.



Fe Heat Map Ni Heat Map Zn Heat Map

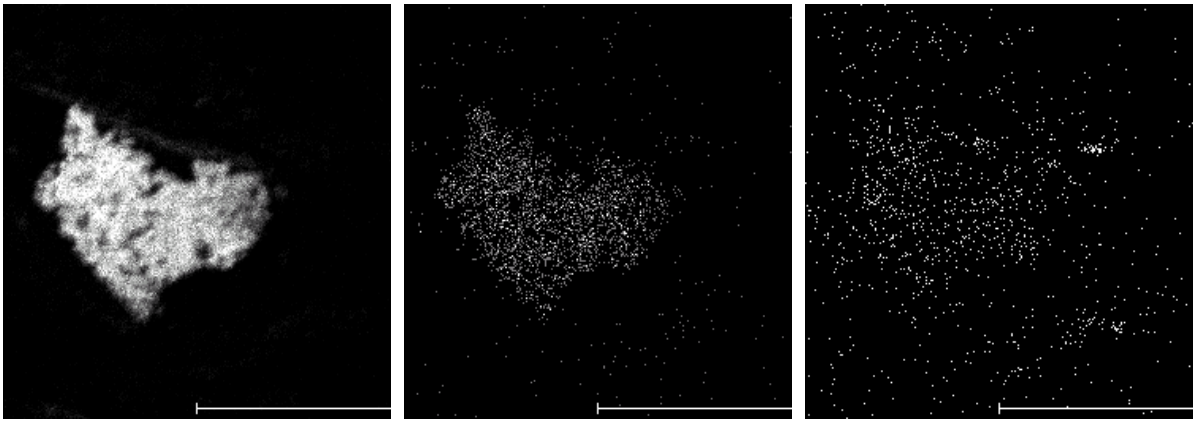
Figure 6: Ni and Zn concentration heat maps for framboidal pyrite (Stockton Mine).

Source: Weber et al. (2006) and unpublished supplementary information.

Scale bar = 100 microns.

2.5 Zinc

Previous studies indicate that some metals such as Zn can also be ubiquitous throughout Brunner Coal Measures (BCM), often elevated in sulfides, but also elevated in the rock matrix (Figure 7).



Fe Ni Zn

Figure 7: Ni and Zn concentration heat maps for euhedral pyrite (Stockton Mine).

Source: Weber et al., 2006 and Hughes (2004).

Scale bar = 100 microns.

A review of acid base accounting data (MWM, 2026a) indicates that Zn can be elevated across all AMD material classifications when total S is plotted against pXRF[3] Zn (Figure 8), which confirms a general ubiquitous nature for Zn. However, assessment of low sulfur samples (<0.015 wt% S) suggest that Zn might be lower in these lower S materials (Figure 9).

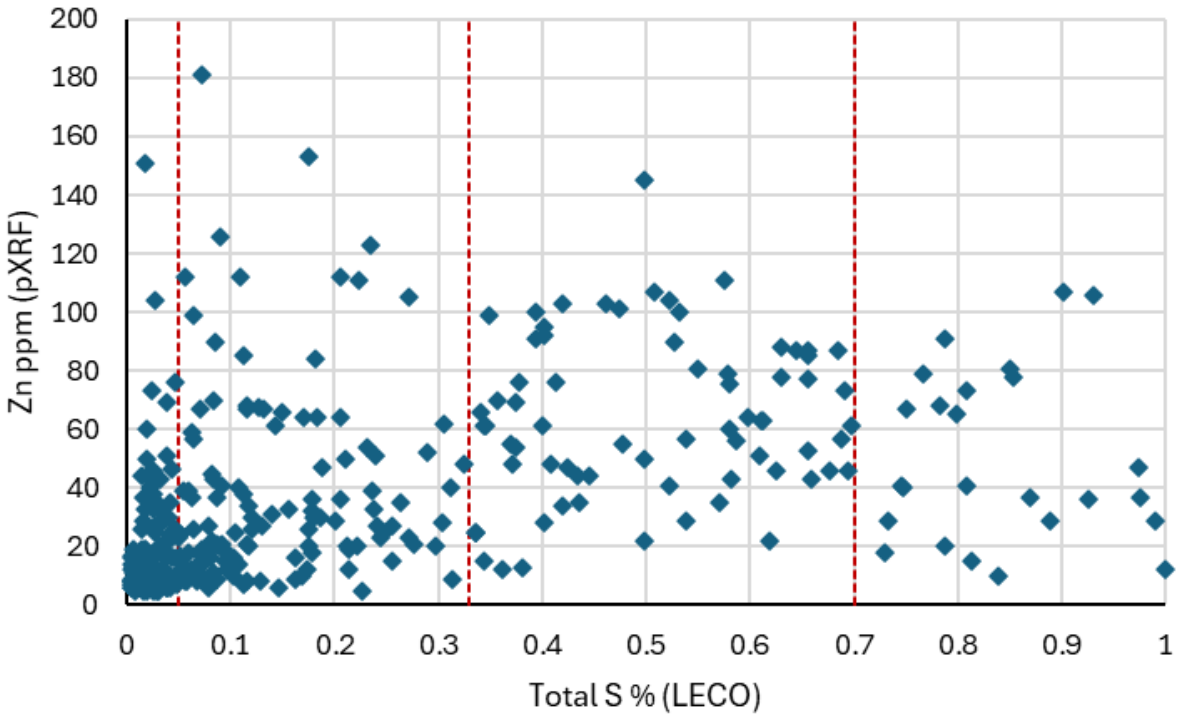


Figure 8: pXRF results for Zn versus total sulfur wt% (MFS Project sub-area)

[3] *Portable X-ray Fluorescence.*

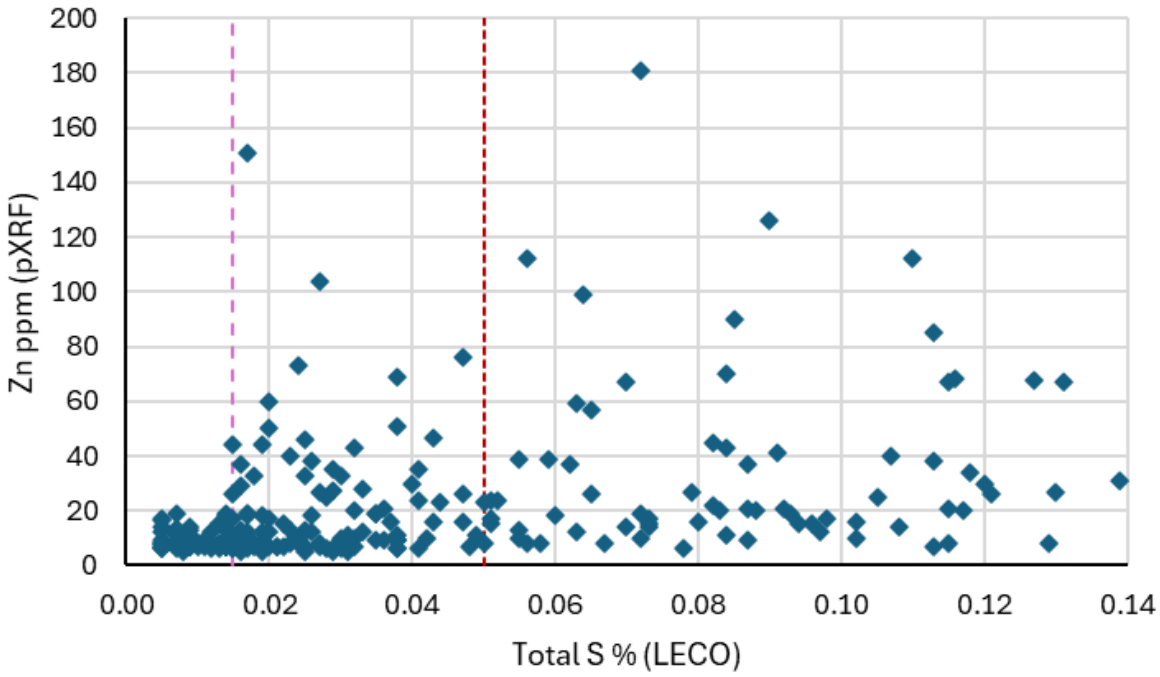


Figure 9: pXRF results for Zn versus total sulfur % showing lower sulfur materials (MFS Project sub-area).

Column leach test data are available from Mount Frederick South (MWM, 2026b) with samples DC16-005 having a 0.09 wt% S content. The data suggests that Zn concentrations in leachate are low when the sulfur content is < 0.015 wt% (Figure 10) supporting the observation provided in Figure 9 that Zn may be a lower risk for samples with < 0.015 wt% S. This may provide a valuable opportunity for material management during the BPCP if materials need to be placed in locations where water management and treatment are not possible.

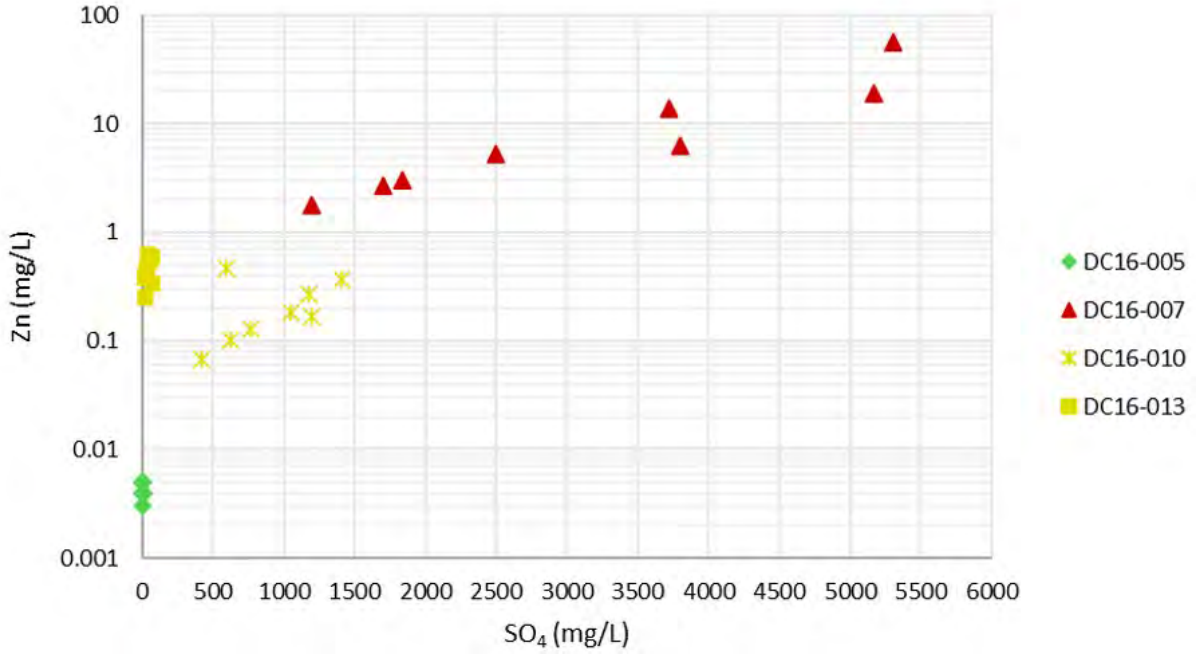


Figure 10: Sulfate versus Zn content for Mount Frederick South column leach test data.

A review of wall wash leachate data for Zn of current and operating sites (Pope et al., 2018a) indicated that in general Zn was an ~order of magnitude higher than other trace metals such as Ni for materials ranging in age from 3 days to 138 years (Figure 11). This suggests that Zn is a widespread and persistent issue for mine impacted waters from the BCM.

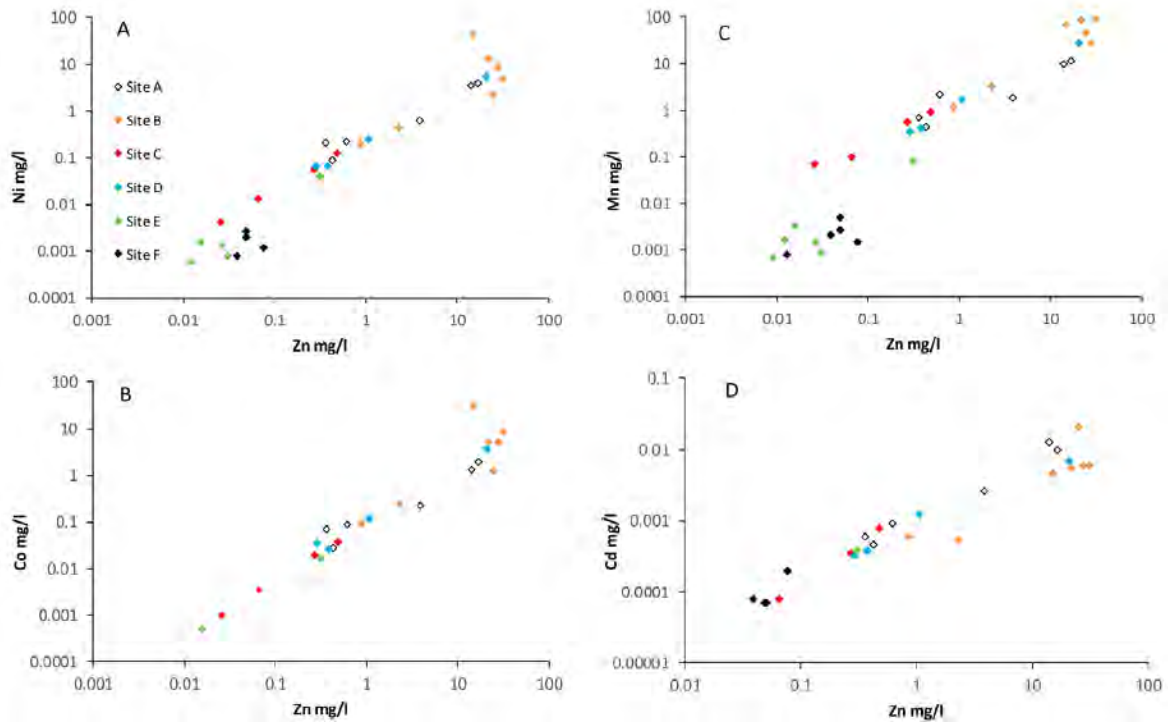


Figure 11: Zn versus trace element concentrations (Brunner Coal Measures).

Source: Pope et al. (2018a).

Pope et al. (2018a) plotted Zn concentration data against calculated acidities (Figure 12). Although the data are plotted as log there remains an increase in Zn with an increase in measured acidity. This suggests that any relationship with sulfate (as acidity is directly related to sulfate concentration) remains valid for the construction of an ELF water quality model.

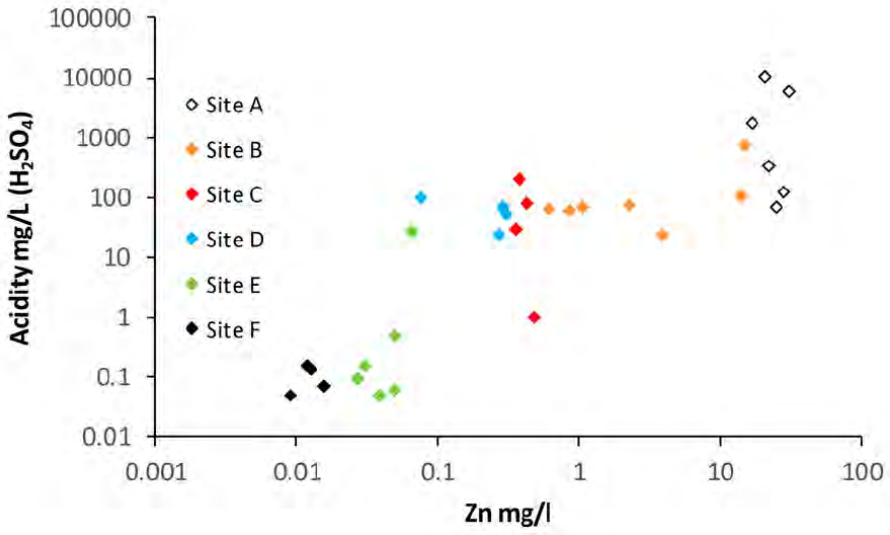


Figure 12: Relationship between Zn release and acidity for wall wash samples

Source: Pope et al. (2018a)

BRL indicate, based on the block model for MFS, using a sulfur cutoff of <0.015% that the total volume of this low sulfur material is 6,757,700 tonnes or a total of 2,774,400 m^3. Which suggests material with low Zn content are available for construction purposes and could be placed in more sensitive areas (i.e., where treatment is not possible).

2.6 AMD Decay

The decrease in acidity and PCOC loads associated with AMD occurs over many decades, with AMD being recognised as an issue that can persevere for decades to centuries. This section reviews relevant data on the decay of AMD loads for materials associated with the BCM.

2.6.1 Underground Coal Mines

AMD decay rates for underground coal mines were assessed to consider how acidity loads from these mine domains decay over the long term to provide context for BPCP overburden disposal areas.

A range of acidity decay rates has been published for underground mines ranging between approximately 2 and 4% per annum for USA and UK coal fields:

- Demchak *et al*. (2001) indicated an annual decrease in acidity of 2.2% for 40 coal mines in West Virginia between 1968 and 2000.
- Ziemkiewicz (1994) used a similar rate of 2% decrease per year to determine changes in AMD with respect to time.
- Wood et al. (1999) calculated a rate of 3.3% acidity decrease per annum in coal mine drainage in Scotland.
- Mack and Skousen (2008) determined a 2.1% decrease per annum for coal mines in West Virginia.

For many of the same mines reported in Mack and Skousen (2008), Mack et al. (2010) found exponential decay models were a better overall representation of acidity decay, but noted for some mines, a linear decay response of 2% per annum was apparent. In their work, they derived an average exponential decay constant ranging between 0.03 and 0.04 yr^{-1}.

The time taken for underground coal mine water drainage to reach a new steady plateau once mining had stopped was in the order of years to decades, and typically less than 40 years (Younger, 1997; Wood *et al.*, 1999, Demchak *et al.*, 2004; Mack *et al.*, 2010).

2.6.2 Stockton Coal Mine

A review of AMD liabilities for the Stockton Coal Mine was completed in 2015 (O'Kane Consultants, 2015). A nominal value of 50% was provided by Okane Consultants (2015) as a placeholder to consider the decrease in acidity load following cover installation with the recommendation that further work was undertaken. This 50% decrease was built into the Stockton AMD liability model (Gandy and Younger, 2007; Treasury, 2017) as a step change 10 years after the cover system over the waste rock was constructed. The model also used an exponential acidity load decay of 0.62% per annum for WRS, which was applied on a catchment scale. This was based on the work of Gandy and Younger (2007),

who used data from the Stockton Egypt Field Trials (Egypt trial pads) to derive long term rates for acidity decay[4].

In 2007 the Egypt trial pads had only been running a few years, and stored oxidation products had not been flushed from the system and reactive sulfides were still contributing a high sulfate/PCOC load. Data indicated that exponential decreases have been observed since the Egypt trial pads were established (Figure 13), however there is a paucity of data from years 5 to 20.

These data demonstrate that rapid decreases in sulfate and acidity loads can occur within the BCM materials without any engineering controls. However, data indicate a significant acidity load can be generated in the short term, decreasing rapidly into the medium term (~20 years).

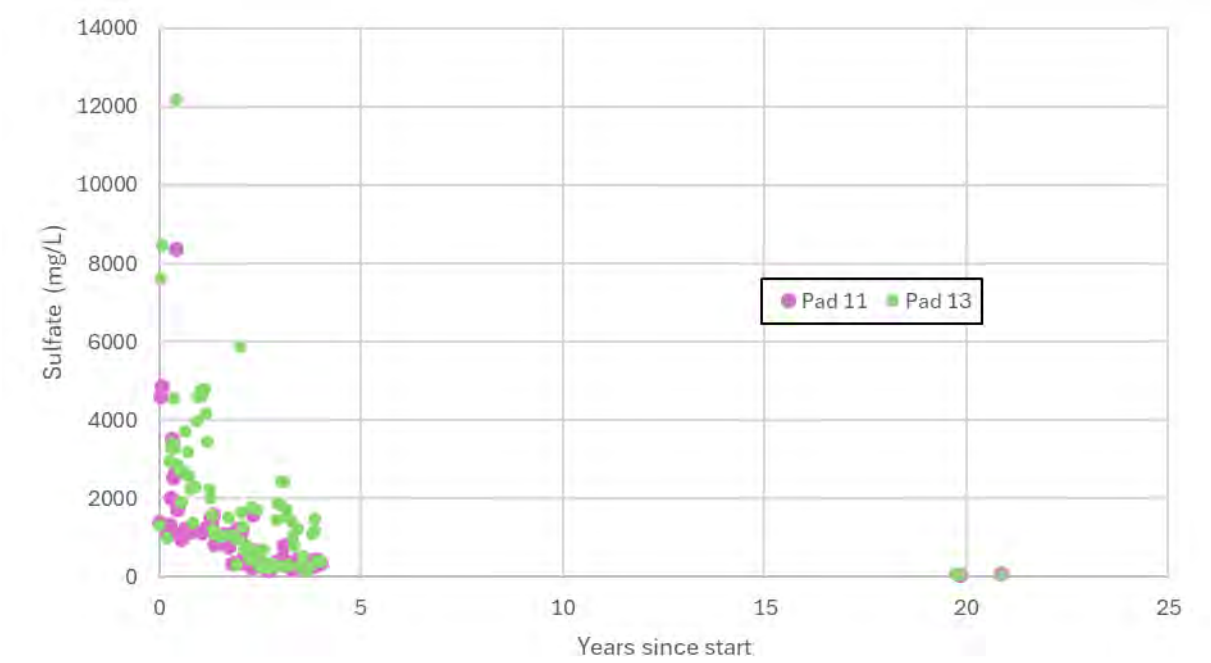


Figure 13: Egypt control trial pad data: sulfate

Note: Pad 11 and Pad 12 data are control sites with no cover system or other amendments

2.6.3 Mangatini Catchment – Stockton Coal Mine

BRL maintain the 'Stockton AMD Model' to track waste rock disturbances at the Stockton Mine. Key components of the Stockton AMD model relating to acidity load forecasting include:

- Waste rock disturbance forecasts (units of kbcm[5] per financial year) within the St Patrick, Mangatini, and Millerton catchments. Noting this does not include Cypress activities.
- Estimates of new acidity generated for each financial year dependant on waste rock disturbance (at a rate of 0.094 t $CaCO_3$/yr per kbcm disturbed) in the Mangatini catchments.

[4] The Egypt field trial pads were established in 2004. These trials included 17 pads consisting of 500 tonnes of overburden with lysimeters installed to measure flow rates and seepage quality. Further details are available (Connor, 2005).

[5] 1000 bank cubic metres

- Expected acidity load reduction due to implementation of AMD controls (to reflect capping and rehabilitation resulting in a 50% reduction in acidity load as stipulated in the Stockton Mine deed of sale and spread over the rehabilitation period) (O'Kane, 2015).
- Quantification of acidity load to be treated in each catchment, which is equal to the total acidity load minus any acidity load reduction due to implementation of AMD controls.

The Stockton AMD model includes data back to the 2016 financial year (FY16), which was used as the baseline year for 100% Crown generation of AMD at Stockton. The acidity load is then forecast out to FY34 based on waste rock disturbance and implementation of AMD controls. Measured Mangatini Catchment acidity load data for the FY16 to FY22 periods were compared against the Stockton AMD model forecasts. The Mangatini annual acidity load is based on loads entering the Mangatini Sump and is shown in Figure 14.

Overall, the BRL modelled treatable acidity load is comparable to measured MGIU acidity load through the FY17 to FY22 period. This supports the use of the BRL Stockton AMD model for forecasting acidity load based on scheduled material disturbance and rehabilitation activities.

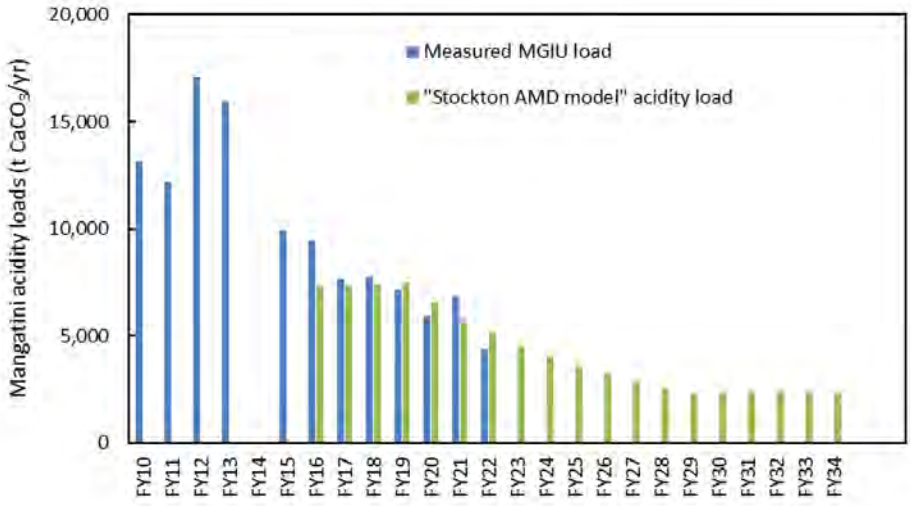


Figure 14: Mangatini catchment acidity load forecast.

2.6.4 Summary

The data provided in this section suggests that a 50% decrease in acidity loads from rehabilitated landforms after 10 years is a reasonable assumption to understand long term AMD liabilities for waste rock dumps (that have no control of advective oxygen ingress). Data that support this assumption includes:

- Egypt Trial Pad data
- Mangatini catchment acidity load model (O'Kane, 2015).

2.7 Summary

The concepts provided in this section provide the basis for the development of the ELF water quality model for the BPCP from empirical data from the BV ELF.

3 BV ELF CONCEPTUAL SITE MODEL

This section discusses the conceptual model for the existing Escarpment Mine and the BV ELF, which is used as an analogue model to provide empirical data to derive the ELF water quality predictive model for the BPCP.

3.1 Escarpment Mine Overview

Key components of the existing Escarpment Mine (Figure 15) are summarised in Table 2 with key components of the BV ELF water quality model identified.

Table 2: Escarpment Mine - domain summary

SITE COMPONENT	BV ELF SEEPAGE MODEL	EXPLANATION
Red Shed Adit	✓	Seepage from the older underground mine enters the BV ELF.
Red Shed Pit Highwall	✓	Surface flow from the Red Shed Highwall drains to the Red Shed Pit Pond where water ponds on the BV ELF.
Pluto Bund	✓	An upstream bund that prevents run-on water from entering the BV ELF. Minor seepage from this pond is expected through the bund into the BV ELF.
PLUTO	✗	Pipeline under the overburden (PLUTO), which drains water from the Pluto Bund Pond diverts run-on water through the ELF via a pipe. Not considered part of the BV ELF water quality model.
BV ELF seepage	✓	Seepage from the BV ELF that discharges through a v-notch weir into the BV ELF mussel shell reactor (MSR) where treated water flows to Pit 3. By-pass water flows to Pit 3 as well.
Eastern Diversion Drain (EDD)	✗	Captures runoff from the BV ELF and directs flow around Pit 3 to the site sediment ponds before discharge off site. Not considered part of the BV ELF water quality model.
BV ELF MSR	✗	The MSR that treats base flow from the BV ELF underdrain. Not considered part of the BV ELF water quality model.
ROM Pad	✗	The previous coal stockpile area (not used). Not considered part of the BV ELF water quality model.
Pit 3 Pit Lake	✗	The pit lake that receives MSR treated water. Not considered part of the BV ELF water quality model.
Escarpment Adit	✗	An adit that discharges to the V37 Stream (and then the Cascade Stream). Not considered part of the BV ELF water quality model.

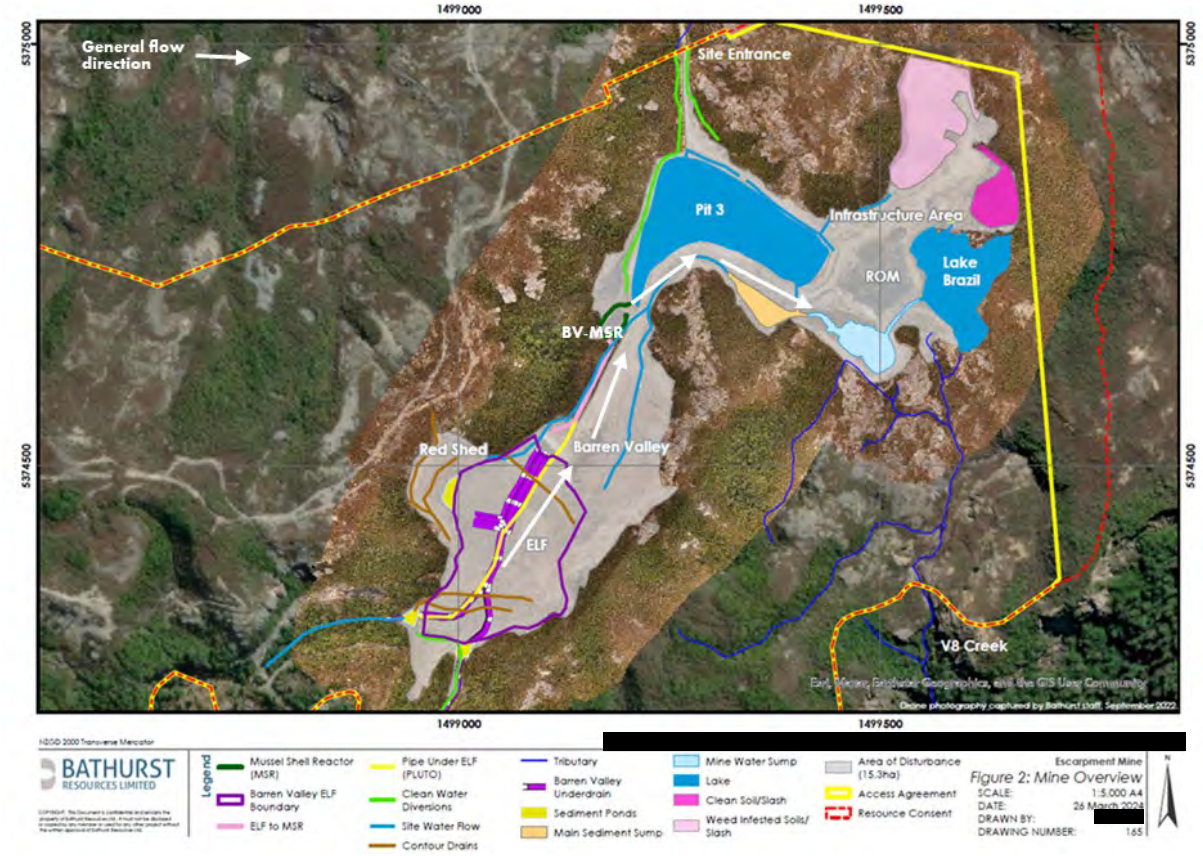


Figure 15: Escarpment Coal Mine overview.

3.2 BV ELF: As-Built Design

The BV ELF key design details and sulfur content are provided in Table 3.

Table 3: BV ELF parameters.

PARAMETER	VALUE
BV ELF Area (ha)	3.33
BV ELF average height (m)	10.71
BV ELF and highwall catchment area (ha)	5.035
Density (t/m^3)	2.09
BV ELF fill (m^3)	356,596
Tonnage	745,286
Lime added (tonnes)	962
Average sulfur proportion content (wt%)	0.18

[redacted].

3.3 Barren Valley ELF Conceptual Site Model

The purpose of developing the conceptual site model (CSM) was to support the derivation of flows associated with NP by removing run-on from the model.

The different model components for the BV ELF CSM are presented in Table 4. A graphical representation of the BV ELF CSM is shown in Figure 16.

Table 4: BV ELF CSM components.

MINE DOMAIN	MODEL COMPONENT
Pluto Bund Seepage	A
Red Shed Adit (average sonde data)	B
(Red Shed Pit) Highwall Catchment Area (brown area)	C
Red Shed Pit Pond BV ELF Catchment Area (blue area)	D
BV ELF Pond Catchment Area	E
Total Run on water seepage	F
BV ELF Weir (sonde data)	G
BV ELF Pond Seepage and undetermined loss	H
BV ELF Catchment (BV ELF (3.33 ha) + Highwall (1.66 ha) = 4.99 ha	K

Model components I and J are excluded from Table 4, as they are associated with scenario modelling rather than the BV ELF CSM.

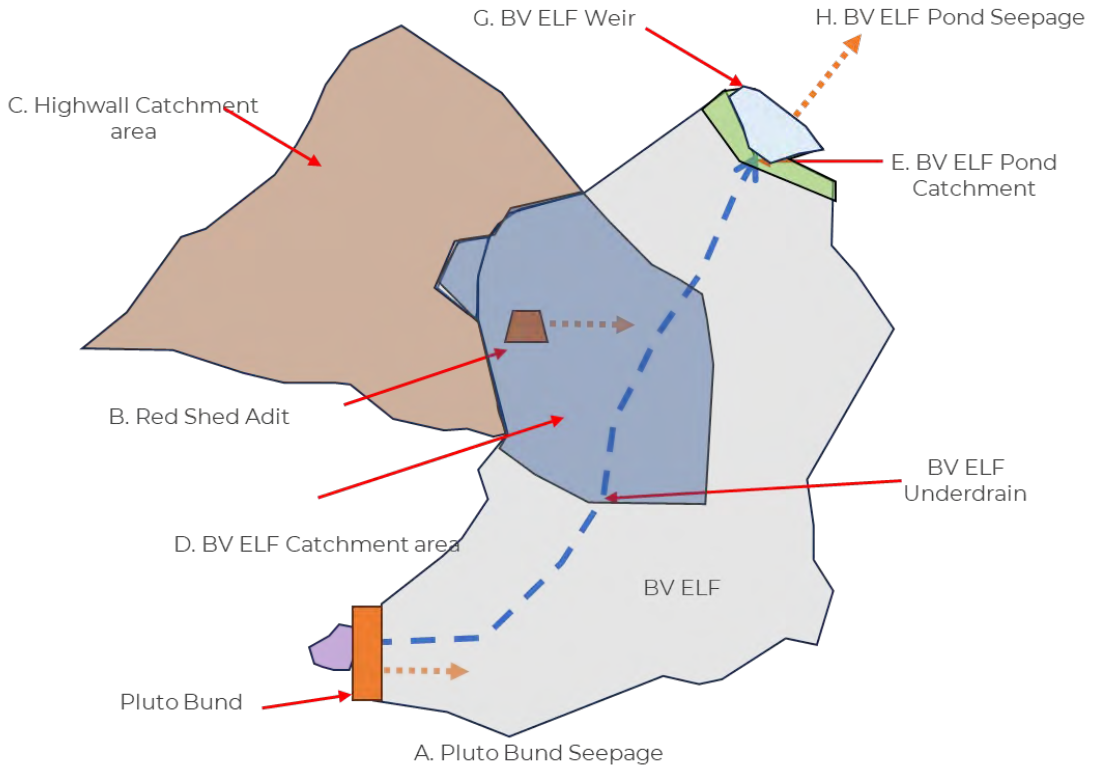


Figure 16: BV ELF CSM.

4 BV ELF FLOW RATES

The following section provides a summary of the flow rates for each component of the CSM.

4.1 Rainfall

The average annual rainfall on the Denniston Plateau is ~5,469 mm/yr[6]. To derive a representative rainfall for the BV ELF catchment, the data period for the BV ELF sonde data (May 2023 – July 2024) was used. This rainfall was 4,727 mm/year equivalent.

4.2 Pluto Bund Seepage

The Pluto Bund collects surface water runoff from the catchment above the BV ELF (i.e., potential run-on), which is then directed under the BV ELF via a pipeline (PLUTO) (Figure 17). It is assumed that some water also seeps through the Pluto Bund, contributing to the BV ELF acidity load model, though these seepage values remain estimated rather than quantified.

A nominal flow rate of 0.1 L/s has been used as an assumption, though this value has never been formally quantified. Flow rates may also be influenced by groundwater contributions, and a hydrogeological assessment could refine this estimate. However, it was deemed that a flow rate of 0.1 L/s was suitable.

Figure 17: Pluto Pond / Bund and potential seepage to the BV ELF.

4.3 Red Shed Adit

The Red Shed Adit, located in the area known as the 'Red Shed,' is an old adit that was mined out to remove the coal and the area was then buried by the BV ELF and is assumed to discharge into the BV ELF.

[6] *Average rainfall was derived from the Lake Brazil met station (640 mRL) at the Escarpment Mine.*

Flow rates were monitored using a level logger installed at the Red Shed v-notch weir prior to the BV ELF being constructed (Figure 18), with recorded values ranging from 0.000005 to 0.5 L/s and an average of 0.173 L/s. A noticeable increase in the flow rate was observed in September 2015, likely due to the sensor being bumped or adjusted, resulting in a higher average flow rate of 0.280 L/s from 17/09/2015 onward. Site personnel also suggest that water rerouting during this period may have increase surface flows to this point. Earlier data showed a lower average flow rate of 0.103 L/s which is believed to be more representative of the actual flow reporting to the BV ELF.

A flow rate of 0.103 L/s is assigned to this model component.

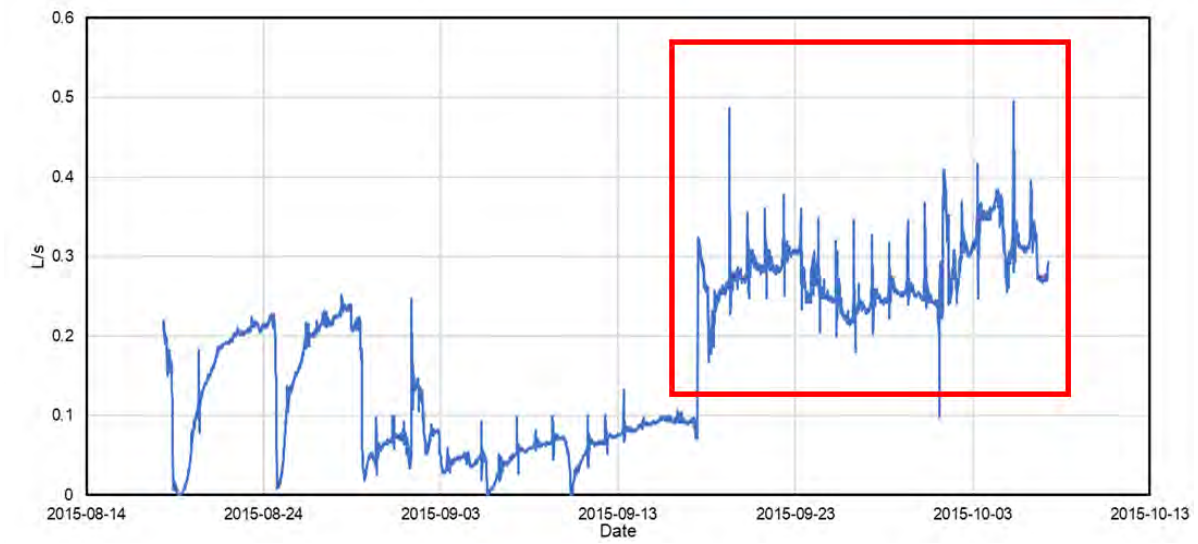


Figure 18: Red Shed Adit sonde data.

4.4 Red Shed Pit Highwall Catchment

It is assumed that the Red Shed Pit Highwall (1.66 ha) drains to the Red Shed Pit Pond (RSPP), which has a catchment of 2.75 ha that includes surface runoff from the BV ELF (Figure 19).

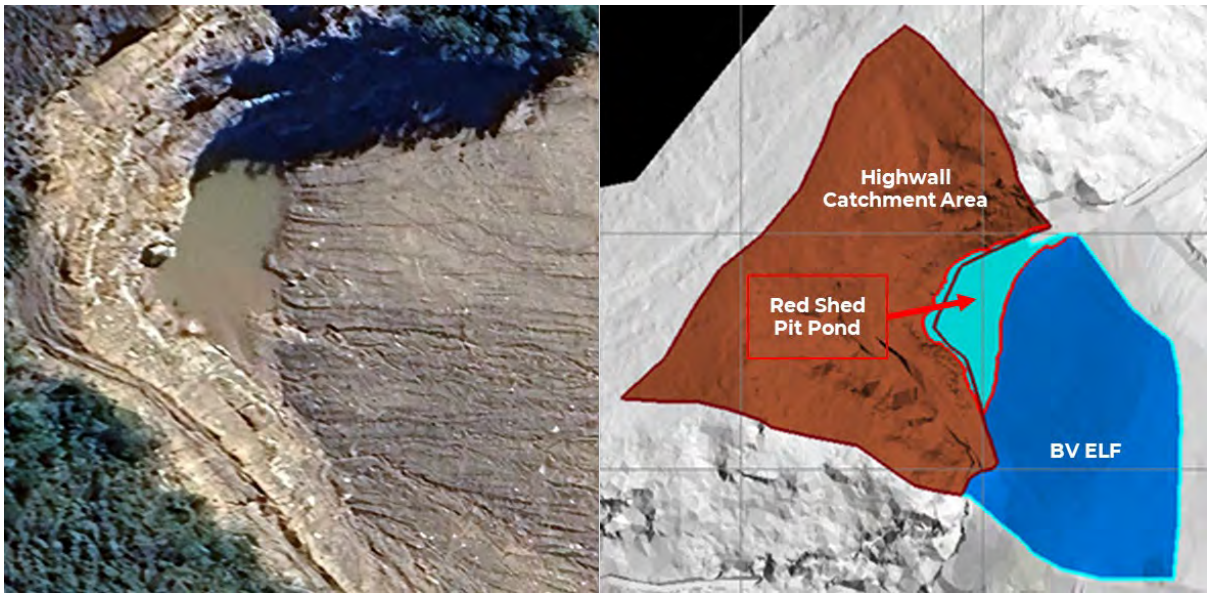


Figure 19: Highwall Catchment and RSPP area.

4.5 Red Shed Pit Pond

The RSPP receives runoff from two sub-catchments:

- Highwall Catchment Area (1.66 ha): It was assumed this area has a runoff coefficient of 90%.
- BV ELF Catchment Area (1.08 ha): A runoff coefficient of 100% (ignoring evaporation) was applied to account for seepage and an undetermined amount of runoff to the RSPP (i.e., flow must all report to the BV ELF v-notch weir).

The model was tested to determine whether all water reporting to the RSPP flowed through the BV ELF to report as seepage or whether the RSPP spilled. A numerical model was developed to look at the flow that would report to the RSPP (Table 5). Results indicate a water imbalance when compared to the measured BV ELF v-notch weir flow rate of 3.35 L/s (see Section 3.9). Due to the flow imbalance and uncertainty in data, all water reporting from the BV ELF was assumed to come from the BV ELF, where water is derived from net percolation. This is considered conservative as some load may be reporting from the highwall area.

Table 5: RSPP water balance model.

MINE DOMAIN	MODEL COMPONENT	FLOW RATES (L/S)
BV to RSPP catchment (1.08 Ha, 100% of rainfall)	C	1.618
Highwall to RSPP (1.66 Ha, assumed 90% runoff coefficient)	D	2.238
Total		**3.856**
Average BV ELF v-notch weir flow rate	G	3.350
Water Balance		**-0.506**

4.6 BV ELF Weir

Data was available from the BV ELF v-notch weir from 24 May 2023 to 4 July 2024. Data were reviewed as part of the quality assurance process to identify significant shifts in water level readings. Three notable deviations were observed:

- September 13, 2023 (12:40): Decrease of ~0.10 m.
- October 30, 2023 (13:10): Increase of ~0.11 m.
- March 1, 2024 (09:30): Increase of ~0.01 m.

These shifts were identified by inspecting changes greater than 10 mm in stage height during dry periods (i.e., when no rainfall occurred in the preceding four hours). Analysing fluctuations during rainfall events was not feasible due to rapid variations in the data. While additional shifts meeting the same criteria were detected, they were excluded due to their minor magnitude and the relative accuracy of surrounding data points.

Manual flow gauging measurements were plotted against calculated values based on a 90-degree V-notch weir assumption. The first set of manual gauging data (July 7, 2023 – October 31, 2023) closely aligned with the calculated stage-flow relationship. However, the following data points were removed due to inconsistencies:

- August 18, 2023: Suspected data entry error; value matched the Pluto Pond gauging.
- August 22, 2023: Did not align with the calculated curve.

The remaining manual gauging data provided the best fit for defining the flow-stage relationship. The unused data points, relative to the raw stage height, are shown in grey in Figure 20.

To improve the dataset's usability, manual gauging from November 27, 2023, to April 20, 2024, was used to estimate a stage correction, back calculating the expected stage from the measured flow. The June 5, 2024, gauging was excluded due to inconsistencies observed in flow measurement variances.

For efficiency, stage corrections were applied at the time of manual gauging rather than being interpolated between measurements. This adjustment successfully aligned post-November 27, 2023, gauging data with the previously established rating curve, as illustrated by the yellow data points in Figure 20.

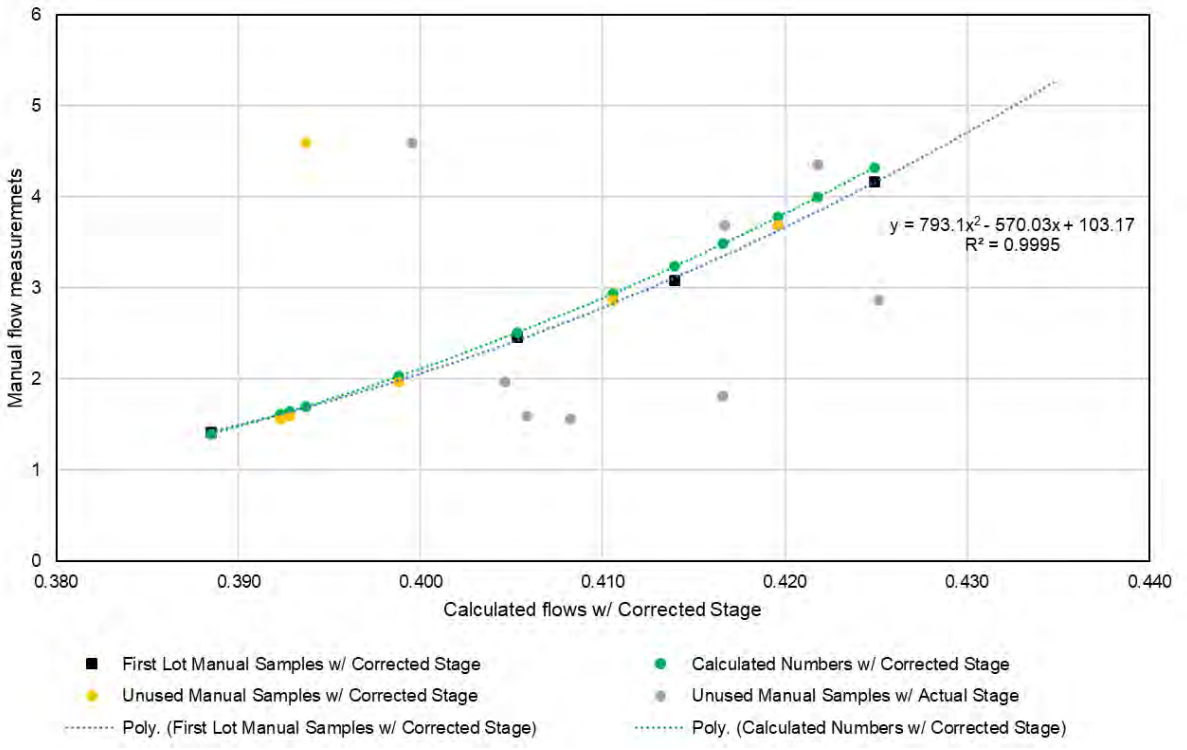


Figure 20: Manual flow measurements vs calculated flow with stage height.

Data shown in Figure 21 illustrates the progressive adjustments applied to the weir stage data:

- Yellow represents the raw stage data before any corrections.
- Blue incorporates adjustments based on the three observed water level shifts identified in the analysis.
- Orange applies further adjustments using manual gauging data to correct stage values and improve alignment with calculated flow relationships.

These corrections refine the dataset, ensuring greater accuracy in stage-flow analysis.

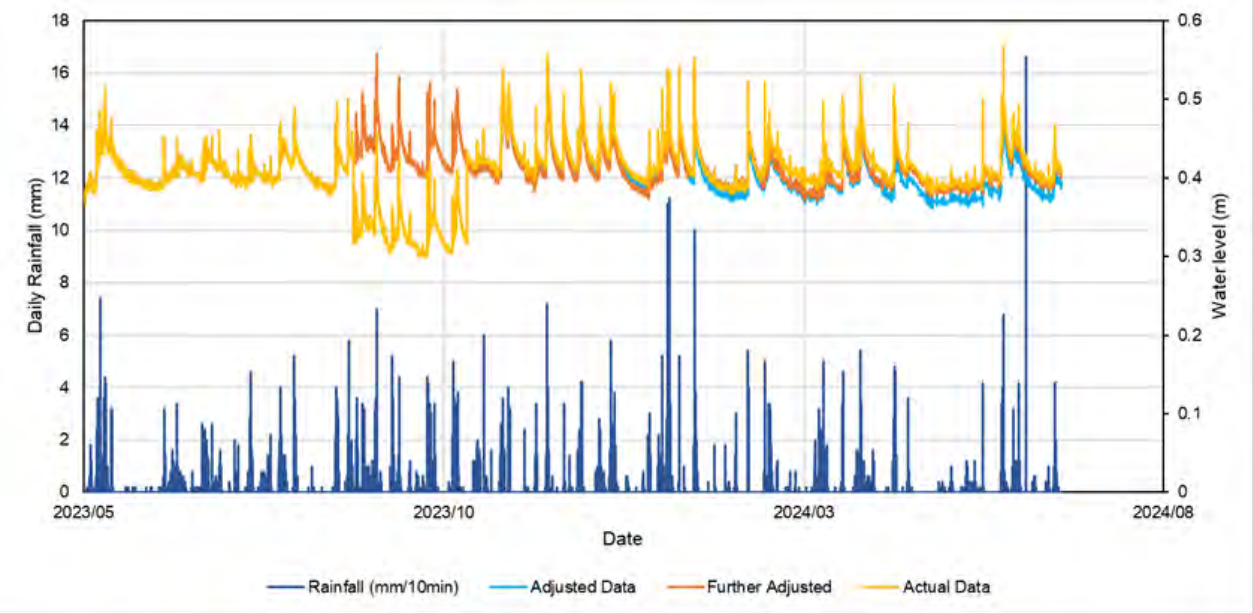


Figure 21: BV ELF water level and rainfall.

After these stage adjustments were made, the following relationship, based on manual flow gauging (Figure 20), was used to calculate weir flow relative to stage:

Equation 1: $793.1x^2 - 570.03x + 103.17$

An additional flow check was completed by calculating the flow using the v-notch flow formula to ensure the flow:stage relationship was appropriate. The results and observations from this work were:

- BV ELF v-notch weir flow rates:
    - Based on the stage-flow relationship: 3.35 L/s.
    - Based on calculated stage values: 3.48 L/s.
    - Difference between the two methods: 4%.
- Weir flow rates excluding periods of rainfall (to account for surface runoff from the upper catchment):
    - Using the relationship curve: 2.99 L/s.
    - Using calculated stage values: 3.10 L/s.

For comparison, the average annual rainfall at Lake Brazil is ~5,469 mm/year compared to 4,727 mm/year observed over the period of BV ELF sonde data (May 2023 – July 2024). This suggests that a conversion factor of 1.16 could be applied to the weir flow data to better estimate the average annual flows; this would result in a flow of 3.88 L/s. However, the draindown period for the BV ELF has been estimated at 20 months (Section 5.3 and Section 6.2) hence the low rainfall is unlikely to affect the overall measured flow at the BV ELF Weir given the delay in seepage reporting to the underdrain.

The observed average flow rate of 3.35 L/s was used for the BV ELF water quality model assessment.

4.7 Water Balance and Summary

Based on the total BV ELF catchment (4.99 ha) the total flow that could report to the BV ELF weir (based on 100% rainfall) is 7.480 L/s. The flow measured at the BV ELF v-notch weir is 3.35 L/s. Run-on includes seepage from the Pluto Bund, the Red Shed Adit (0.203 L/s) and run-on from the Red Shed Pit Highwall (2.238 L/s). There is potentially some seepage loss through the BV ELF Pond, nominally assigned a value of 0.1 L/s (Table 6).

The analysis indicates that overall, the primary loss of PCOC load from the BV ELF is via the v-notch weir. This flow rate of 3.35 L/s is then used with measure water quality to develop the water quality model. It is assumed all load is from the BV ELF underdrain (noting minor contributions from the BV ELF Pond catchment).

Table 6: BV ELF water balance.

MINE DOMAIN	COMPONENT	FLOW RATE (L/s)
Entire catchment (4.99 Ha, 100% of rainfall)	K	7.48
Average weir flow rate	**G**	**3.35**
BV ELF Pond seepage losses	H	-0.10
BV Pond catchment runoff and seepage (0.34 Ha, 100% of rainfall)	E	0.51
BV to RSPP catchment (1.08 Ha, 100% of rainfall)	D	1.62
Highwall to RSPP (1.66 Ha, assumed 90% runoff coefficient)	C	2.24
Red Shed Adit	B	0.103
Pluto Bund	A	0.10

Model components I and J are excluded from Table 6, as they are associated with scenario modelling rather than the BV ELF CSM.

5 BV ELF WATER QUALITY

This section summarises key water quality data for the BV ELF including:

- Pluto Bund – which has minor AMD impact and is assigned to Pluto Bund seepage water quality (Component A). Data (Table 7) indicates the effect on AMD load is expected to be negligible when flow rate (0.1 L/s) is considered. The minor AMD load from the Pluto Bund is assigned to net percolation to be conservative.
- Red Shed Adit - is impacted by AMD (Table 8), however the load is expected to be negligible when flow rate (0.103 L/s) is considered. The minor AMD load is assigned to net percolation to be conservative.
- BV ELF seepage water quality – which is impacted by AMD associated with the overburden within the facility and flow rates are assumed to be derived from net percolation of rainfall.

5.1 Pluto Bund Water Quality

Eleven water quality samples are available from the Pluto Pond, which are used as proxy for the Pluto Bund seepage water quality (Table 7). The following observations are provided:

- The average pH was 4.24.
- Al and Fe had average concentrations of 0.74 mg/L and 0.178 mg/L respectively.
- Sulfate ranged from 12.6 – 28.3 mg/L, with an average concentration of 18.8 mg/L.

Based off the nominal flow rate (0.1 L/s) and an average acidity of 18.1 mg $CaCO_3$/L, an average acidity load of 0.157 kg/day or 0.057 t/yr was calculated.

Table 7: Pluto Bund seepage water quality data (April 2022 – November 2023).

PARAMETER	COUNT	AVE	MED	MIN	MAX
pH (pH units)	11	4.24	4.20	4.30[1]	4.10[1]
EC (mS/m)	11	20.5	7.80	5.30	86.0
Acidity (pH 7.0 mg $CaCO_3$/L)	2	14.0	14.0	13.0	15.0
Acidity (pH 8.3 mg $CaCO_3$/L)	8	18.1	17.5	12.0	27.0
Nominal flow rate (L/s)	1	0.1	-	-	-
Average acid load (kg/day)	1	0.157	-	-	-
Average acid load (t/yr)	1	0.057	-	-	-
Al	10	1.04	0.98	0.64	1.68
As*	2	0.001	0.001	0.001	0.001
B*	2	0.03	0.03	0.03	0.03
Ca	11	3.82	3.70	1.90	6.17
Cd	3	0.0002	0.0002	0.0001	0.0002
Co	2	0.0021	0.0021	0.0015	0.0027
Cr*	2	0.001	0.001	0.001	0.001
Cu	3	0.0014	0.0012	0.0011	0.0018
Fe	11	0.265	0.200	0.094	0.730
Pb*	2	0.0005	0.0005	0.0005	0.0005
Mg	11	0.715	0.680	0.540	1.050

PARAMETER	COUNT	AVE	MED	MIN	MAX
Mn	11	0.080	0.073	0.049	0.142
Ni	10	0.0047	0.0050	0.0031	0.0056
NO_3-N*	2	0.01	0.01	0.01	0.01
SO_4	5	18.8	14.8	12.6	28.3
Tl*	2	0.0005	0.0005	0.0005	0.0005
Sn*	1	0.0005	0.0005	0.0005	0.0005
Zn	10	0.027	0.026	0.017	0.039

Source: BRL 51279_RPT_Water (water quality excel database).

1. Minimum and maximum pH values have been swapped (maximum concentrations correlate to the lowest pH value) to ensure pH relate to same geochemical conditions as other data in the dataset.

All units are presented in mg/L unless otherwise specified.

A hyphen (-) indicates no value is given.

** Some samples in the dataset were below the limit of reporting (LOR).*

5.2 Red Shed Adit Water Quality

Water quality samples from Red Shed Adit were collected between February 2015 – October 2015 before the BV ELF was constructed. Data for Red Shed Adit is limited to five samples. Water quality data are provided in Table 8. The following observations are provided:

- pH ranged between 3.20 – 3.30 with an of average of 3.28.
- Al and Fe were low for AMD impacted drainage (maximum concentrations being 1.2 mg/L and 4.3 mg/L respectively).
- Sulfate ranged from 32.0 – 53.8 mg/L, with an average concentration of 41.5 mg/L.
- Acidity ranged from 40.0 – 59.0 mg $CaCO_3$/L with an average of 46.4 mg $CaCO_3$/L.
- The average flow rate of 0.103 L/s and the average acidity of 46.4 mg $CaCO_3$/L was used to calculate the acidity load, that being 0.413 kg/day or 0.151 t/yr.

Table 8: Red Shed water quality data (February 2015 – October 2015).

PARAMETER	COUNT	AVE	MED	MIN	MAX
pH (pH units)	5	3.28	3.30	3.30[1]	3.20[1]
EC (µS/cm)	5	26.2	25.0	23.0	30.9
Acidity (pH 8.3 mg $CaCO_3$/L)	5	46.4	46.0	40.0	59.0
Flow rate (L/s)	4,781	0.103	0.20	0.000005	0.50
Average acid load (kg/day)	1	0.413	-	-	-
Average acid load (t/yr)	1	0.151	-	-	-
Total hardness (calculated) (mg $CaCO_3$/L)	2	2.4	2.4	2.2	2.7
Al	5	1.2	1.1	0.9	1.9
Ca	2	0.6	0.6	0.5	0.7
Cd*	3	0.0001	0.0001	0.0001	0.0001
Co	3	0.0025	0.0021	0.0016	0.0038
Cr*	3	0.0005	0.0005	0.0005	0.0005
Cu	3	0.0031	0.0035	0.0020	0.0037
Fe	5	3.3	3.0	2.6	4.3
Pb*	3	0.00025	0.00025	0.00025	0.00025
Ni	5	0.006	0.006	0.004	0.009

PARAMETER	COUNT	AVE	MED	MIN	MAX
Mg	2	0.3	0.3	0.2	0.3
Mn	3	0.016	0.014	0.011	0.024
SO_4	5	41.5	38.7	32.0	53.8
Tl	3	0.0035	0.0033	0.0032	0.0040
Zn	5	0.03	0.03	0.01	0.04

Source: BRL 51279_RPT_Water (water quality excel database).

1. Minimum and maximum pH values have been swapped (maximum concentrations correlate to the lowest pH value) to ensure pH relate to same geochemical conditions as other data in the dataset.

All units are presented in mg/L unless otherwise specified.

A hyphen (-) indicates no value is given.

** Some samples in the dataset were below the LOR; in which case half the LOR was used.*

Water quality description was derived from a total of 5 water quality samples.

5.3 BV ELF Seepage Water Quality

Water quality samples for the BV ELF seepage were collected between 2015 – 2024. Water quality data are plotted against material quantities placed in the BV ELF. The cumulative material movement[7] was plotted alongside acidity concentrations for seepage from the BV ELF (Figure 22). The three generic phases of ELF water quality are presented:

- **Phase 1**: Construction Phase from August 2014 – April 2016
- **Phase 2**: Stabilisation Phase from May 2016 – December 2017 (20 months).
- **Phase 3**: Decay Phase from January 2018 – onwards.

During Phase 1 as more material was placed in the ELF the acidity concentration increased. Following rock placement and wetting up, the acidity concentrations began to stabilise (Phase 2). This was also when the underdrain of the BV ELF was flooded minimising advective ingress of oxygen into the ELF. At the beginning of 2018, there is an overall decreasing trend in acidity indicating that the BV ELF has geochemically matured and entered Phase 3 of its life cycle (the Decay Phase).

[7] *Cumulative material movement volumes included the combined volumes of NAF, PAF, low risk acid forming (LRAF), and risk high acid forming (HRAF) material – data from BRL (2018).*

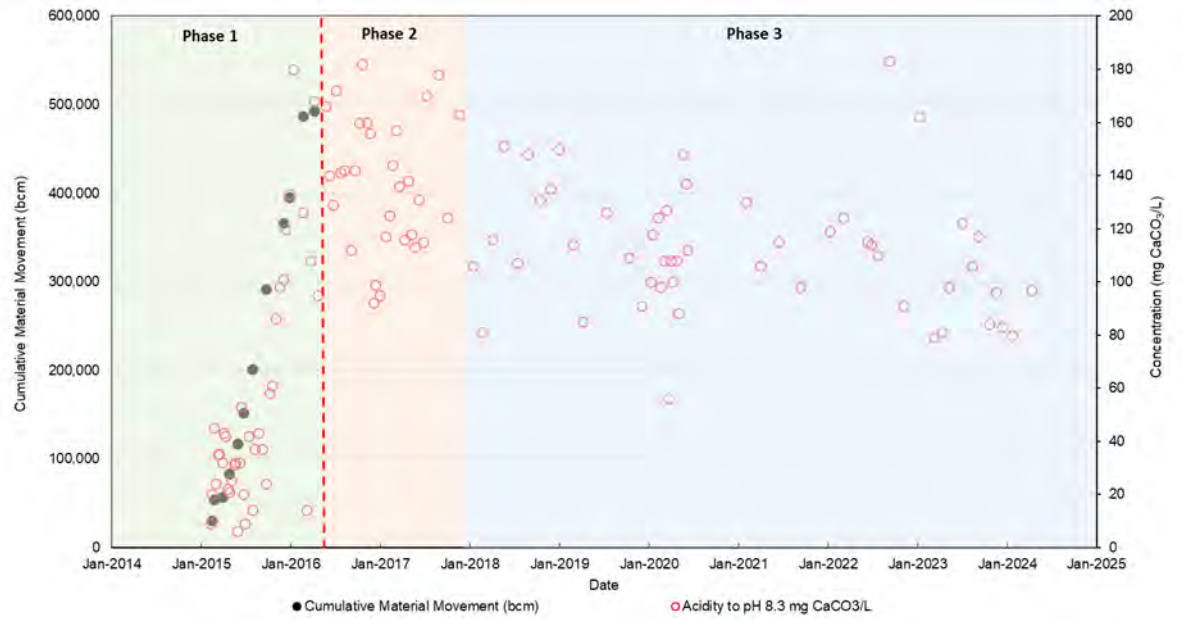


Figure 22: BV ELF acidity concentration.

Source: BRL 51279_RPT_Water (water quality excel database).

The red line indicates when the BV ELF underdrain was flooded in ~ April 2016.

Green shading indicates Phase 1: Construction Phase.

Yellow shading indicates Phase 2: Stabilisation Phase.

Blue shading indicates Phase 3: Decay Phase.

Note: Volumes do not match the total tonnes presented in Table 3. Table 3 relates to the materials that are within the catchment that reports to the BV ELF v-notch weir. This figure presents all material movements.

5.4 BV ELF Seepage Water Quality

This section summarises the seepage water quality data for the BV ELF. These data, together with flows are used to determine PCOC loads, which are used to develop deterministic predictive models for the BPCP. Relationships are derived between sulfate and PCOC so that water quality estimates for the proposed ELFs associated with the BPCP can be derived. Sulfate is a key indicator of AMD and the severity of AMD; hence the use of sulfate relationships is considered appropriate (further discussion is provided in Section 2.4).

Some PCOC data were limited for the BV ELF seepage water quality as monitoring of these parameters were limited. Column leach test data for Tl, Pb, Na, and K (Section 4.5) and S23 data from Mine Creek at Stockton Coal Mine was used for Cd, Cr, Co, Cu (Section 5.6) to provide a more robust relationship (i.e., more data) between sulfate and these PCOC.

PCOC are presented graphically in Figure 23 through to Figure 27 with each geochemical phase of the BV ELF shown. This was to provide visual context for how data from the BV ELF has been used to predict PCOC loads for other engineered landforms that are proposed as part of the BPCP.

5.4.1 BV ELF Timeseries Data Plots

Time series data are provided in the following figures to demonstrate the changes to water quality over the construction, stabilisation, and decay phases of the BV ELF. As shown by pH trend data (Figure 23) there is significant variability during the Construction Phase with pH ranging from ~pH 3.2 to ~pH

6.2, which would have a strong influence on water quality and pH sensitive metals (e.g., Fe and Al). During the stabilisation and decay phases geochemical trends are consistent.

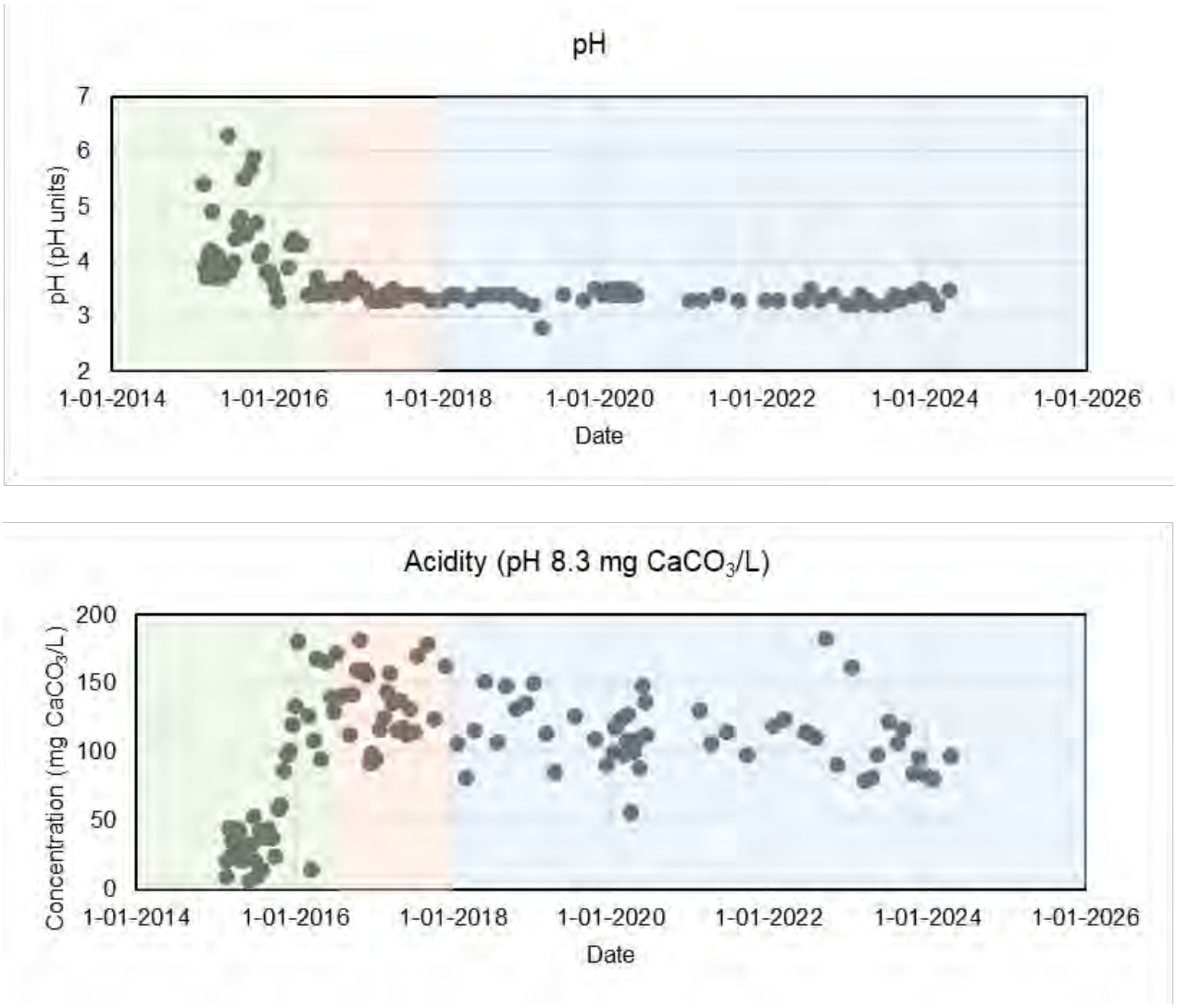


Figure 23: BV ELF pH and acidity concentrations (February 2015 – April 2024).

Source: BRL 51279_RPT_Water (water quality excel database).

All metals concentrations are dissolved.

Green shading indicates Phase 1: Construction Phase.

Yellow shading indicates Phase 2: Stabilisation Phase.

Blue shading indicates Phase 3: Decay Phase.

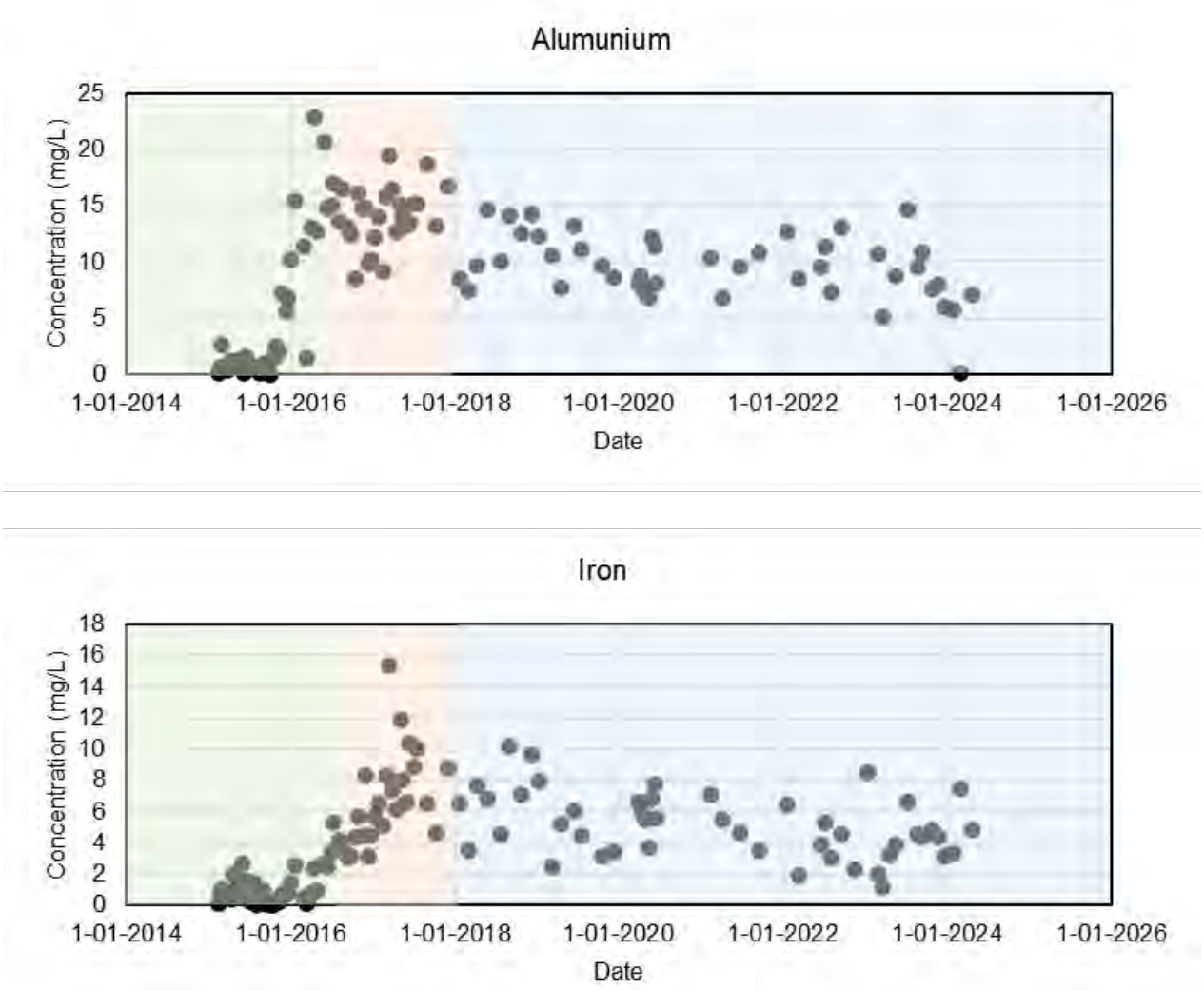


Figure 24: BV ELF Al and Fe concentrations (February 2015 – April 2024).

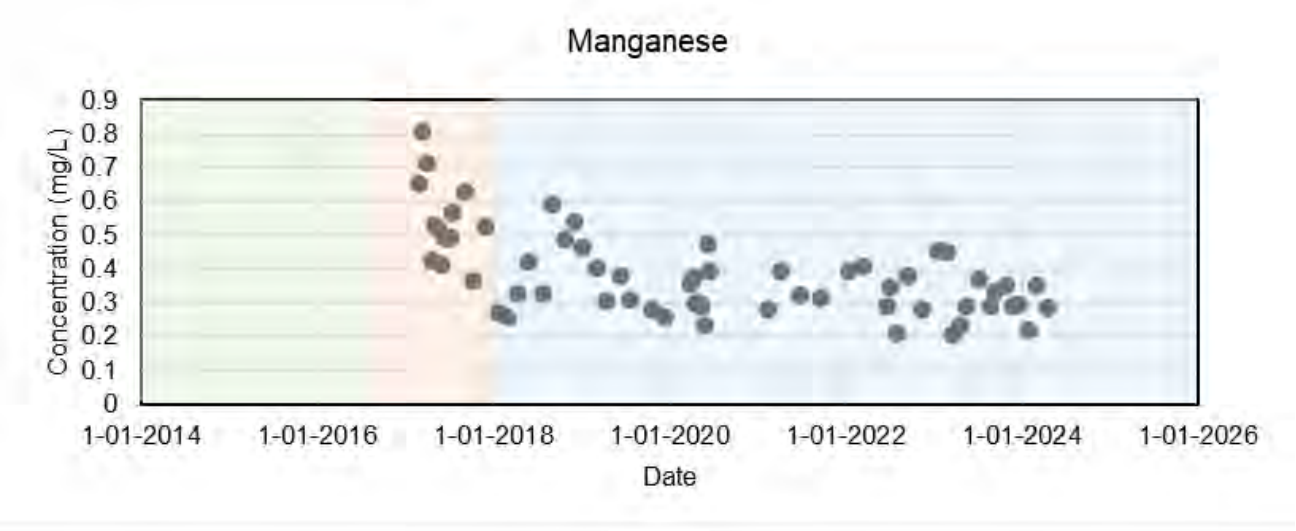
Source: BRL 51279_RPT_Water (water quality excel database).

All metals concentrations are dissolved.

Green shading indicates Phase 1: Construction Phase.

Yellow shading indicates Phase 2: Stabilisation Phase.

Blue shading indicates Phase 3: Decay Phase.



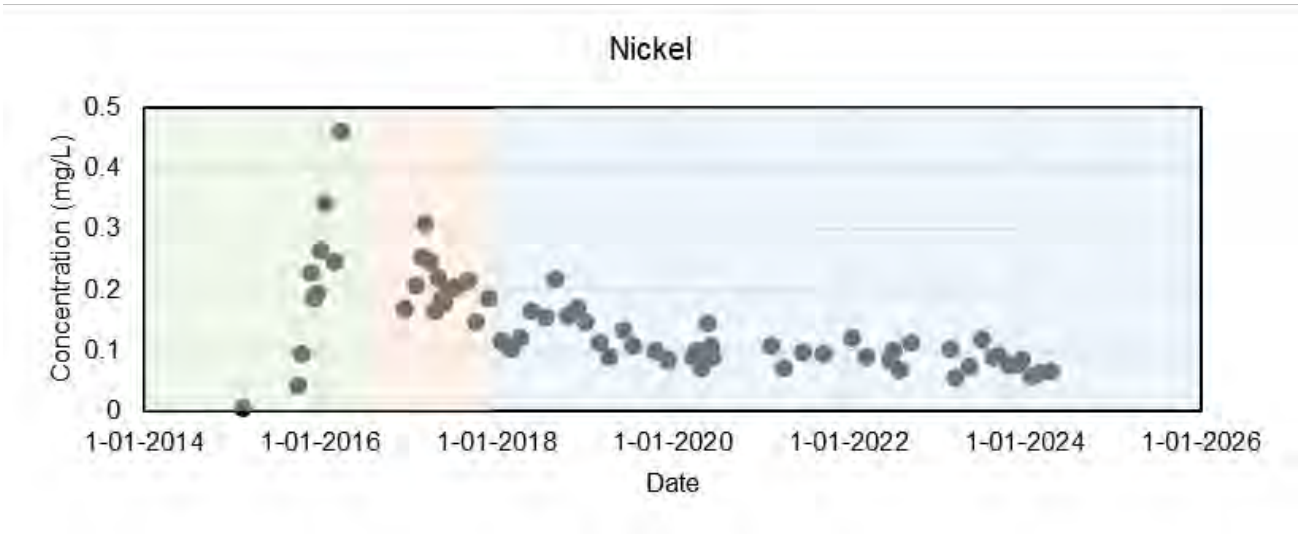


Figure 25: BV ELF Mn and Ni concentrations (February 2015 – April 2024).

Source: BRL 51279_RPT_Water (water quality excel database).

All metals concentrations are dissolved.

Green shading indicates Phase 1: Construction Phase.

Yellow shading indicates Phase 2: Stabilisation Phase.

Blue shading indicates Phase 3: Decay Phase.

Note: Mn data was not collected during the construction phase.

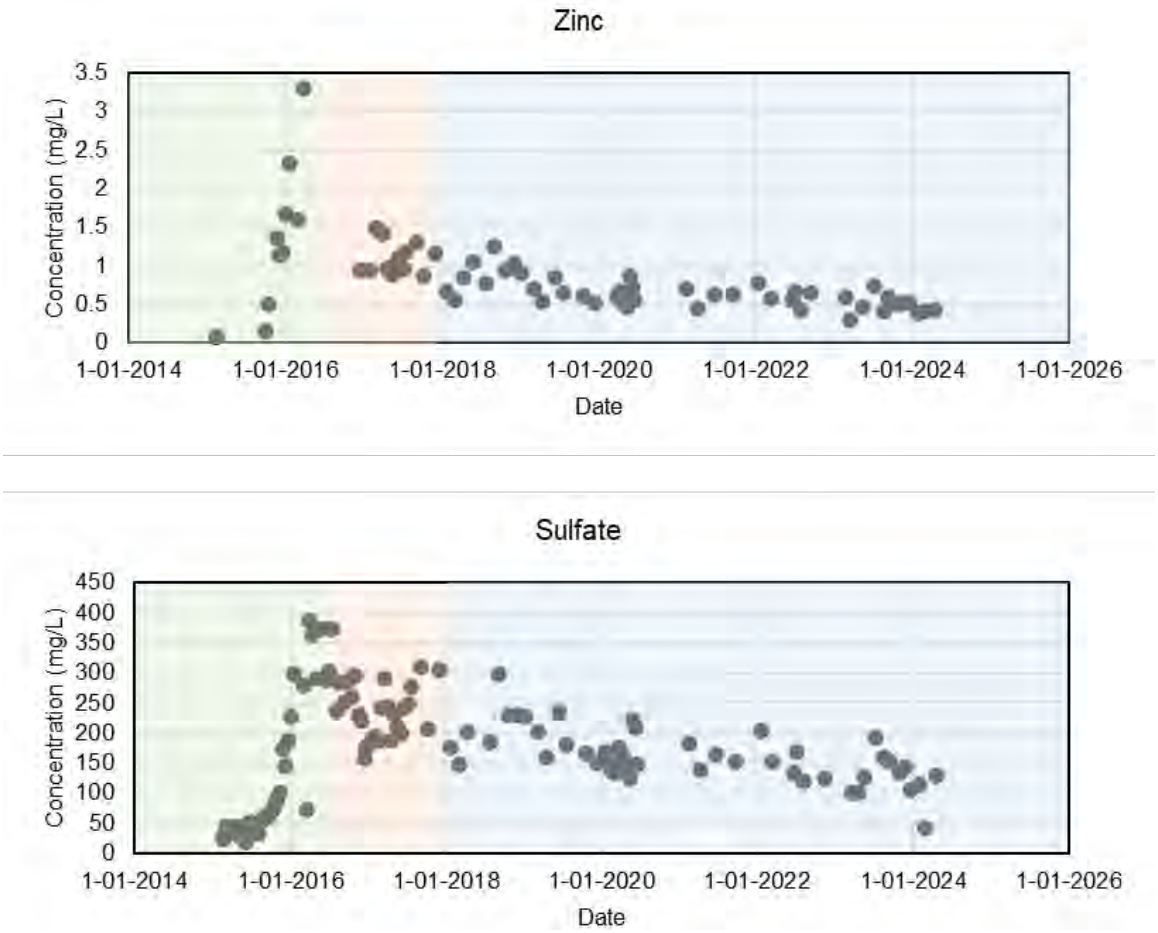


Figure 26. BV ELF Zn and SO_4 concentrations (February 2015 – April 2024).

Source: BRL 51279_RPT_Water (water quality excel database).

All metals concentrations are dissolved.

Green shading indicates Phase 1: Construction Phase.

Yellow shading indicates Phase 2: Stabilisation Phase.

Blue shading indicates Phase 3: Decay Phase.

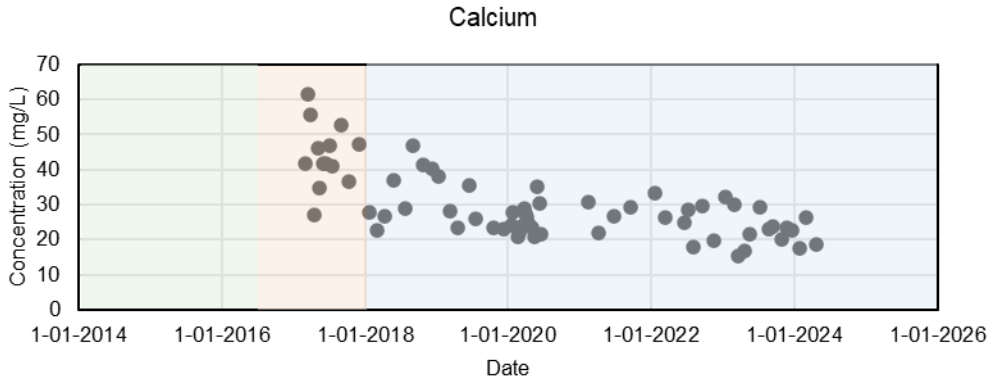


Figure 27: BV ELF Ca concentration (February 2015 – April 2024).

Source: BRL 51279_RPT_Water (water quality excel database).

All metals concentrations are dissolved.

Green shading indicates Phase 1: Construction Phase.

Yellow shading indicates Phase 2: Stabilisation Phase.

Blue shading indicates Phase 3: Decay Phase.

Note: Ca data was not collected during the construction phase.

5.4.2 BV ELF Sulfate: PCOC Analysis

Sulfate is a key indication of sulfide mineral oxidation and AMD generation. Sulfate is often related to key PCOC, particularly in AMD impacted waters. To develop an ELF water quality model to forecast PCOC from sulfate concentrations, the data from the BV ELF were used to develop relationships. A strong correlation was identified when the r^2 value was > 0.5 and it was assumed the derived relationship could be applied. Intercepts were set to 0. These data are provided in the following figures (Figure 28 to Figure 31):

- As noted in Section 5.4.1 there is significant variability during the Construction Phase with pH ranging from ~pH 3.2 to ~pH 6.2, which would have a strong influence on water quality. To ensure the most reliable relationship was obtained between sulfate and each PCOC, a trend line was also fitted for data that related to the Stabilisation Phase and the Decay Phase. If the relationship for the combined stabilisation and Decay Phase data had a higher r^2 value, then this was selected for the development of water quality source terms. Generally, results demonstrated that both relationships were reasonably comparable.
- As shown in the following images, there was a lack of data for some parameters (Cd, Co, Cr, Cu, K, Na, Pb, Tl), which created a poor r^2 value. In such instances column leach test data (K, NZ, Pb, Tl Section 5.5) or S23 data (Cd, Co, Cr, Cu Section 5.6) were used to derive the relationship between sulfate and the PCOC.

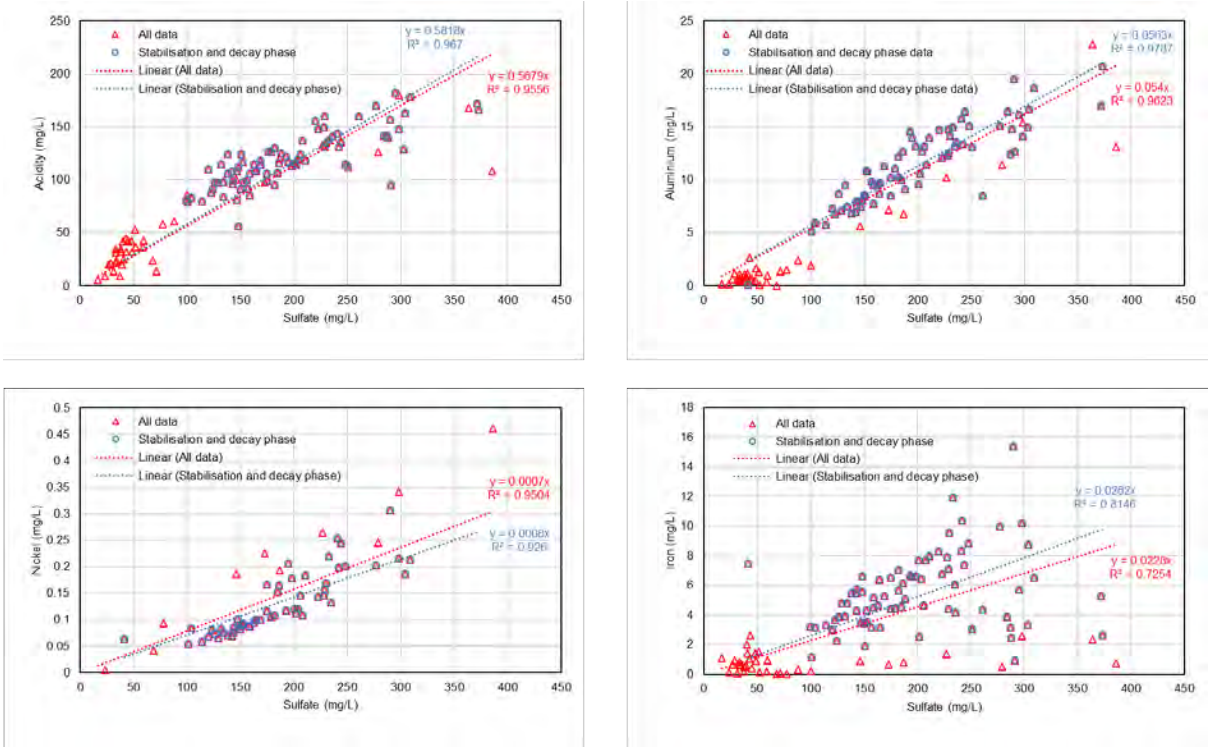


Figure 28: Sulfate versus PCOC: Acidity, Al, Ni, Fe.

BV ELF Water Quality.

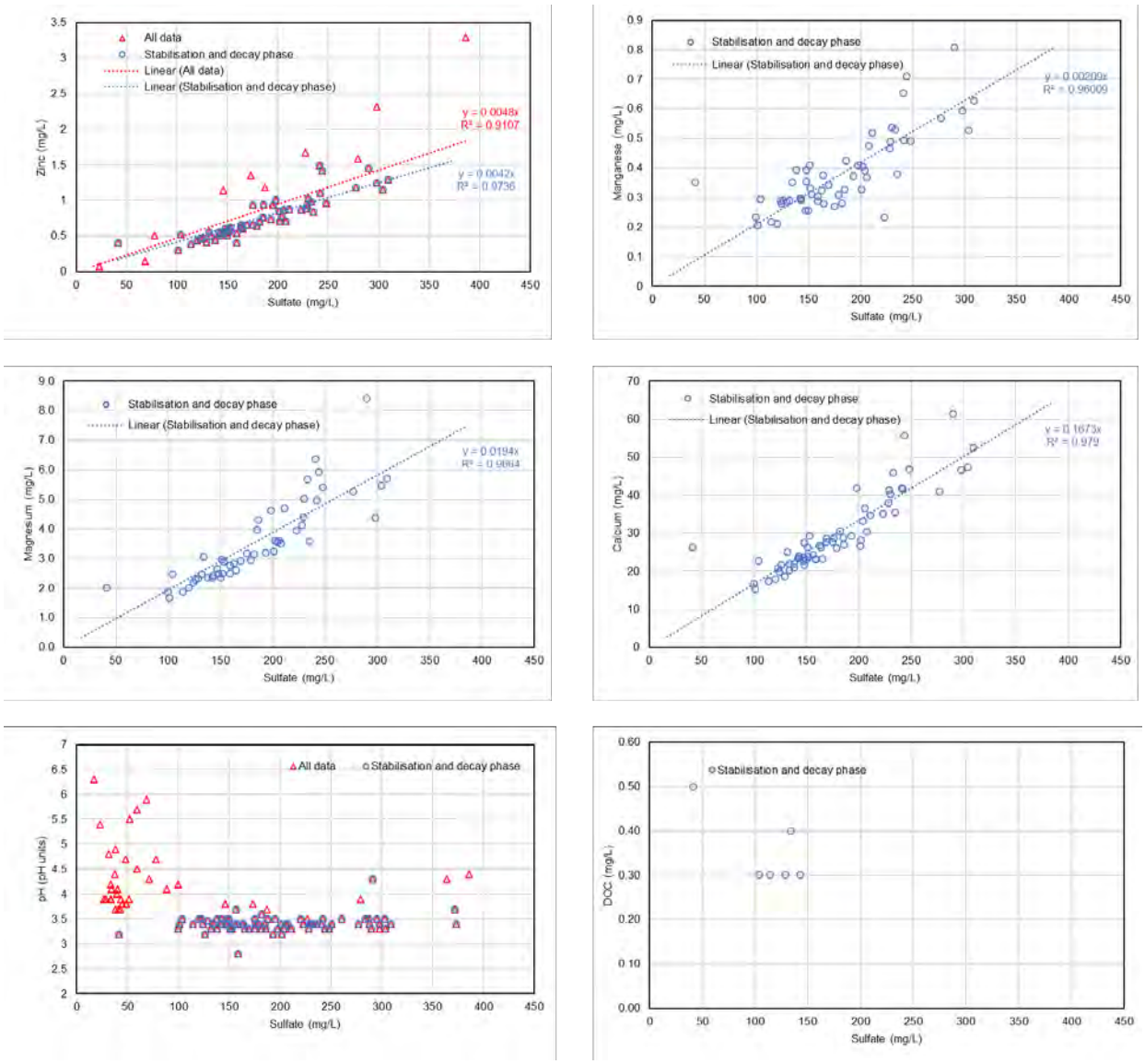


Figure 29: Sulfate versus PCOC: Zn, Mn, Mg, Ca, pH, and DOC.

BV ELF Water Quality.

Data for Mn, Mg, Ca, and dissolved organic carbon (DOC) were only available during the stabilisation and Decay Phase.

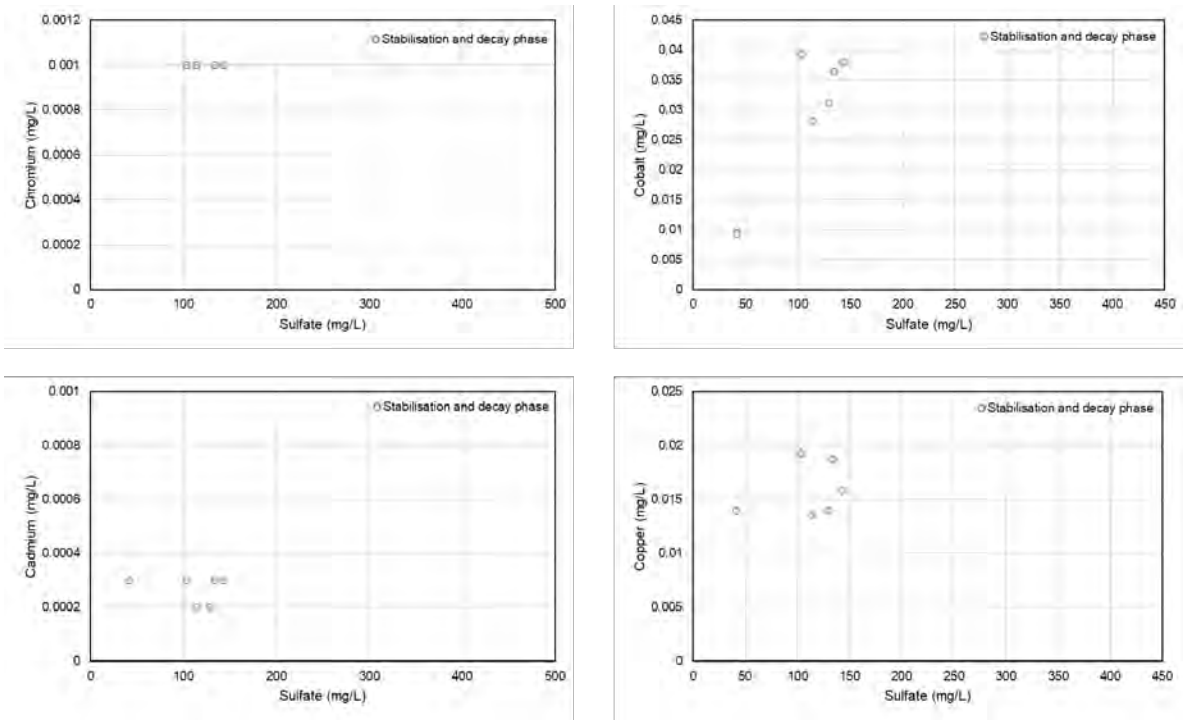


Figure 30: Sulfate versus PCOC: Cr, Co, Cd, Cu.

BV ELF Water Quality.

Data for Cr, Co, Cd, Cu only available during the stabilisation and Decay Phase and data collection was limited.

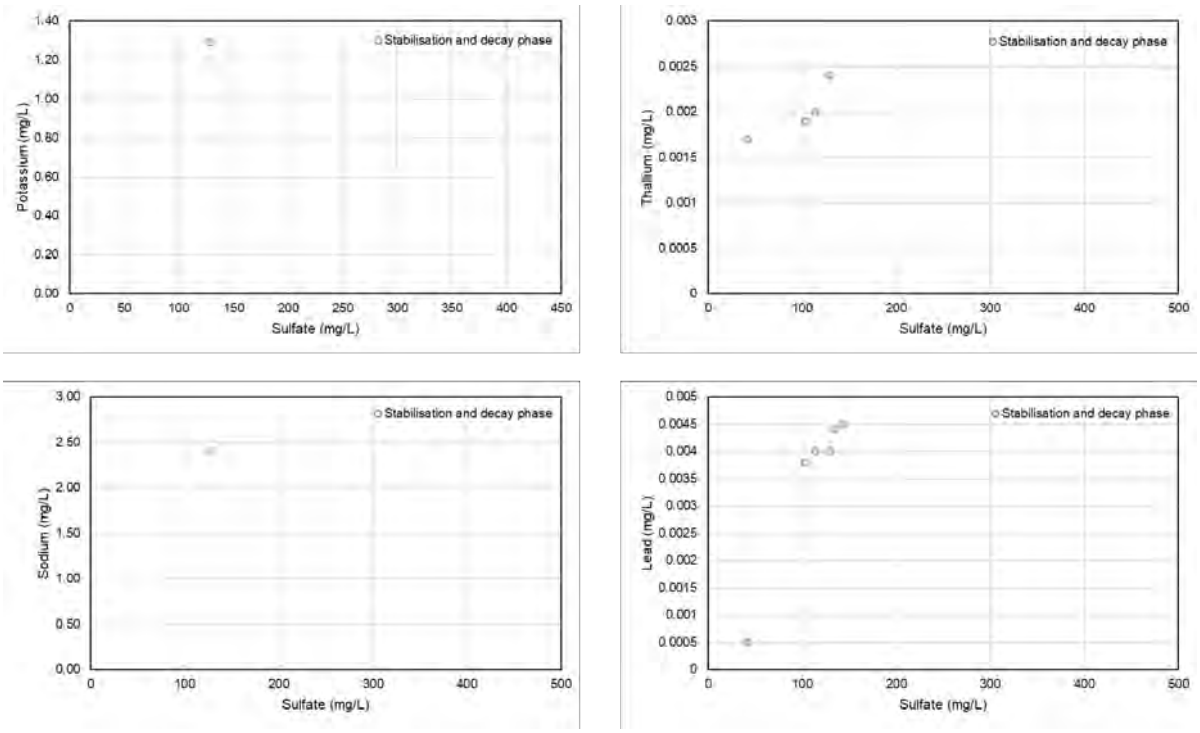


Figure 31: Sulfate versus PCOC: K, Tl, Na, and Pb.

BV ELF Water Quality.

Data for K, Tl, Na, and Pb were only available during the stabilisation and Decay Phase.

5.4.3 BV ELF Data

Water quality data from the BV ELF underdrain were tabulated to understand the long-term water quality trends for this mine domain. Water quality from the BV ELF has changed over time, hence only water quality data from May 2016 to April 2024 has been presented (i.e., Stabilisation and Decay Phase water quality). These data are presented in Table 9. The following observations are provided:

- pH ranged from 4.30 – 2.80 with an average of 3.39.
- Al and Fe concentrations ranged from 0.1 – 20.7 mg/L and 0.950 – 15.4 mg/L respectively.
- Flow rates from the BV ELF underdrain are 3.35 L/s (based on 2024 monitoring data – see Section 4).
- Analysis showed that acidity was between 56 – 183 mg $CaCO_3$/L with an average acidity of 121 mg $CaCO_3$/L. Based on the average flow rate (3.35 L/s) an acidity load of between 35.0 kg/day or 12.8 t/yr was calculated.

Table 9: BV ELF water quality (May 2016 to April 2024).

PARAMETER	COUNT	AVE	MED	MIN	MAX
pH	83	3.39 [1]	3.40 [1]	4.30 [2]	2.80 [2]
Conductivity at 25°C (mS/m)	75	50.6	50.2	33.2	72.4
Acidity to pH 8.3 (mg $CaCO_3$/L)	82	121.0	116.5	56.0	183.0
Average acid load (kg/day)	-	35.0	-	-	-
Average acid load (t/yr)	-	12.8	-	-	-
TDS	1	146	146	146	146
Turbidity	1	9.42	9.42	9.42	9.42
D(NP)OC	6	0.350	0.300	0.300	0.500
Nitrite-N*	1	0.010	0.010	0.010	0.010
Nitrate-N	9	0.044	0.040	0.010	0.100
Ammoniacal-N*	1	0.05	0.05	0.05	0.05
Total-N	1	0.175	0.175	0.175	0.175
Al	76	11.5	11.4	0.100	20.7
As*	4	0.001	0.001	0.001	0.001
B*	4	0.030	0.030	0.030	0.030
Ca	67	30.0	27.5	15.3	61.4
Cd	6	0.00027	0.00030	0.00020	0.00030
Cl	1	3.34	3.34	3.34	3.34
Co	6	0.0304	0.034	0.0094	0.0393
Cr*	4	0.001	0.001	0.001	0.001
Cu	6	0.0159	0.0149	0.0136	0.0193
Fe	79	5.52	5.17	0.950	15.4
K	1	1.29	1.29	1.29	1.29
Hg*	1	0.0005	0.0005	0.0005	0.0005
Pb*	6	0.0035	0.004	0.0005	0.0045
Mg	57	3.54	3.20	1.67	8.42
Mn	61	0.385	0.355	0.205	0.808
Na	1	2.40	2.40	2.40	2.40
Ni	60	0.128	0.108	0.054	0.307

PARAMETER	COUNT	AVE	MED	MIN	MAX
Sb*	1	0.001	0.001	0.001	0.001
Se*	1	0.005	0.005	0.005	0.005
Si	1	8.44	8.44	8.44	8.44
Sn*	2	0.0005	0.0005	0.0005	0.0005
SO_4	81	195.2	182	41.4	373Fsulfate
Tl	4	0.002	0.00195	0.0017	0.0024
Zn	60	0.755	0.664	0.302	1.49

Source: BRL 51279_RPT_Water (water quality excel database).

1. *Based on [H+] concentration.*

2. Minimum and maximum pH values have been swapped (maximum concentrations correlate to the lowest pH value) to ensure pH relate to same geochemical conditions as other data in the dataset.

All units are presented in mg/L unless otherwise specified.

A hyphen (-) indicates no value is given.

An asterisk (*) indicates the value is below the LOR.

5.5 Column Leach Test Data

Colum leach test (CLT) data are available for waste rock samples from the ESE sub-area and the MFS sub-area with data being discussed previously (MWM, 2026b). With limited data for some parameters (e.g., Cd, Co, Cr, Cu, K, Na, Pb, Tl) the CLT data was used to derive stronger relationships than those available for the BV ELF (i.e., Section 5.4).

An assessment of data indicated that ESE columns and MFS column results demonstrated no significant difference between sulfate and PCOC data for the two Project sub-areas (MWM, 2026b). The key driver of whether PCOC are elevated is whether the material is non-acid forming or potentially acid forming. Zn data are provided in Figure 32 to explain this.

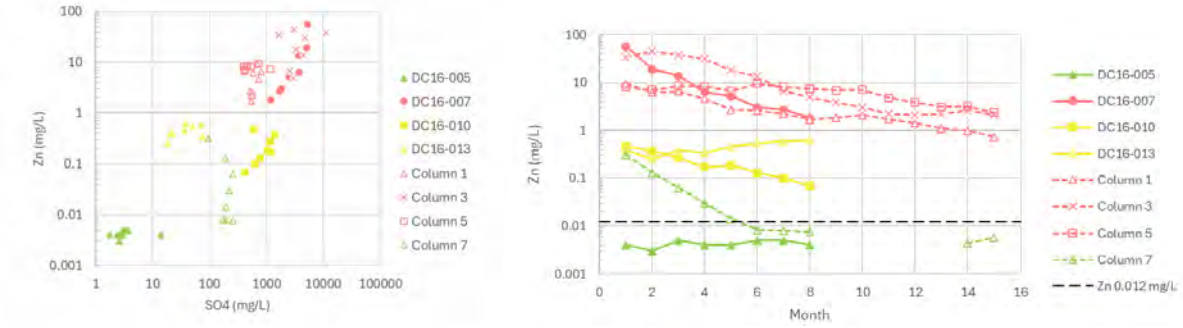


Figure 32: ESE (Columns 1-7) and MFS (samples DC16) Column Leach test data.

Source: MWM, 2026b: Green = PAF; Yellow = Low Risk (PAF); Green = NAF

Data from all ESE and MFS CLTs are used to derive PCOC concentrations based on SO_4 relationships. K, Na, Pb, and Tl results are provided in Figure 33. Data indicates that a poor relationship (i.e., $r^2 < 0.5$) was determined for Pb, Na, and DOC. However, to enable the model to function and for these PCOC to increase in concentration with increasing sulfate concentrations, the positive relationships were used.

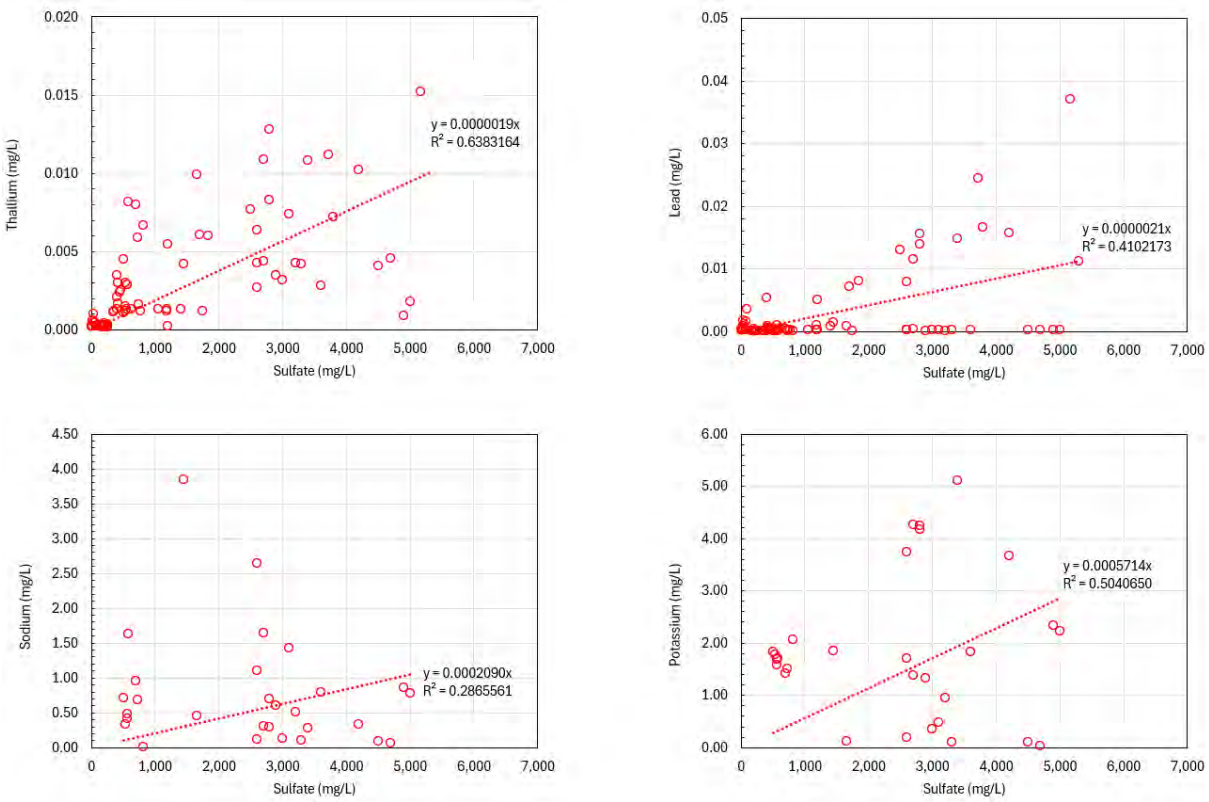


Figure 33: Column leach test sulfate versus PCOC: Tl, Pb, Na, and K.

ESE and MFS column leach test data.

5.6 S23 Water Quality Data

Water quality monitoring data was investigated from catchments within the wider Stockton Plateau with the aim of providing stronger relationships between SO_4 and Cd, Co, Cr, Cu. Relationships were derived from water quality monitoring site S23 in the south tributary of Mine Creek.

Relationships between PCOC and SO_4 were derived for PCOC with poor relationships or limited data from the BV ELF and CLT data (i.e., Cr, Cd, Co, Cu) (Figure 34). S23 data was applied as an analogue site for PCOC and SO_4 relationships as:

- The S23 catchment is AMD impacted within the BCM.
- There is an extensive water quality monitoring data for PCOC of interest providing confidence of trends.
- The sulfate concentrations were comparable. For instance, the higher SO_4 data covers the values expected through the construction and early Stabilisation Phases (i.e., S23 SO_4 median 1,385 mg/L over selected data range).
- Strong trends identified for Cr, Cd, Co, Cu

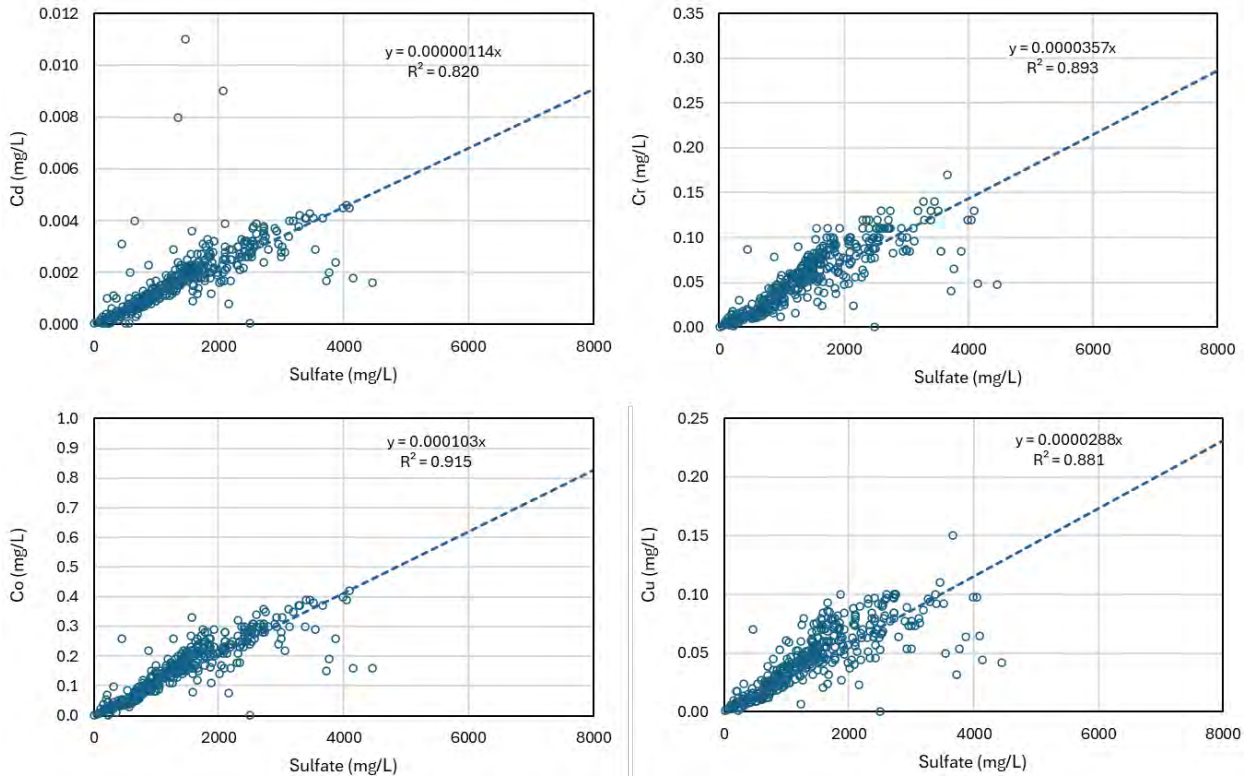


Figure 34: S23 Sulfate versus PCOC: Cd, Cr, Co, Cu.

S23 data.

5.7 Arsenic

Water quality data for BV ELF underdrain seepage indicated that arsenic (As) was below the limit of reporting, however data was limited to four samples, and this might not be a robust assessment of whether As can be elevated in AMD impacted waters. Hence, additional data was obtained from the BPCP AEE studies and Stockton to confirm As is not considered a PCOC for the BV ELF water quality model.

5.7.1 Column Leach Test Data

Data from column leach tests, undertaken on MFS and ESE materials was assessed (Figure 35). Results indicate that:

- Arsenic sulfate relationships for column leach test (CLT) data indicates that acid forming materials (e.g., Low Risk (LR) and PAF) can exceed arsenic trigger values (ANZG, 2018) for 95% level of protection (0.013 mg/L).
- Arsenic is below ANZG (2018) values when sulfate data is <420 mg/L with increase in As observed at higher sulfate concentrations.
- Maximum sulfate data recorded from BV ELF water quality data is 386 mg/L which explains why As may be low.
- Noting that column lech test data are often scaled down to lower concentrations when being applied to the field due to lesser amounts of oxygen, larger grainsize, lower temperatures, etc.

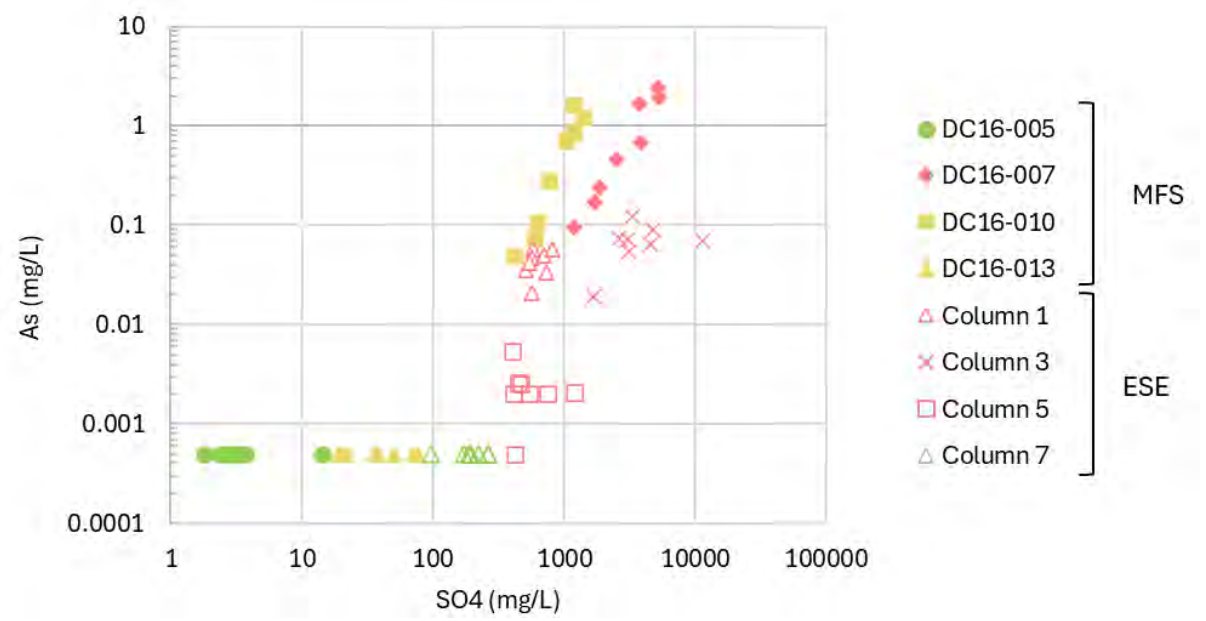


Figure 35: Arsenic and sulfate relationship for column leach tests.

Data is coded as per process flow material classification (MWM, 2026b) Red =PAF, Yellow = LR, Green = NAF.

5.7.2 Mangatini Catchment

Given a substantial empirical data exists for Stockton with much higher sulfate concentrations, the data from Stockton were reviewed to determine if As could be elevated within AMD impacted waters.

Water quality data from Mangatini catchment at Stockon includes data from treated and untreated sites, where treatment includes neutralisation of AMD impacted waters with CaO. These data were assessed to understand the mobility of arsenic in this environment:

- Results in Figure 36 indicate instances where arsenic is above ANZG (2018) trigger values at Stockton, particularly
    - Duncans SW (Duncan's Sump) that receives untreated AMD impacted water.
    - MGIU, which is upstream of the CaO treatment system in the Mangatini Stream.
- Figure 37 presents data from AMD affected water quality monitoring sites at the Stockton Mine where untreated water can exceed ANZG (2018) 95% values.

However, water quality data from sites receiving treated AMD discharge, e.g., MGD, MGIT, S14C and NR, indicate no exceedance of ANZG (2018) values for As (Figure 36) except for one sample from S14C that is likely to be erroneous. The removal of this As is likely due to adsorption to $Fe(OH)_3$ precipitates that form following treatment.

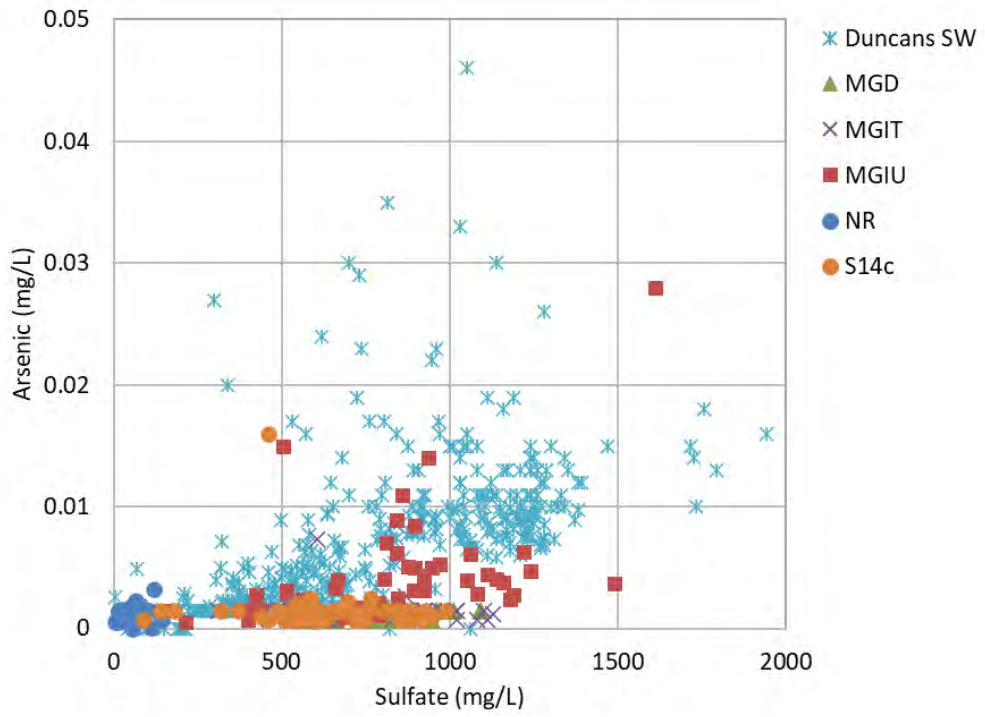


Figure 36: Arsenic and sulfate relationship for Mangatini water quality monitoring sites.

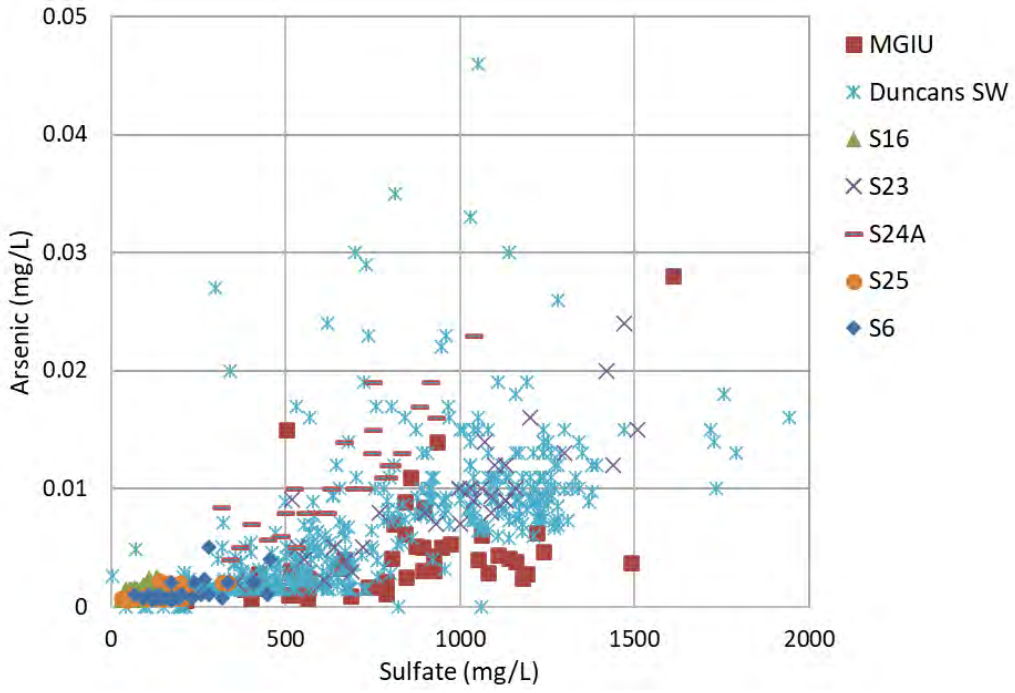


Figure 37: Arsenic and sulfate relationship for AMD affected water quality monitoring sites.

Water quality data for treated water indicates As is not elevated above ANZG (2018) at the 95% level of protection. Exceedance of As values is indicated in untreated water. Higher As concentrations in CLT PAF and LR material illustrates the importance of placement of higher risk material within anoxic conditions within an ELF to prevent sulfide mineral oxidation.

5.7.3 MSR Passive Treatment

MSR have been investigated for many years at the Stockton and at the existing Escarpment mines. Influent data for the Whirlwind MSR at the Stockton Mine[8] is < 0.001 mg/L (LOR) and effluent data is also < LOR. Studies by the University of Windsor have demonstrated effective removal of As within the iron sludge layer that forms on the top of MSR (Figure 38). This also demonstrates the As adsorption processes for passive treatment systems will be effective.

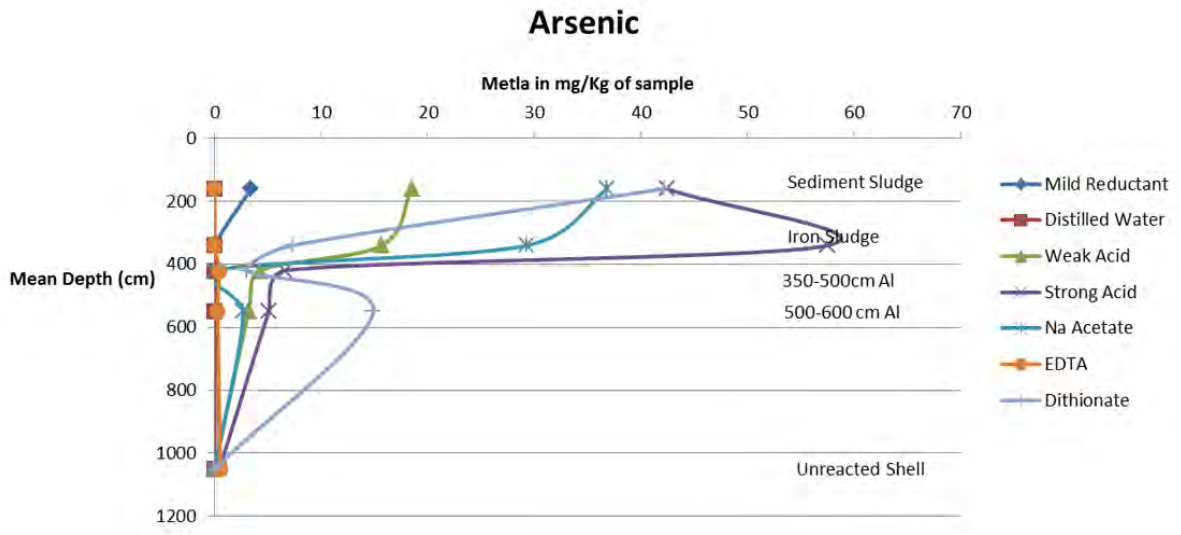


Figure 38: As extraction profile for Manchester Street MSR, Stockton

Source: Diloreto (2013).

5.7.4 Summary

AMD impacted waters require treatment and water treatment is planned at the BCPC to treat acidity and PCOC. This will generate $Fe(OH)_3$ precipitates that will support the removal of arsenic (adsorption). Given arsenic is only elevated on occasion for the most AMD impacted waterways (high sulfate), and a process will be present where it is effectively removed (passive and active treatment), the risks are considered low and arsenic was not included in the geochemical model.

[8] Provided by BRL.

6 BV ELF GEOCHEMICAL MODEL

A number of ELFs are proposed for the BPCP. To understand the potential effects of AMD impacted seepage from each ELF, the ELF basal sub-catchments were determined and the seepage points identified for these basal sub-catchments by BRL. A total of 20 ELF basal sub-catchments have been identified:

- Six ELF basal sub-catchments within the ESE sub-area.
- Fourteen ELF basal sub-catchments within the MFS sub-area.

The following section explains how water quality is derived for the various sub-catchments that are proposed for the BPCP over the ELF water quality phases.

6.1 Introduction

Most rocks, following blasting contain stored water soluble PCOC that can be mobilised by the flow of water through these materials (e.g., net percolation (NP)). Stored PCOC can also be generated by ongoing oxidation of sulfides after placement in the ELF.

Two processes are considered:

- Dissolution of stored oxidation product: This process involves the release of solutes through the dissolution of readily available soluble minerals by NP. The release of solutes occurs predominantly in the short term due to flushing of these PCOC by net percolation through the ELF.
- Oxidation: This refers to the oxidation of sulfides in zones of the ELF that have oxygen available, resulting in the generation of additional stored sulfate and associated solutes over the long term.

Products of these processes within the BV ELF are identified in current water quality data. These processes are expected to vary over the three distinct water quality phases identified for the BV ELF, which is in alignment with previous studies.

Phase 1: Construction Phase

- August 2014 – April 2016.
- Low PCOC concentrations that increase with an increasing amount of waste rock placement within the ELF and gradual wetting up of the materials.
- Generally, peak concentrations of PCOC coincide with maximum material placement.

Phase 2: Stabilisation Phase

- May 2016 – December 2017 (20 months).
- Flow rates are generally stable as the ELF wets up and then flushes stored oxidation products from the waste rock. For the BPCP, it is assumed the duration of the Stabilisation Phase for final rehabilitated areas of the ELF also aligns with the duration of the draindown phase (created by the installation of a lower permeability cover system).

- Concentrations of PCOC remain stable.

Phase 3: Decay Phase

- January 2018 – onwards.
- Phase 3 relates to the decrease in PCOC concentrations from peak concentrations observed in the Stabilisation Phase.
- During this phase, water infiltration rates remain steady, but the rate of solute generation declines (lesser oxidation of sulfides and flushing out of stored oxidation products).

6.2 Stabilisation Phase Duration

It is assumed the duration of the Stabilisation Phase aligns with the duration of the draindown phase (created by the installation of a lower permeability cover system). The duration of the Stabilisation Phase has been estimated from sulfate, acidity, and aluminium (key indicators of acidity) with data trends presented in Figure 23, Figure 24, Figure 26. These data indicate that the Stabilisation Phase for the BV ELF is ~20 months.

The duration of the Stabilisation Phase is related to average height of the ELF. This relationship was applied to the other BPCP basal ELF sub-catchments though applying a scaling factor to the BV ELF (Table 10). Results are comparable to the time frame proposed by Okane Consultants (2014) for the original Escarpment ELF (50 m high) where >99% of the cumulative draindown occurs within 3-5 years and total draindown occurs over 8 years (Figure 39). Hence, the scaling process to derive the duration of the Stabilisation Phase is considered reasonable to understand the longer-term risks associated with AMD.

Table 10. Stabilisation Phase duration.

PROJECT AREA	BASAL ELF SUB-CATCHMENT	AVERAGE HEIGHT (m)	HEIGHT SCALING FACTOR	STABILISATION PHASE DURATION (YEARS)
ESE	BV ELF	10.71	1	1.7 (20 months)
ESE	BVE	35.1	3.27	5.5
ESE	CON	35.7	3.33	5.6
ESE	NSUL	21.1[1]	1.97	3.3
ESE	PPG	17.6	1.64	2.7
ESE	WWH	59.7	5.57	9.3
ESE	ESC	19.5	1.82	3.0
MFS	MSR1	14.5	1.36	2.3
MFS	MSR2	12.6	1.17	2.0
MFS	MSR3	12.6	1.17	2.0
MFS	MSR4	12.6	1.17	2.0
MFS	MSR5	19.1	1.79	3.0
MFS	MSR6	10.1	0.94	1.6
MFS	MSR7	11.9	1.11	1.8
MFS	MDC1	9.0	0.84	1.4
MFS	MDC2	6.4	0.60	1.0

PROJECT AREA	BASAL ELF SUB-CATCHMENT	AVERAGE HEIGHT (m)	HEIGHT SCALING FACTOR	STABILISATION PHASE DURATION (YEARS)
MFS	MSR8	18.4	1.71	2.9
MFS	MSR9	12.7	1.18	2.0
MFS	MSR10	8.4	0.79	1.3
MFS	MSR11	6.6	0.62	1.0
MFS	MSR12	7.8	0.72	1.2

Yellow: NAF ELF basal sub-catchments (NSUL, PPG, MDC1, and MDC2)

[1] Average height during operations is applied as a conservative approach for deriving stabilisation phase duration. Average height on closure is 15.49 m.

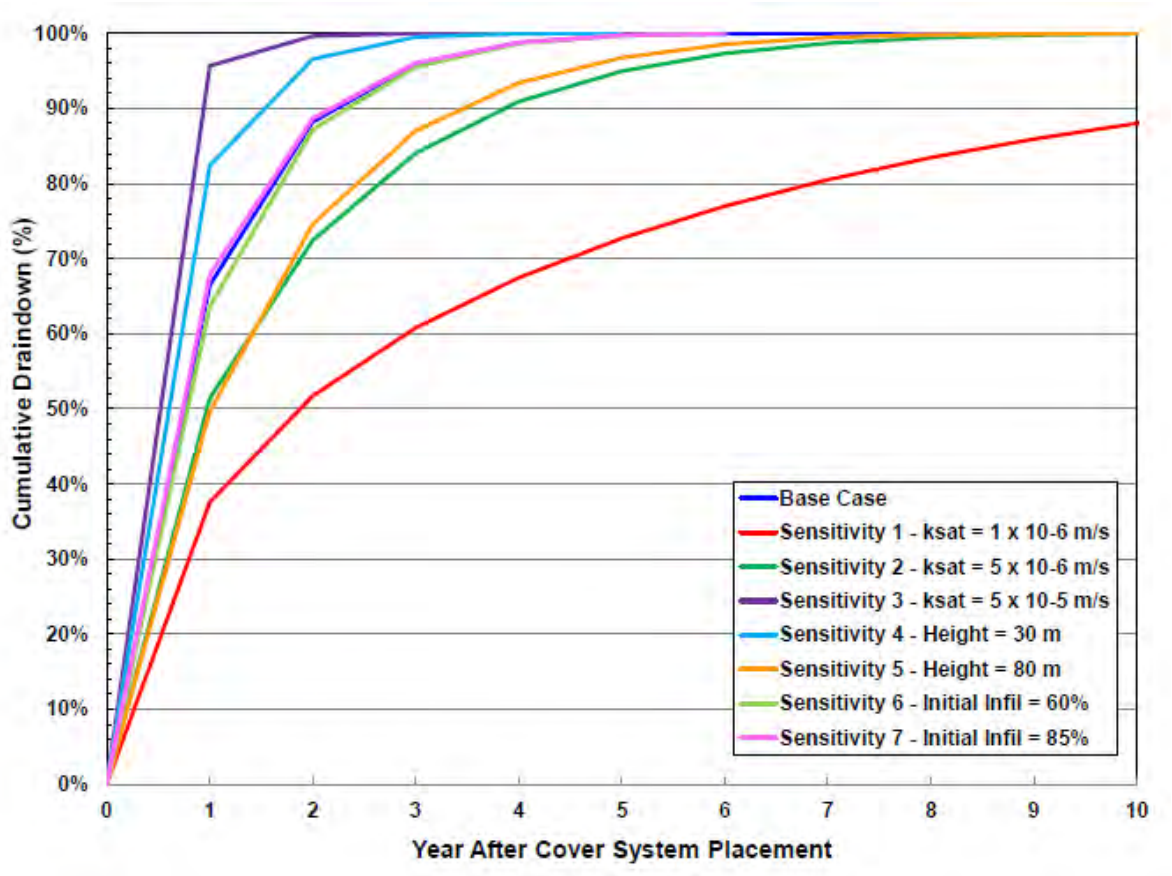


Figure 39. Sensitivity analysis evaluating draindown for a 50 m high ELF.

Source: Okane Consultants (2014).

6.3 Phase 3 – Decay Phase

Data from the BV ELF were used to plot annual sulfate generation rates as a function of material quantity. These results are shown for the Stabilisation Phase (Phase 2) and the Decay Phase (Phase 3) in Figure 40 and demonstrate that in the Decay Phase there is an annual decrease of 9.6% per year (for all materials in the BV ELF). This suggests a rapid decay in sulfate/acidity loads and aligns with observations at Stockton Coal Mine of a rapid decrease in acidity loads in the first 10 years (Section 2.6). Calculations indicate a 9.6% decay represents a decrease of ~50% of the initial sulfate load after 7 years, which remains in alignment with the Stockton AMD Model and analysis of site data that supports this decline (Figure 14).

Data presented in Figure 40 indicate that peak sulfate generation rates are 0.053 kg/t/yr (0.115 kg/m^3/yr). This is based on the measured flow rate and water quality for the BV ELF. It is assumed this load is associated with the ongoing oxidation of sulfides with the assumption that stored oxidation products, present during placement have mostly been removed by flushing during the Stabilisation Phase.

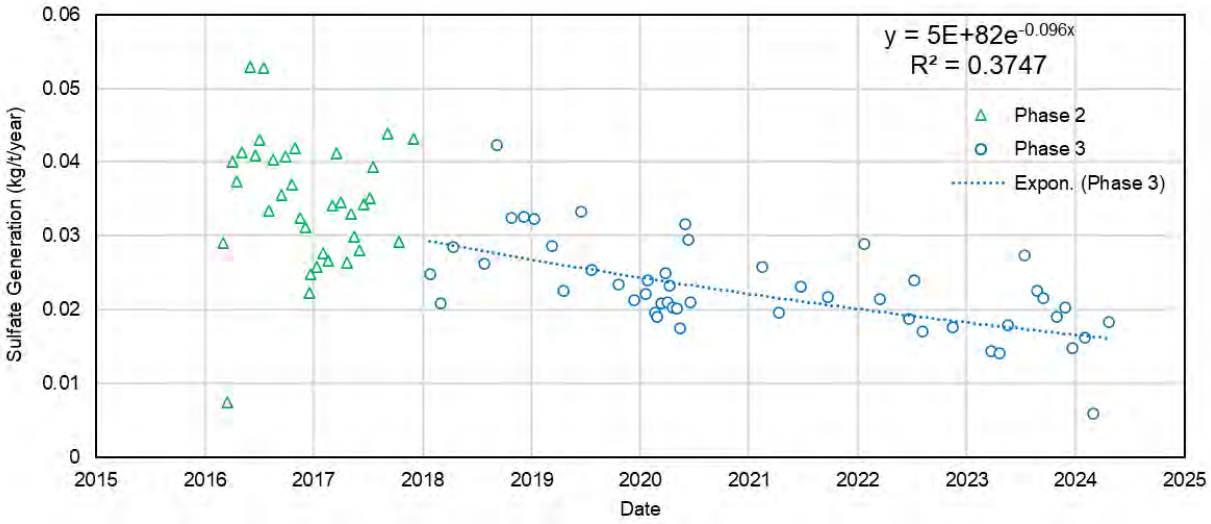


Figure 40. BV ELF sulfate generation rates.

7 ELF LOAD MODEL

An overburden load model was developed for the BV ELF using the data presented in Sections 4 and 5; the hydrogeochemical processes described in Section 2; and the analogue model (Section 6) describing the key ELF geochemical phases and processes.

This ELF load model provides a reliable basis to scale the water quality data to other ELFs associated with the BPCP and:

- Uses empirical data (water quality and flow rate from the BV ELF) to develop the model.
- Addresses the benefits of oxygen exclusion through construction of an engineered landform to prevent advective oxygen ingress.
- Enables scaling of the model to other ELFs based on sulfur content of each landform.
- Provides a tool to develop water quality estimates for other ELFs.

7.1 Load Models

Two components of the ELF load model need to be considered including the load derived from the dissolution of stored oxidation products and the load generated from ongoing oxidation of sulfides and the generation of additional solutes. Hence, two ELF load models were developed:

- Sulfide Oxidation (SOX) load model
- Stored Oxidation Product (SOP) load model

Load models were developed based on sulfate data. These models are then applied in conjunction with mine scheduling data, and PCOC correlations, to predict water quality for BPCP basal ELF sub-catchments.

7.2 Sulfide Oxidation (SOX) Load Model

This model determines the ongoing solute load derived from ongoing sulfide mineral oxidation due to diffusive oxygen ingress into the ELF. The following approach was undertaken:

- The SOX was derived from the volume of material within the BV ELF that is assumed to contribute to ongoing solute generation due to the oxidation of sulfides.
- Figure 4 and Figure 5 indicate diffusive oxygen ingress to ~15 m depth, therefore the SOX load was derived from the 15 m shell volume of the BV ELF rather than the entire ELF volume and assumes the core of the ELF is sub-oxic. It is noted that some advective oxygen ingress is present in the BV ELF, hence the allocation of all load from the BV ELF to the 15 m shell volume is therefore a conservative assumption for scaling load (Note: applying all load to the total volume of the BV ELF would reduce the load per unit volume (m^3), which is not conservative).
- To determine the SOX load produced from the 15 m shell, water quality data during the Stabilisation Phase of the BV ELF was used.
    - The 75th percentile data value for sulfate during the Stabilisation Phase (289 mg SO_4/L; Figure 41) was selected to determine the SOX load (as explained by Equation 2 and

Equation 3). This sulfate concentration aligns with the commencement of Phase 3 decay.

- The use of 75th percentile data is conservative as this means the starting sulfate concentration (i.e., 289 mg/L) at the commencement of the Decay Phase is in the upper quartiles (Figure 41) at the start of 2018.

- This value can then be used to determine the load due to ongoing SOX at the start of the Decay Phase.

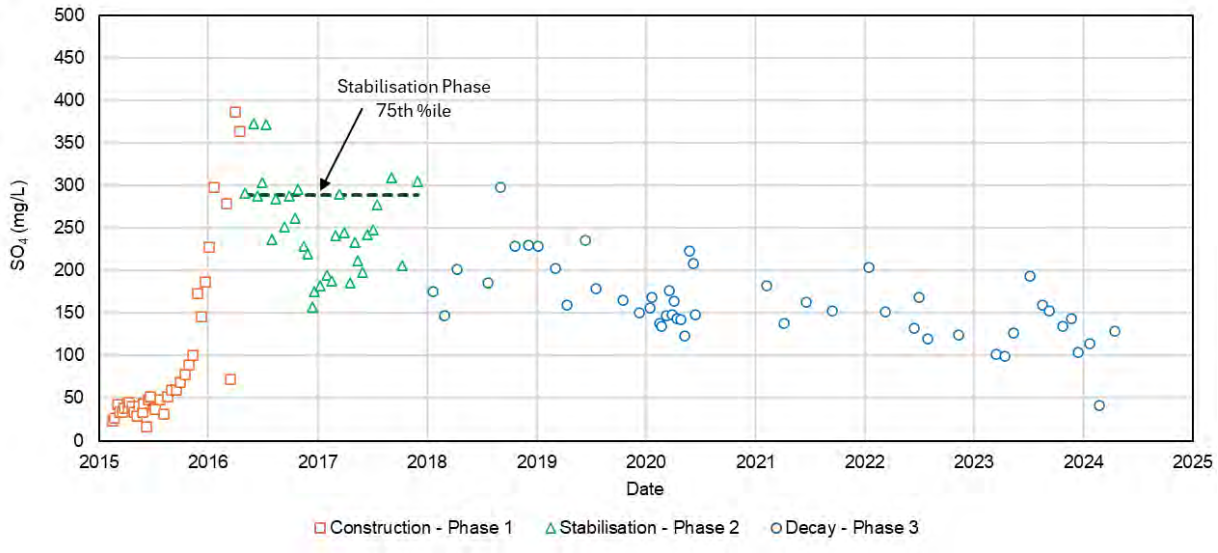


Figure 41. Derivation of SOX load from BV ELF sulfate data.

75th percentile during Stabilisation Phase – 289 mg/L.

The following steps were then applied to derive the SOX load for the BV ELF at the start of the Decay Phase:

1. The sulfate concentration (289 mg/L) was applied to average BV ELF flow (3.35 L/s) providing a SOX load in mg/s:

Equation 2: $289\ mg/L \times 3.35\ L/s = 968.15\ mg/s$

2. The mg/s oxidation load was applied to the volume of material within the oxidising 15 m shell of the BV ELF:

Equation 3: $968.15\ mg/s \,/\, 304{,}895\ m^3 = 0.00318\ mg/m^3/s$

Where m^3 is in loose cubic metres (LCM).

The resulting value (0.00318 $mg/m^3/s$) can then be applied to material quantities to predict water quality due to sulfide oxidation.

7.3 Stored oxidation Product (SOP) Load Model

This model determines the amount of stored oxidation products (SOP) that were generated before the final BV ELF landform was completed. The SOP is associated with stored oxidation products within the

material excavated, with flushing of most stored oxidation products commencing during the BV ELF construction process through to the end of the Stabilisation Phase.

The following approach was undertaken to estimate the contribution of stored oxidation product dissolution to BV ELF water quality:

- The difference between the maximum sulfate data for the Stabilisation Phase and the first-year post stabilisation (i.e., Year 1 of the Decay Phase) was assessed. This enabled the calculation of the SOP load. Where:
    - Maximum sulfate data from the Stabilisation Phase (386 mg/L) was selected to represent peak oxidation of all materials in the BV ELF (combination of SOP and SOX).
    - Maximum sulfate during the first-year post Stabilisation Phase (298 mg/L) was selected to avoid:
        - influence of stored oxidation product dissolution; and
        - significant oxidation decay.
        - Noting this is slightly higher than the Stabilisation Phase 75th%ile sulfate data of 289 mg/L).

The difference between these data were used to estimate the SOP (Figure 42) using Equation 4, Equation 5, and Equation 6. Unlike the SOX load model, it is assumed stored oxidation product is produced by the total volume of material in the BV ELF.

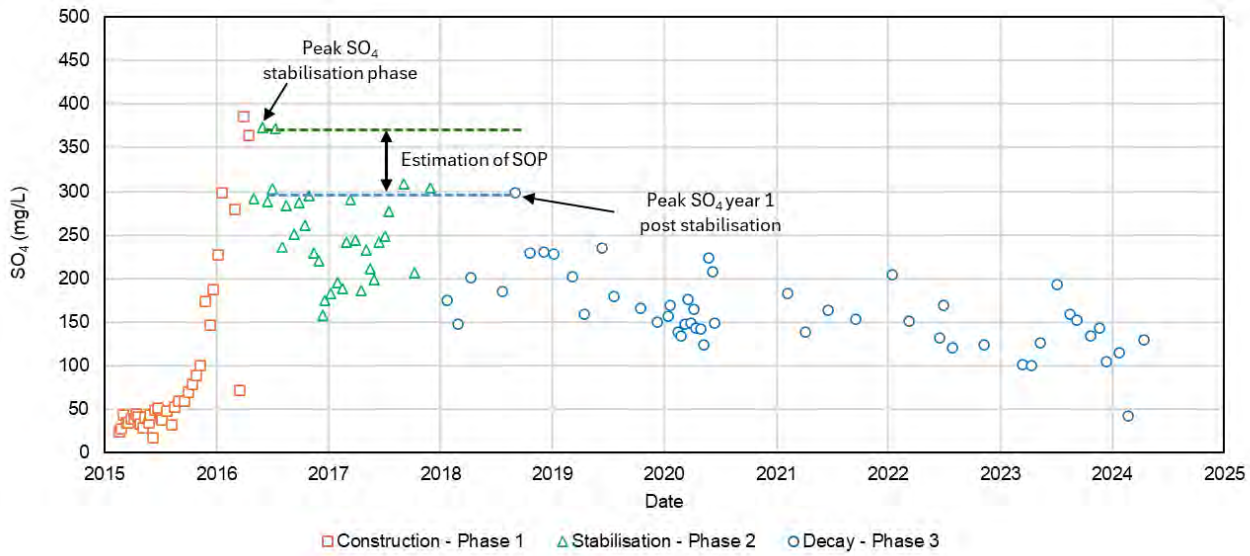


Figure 42. Derivation of SOP load model from BV ELF sulfate data.

The following calculations were applied to derive the SOP using the estimation of stored oxidation products, average flow, and total volume (LCM) of the BV ELF:

1. Estimation of SOP load:

Equation 4: $386\ (SO_4\ mg/L) - 298\ (SO_4\ mg/L) = 88\ (SO_4\ mg/L)$

2. The SOP load (88 mg/L) was applied to the average BV ELF flow (3.35 L/s) providing a SOP load in mg/s:

Equation 5: $88\ (SO_4\ mg/L) \times 3.35\ L/s\ (BV\ ELF\ flow) = 294.8\ (SO_4\ mg/s)$

3. The SOP (mg/s) was applied to the total volume of the BV ELF:

Equation 6: $294.8\ (SO_4\ mg/s) / 356{,}596\ (total\ ELF\ m^3) = 0.00083\ mg/m^3/s$

Where m^3 is in LCM.

The derived SOP load (0.00083 $mg/m^3/s$) can then be applied to other ELFs to predict water quality due to stored oxidation products.

7.4 Load Model Application to the BV ELF

This section uses the derived SOX and SOP loads to forecast water quality from the BV ELF. The SOX and SOP load models were applied to the material movement schedule provided by BRL for the BV ELF. The following processes were applied:

- BV ELF material movements were provided monthly as bank cubic metres by BRL (converted to LCM), with each monthly volume managed as an individual material block in the derivation of the two ELF load models.
- Adjustments were made for material that were utilised elsewhere on the mine site and were not deposited in the BV ELF. This was applied as a scaling factor to each monthly material movement block to align with the actual BV ELF material volume (Table 11).

Processes applied to the SOX model:

- As the SOX load model is only applied to the 15 m ELF shell, an additional scaling factor was applied to the quantity of rock in this shell (i.e., a proportion of the monthly rock was assigned to the 15 m shell each month in the model, at the same proportions determined for the final BV ELF shell).
- A SOX load was then applied to the materials in the ELF shell for the duration of the Stabilisation Phase (20 months), commencing from the month of material placement. This assumes the wetting up and draindown of the ELF starts once material is placed.
- After 20 months, each block of material placed enters the Decay Phase where an annual decay of 9.6% is applied. Entering the Decay Phase is therefore staggered depending on the timing of the original material placement.

Processes applied to the SOP load model:

- For modelling purposes, a SOP load is applied to each material block as it is moved to the BV ELF on a monthly basis. This assumes the wetting up and draindown of the ELF starts once the material block is in place. Older material (i.e., as related to ELF construction) may reach near exhaustion of SOP through this process while still in the Construction Phase.

- As a conservative approach, the SOP load does not decay with time and the same load is applied for the duration of this stabilisation phase.
- The duration that a SOP load is applied to a material block corresponds to the length of the Stabilisation Phase (i.e., Table 10). As the Stabilisation Phase duration is related to height (Table 10) this allows an increased draindown period and therefore flushing of stored oxidation product for higher ELFs.

Table 11 summarises data for the SOX and SOP load models applied to the BV ELF in addition to material movements. Results are presented in Figure 43. The models show a good match to empirical data and indicate a conservative approach (e.g., 82% of BV ELF sulfate data is below predicted water quality after the Stabilisation Phase).

There is higher model uncertainty during the early Construction Phase for the BV ELF where the model overestimates sulfate concentration. This uncertainty reduces as construction progresses.

Table 11. BV ELF data applied to load models.

BV ELF DATA		UNIT	VALUE
BV ELF Characteristics	Average flow	L/S	3.35
	Average total sulfur	wt %	0.18
	Stabilisation Phase duration	Months	20
	Decay phase	Annual %	9.6
Material Movement	Density of rock	t/m^3	2.09
	Total movement BCM (provided)	m^3	493,000
	Total movement LCM (calculated)	m^3	591,600
	BCM to LCM Factor	-	1.2
	Actual LCM (provided)	m^3	356,596
	Actual LCM/Total movement LCM Factor	-	0.60
	15 m shell LCM (provided)	m^3	304,895
	15 m shell LCM/Actual LCM Factor	-	0.86
Sulfate	75%ile SO_4 during Stabilisation Phase	mg/L	289
	Peak SO_4 during Stabilisation Phase	mg/L	386
	Peak SO_4 1st year post Stabilisation Phase	mg/L	298
Load Models	SOX	$mg/m^3/s$	0.00318
	SOP	$mg/m^3/s$	0.00083

1. *BCM = bank cubic metres*

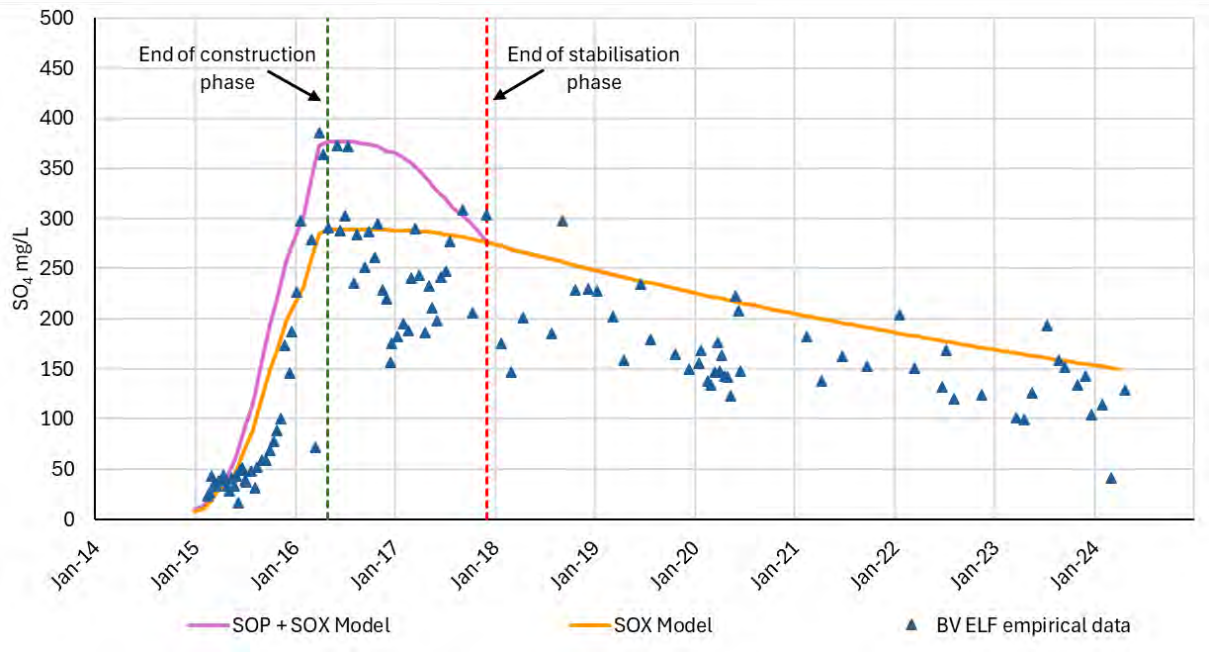


Figure 43. Calculated BV ELF load models and BV ELF sulfate data.

7.5 ELF Load Model Approach

The ELF Load Model was used to estimate water quality from the 20 basal sub-catchments associated with the MFS and ESE ELFs. This approach is discussed in Sections 7.5.1 through 7.5.5 utilising the following data supplied by BRL per ELF basal sub-catchment:

- Annual material movements (LCM m^3)
- Annual rehabilitated material (LCM m^3)
- Annual 10 m shell material rehabilitated (LCM m^3)
- Final 10 m shell average sulfur content (wt% S)
- Annual disturbance (ha)

For the application of the ELF Load Model to the MFS and ESE basal ELF sub-catchments, a material block refers to the annual material movement or annual rehabilitation completed in a given year from material scheduling.

The sulfur content of the 10 m shell is important for the load model as this zone continues to oxidise after the draindown period generating SOX load. The load generated is directly proportional to the quantity of sulfur (i.e., wt% S of the materials as compared to the BV ELF wt% S).

7.5.1 Flow

Derivation of model inputs for flow for individual ELF basal sub-catchments are discussed in MWM (2026d). Flow is calculated as a percentage of disturbance area at time of material block placement versus the final disturbance area in ha.

7.5.2 SOX

A 15 m shell was used in the development of the BV ELF load model based on oxygen ingress data available for the BV. However, when oxygen ingress is limited to diffusion, avoiding advective, the oxygen ingress reaches a maximum depth of ~15 m, but generally is mostly not greater than 10 m (Figure 5 and Section 2.3). This assumes the core of the ELF is sub-oxic (i.e., not oxidising). Based on these data, BRL have committed to ensuring only the outer 10 m shell of the BPCP ELFs are oxidising through engineering controls (i.e., this zone will continue to generate SOX load).

A SOX load is applied to any material that is not included in the rehabilitated portion of the ELF during the Construction Phase on an annual basis. Once material is rehabbed, a long-term SOX load is applied to this material.

7.5.3 SOP

The SOP load is applied to all material as each material block is placed on the ELF for the duration of the respective Stabilisation Phase.

7.5.4 Sulfur

To account for variation in sulfur concentration (and AMD risk) between the BV ELF and other ELF basal sub-catchments, a scaling factor is applied to SOX and SOP per material block. This is based on the difference in sulfur for the various landforms:

- The scaling factor for SOP load applies the average ELF wt% S as this model is applied to all landform material (Table 13).
- The scaling factor for SOX load applies the average wt% S for the 10 m shell (Table 13).

Average sulfur content for ELFs was determined by BRL. For ESE ELFs, the outer 10 m zone of each ELF was assumed to be lower sulfur NAF materials and the sulfur content for the NAF NSUL ELF (Table 13) was applied to this zone. Load model calculations are based on the assumption that this will be implemented.

7.5.5 Decay

For modelling purposes, decay is applied at the end of the Stabilisation Phase for each material block. It is assumed the sulfate decay continues until it matches the long-term acid generation rates determined from oxygen flux modelling through the final rehabilitation surfaces (MWM, 2026c). This is discussed further in the water and load balance model (WLBM) reports for ESE and MFS sub-areas (MWM, 2026f; MWM 2026g).

7.6 Water Quality Model

The water quality model was developed for the ELF Load Model using empirical water quality data and correlations between sulfate and other PCOC that were developed from regression analysis in 5.4, Section 5.5 and Section 5.6. The PCOC:sulfate ratios are presented in Table 12 as ‘Slope’ as the intercept for the trend line is set to 0. These trends are then used to derive peak water quality for the ELF basal sub-catchments based on the derived sulfate concentrations from the SOX and SOP load models.

Table 12. Water quality estimates as a function of sulfate.

PARAMETER	CONSTRUCTION PHASE	STABILISATION PHASE	DECAY PHASE	SLOPE[1] (A)	R^2
Acidity to pH 8.3 (mg $CaCO_3$/L)	180	182	183	0.582	0.967
Alkalinity	0	0	0	-	-
Ca	-	61.4	46.7	0.167	0.979
Mg	-	8.42	5.01	0.019	0.966
Na	-	-	2.40	0.00021	0.287
K	-	-	1.29	0.00057	0.504
SO_4	386	373	298	1	1
Al	23	20.7	14.6	0.056	0.979
Fe	2.62	15.4	10.2	0.026	0.815
Ni	0.46	0.31	0.22	0.0008	0.9260
Mn	-	0.81	0.59	0.0021	0.960
Cr	-	-	0.001	0.000036	0.893
Cd	-	-	0.0003	0.0000011	0.819
Co	-	-	0.0393	0.000103	0.914
Cu			0.0193	0.000029	0.88
Pb	-	-	0.0045	0.000002	0.410
Tl	-	-	0.0024	0.0000019	0.638
Zn	3.29	1.49	1.25	0.0042	0.974
DOC			0.50	-	-
pH (minimum pH value)	3.30	3.30	2.80	-	-

Blue cells = BV ELF water quality (as derived from stabilisation and decay phases)

Green cells are derived from CLT data for MFS and ESE samples

Yellow cells are derived from S23 data

1. *Regression relationships are developed in Section 5 for the stabilisation and decay phases*

A hyphen (-) indicates no data are available. All units in mg/L unless stated otherwise.

The intercept for all data was set to 0.

7.6.1 pH Estimation

ELF seepage pH is difficult to estimate in the scaling approach. Instead, data obtained from the Mine Creek catchment at Stockton was used to derive pH from acidity data (Figure 40). This was considered a suitable approach for modelling inputs. Equation 7 was derived from these data and is used in the WLBM:

Equation 7: $$pH = -log10\ (0.0000035 * net_acidity + 0.00001)$$

This relationship generates a maximum of pH 5 and potentially underestimates long term pH data for NAF ELFs, where pH is expected to be greater than 5. For NAF ELFs the pH is derived from the Escarpment Mine Column Leach Test (CLT 7) assessed by Pope et al (2011) and CRL (2012) of pH 5.81 that had a sulfur content of 0.25 wt% and a NAG pH of 6.8 (MWM, 2026b). It is classified as NAF by the Process Flow Classification Scheme for ESE and MFS (MWM, 2026a). Further details are provided in the source term report (MWM, 2026h).

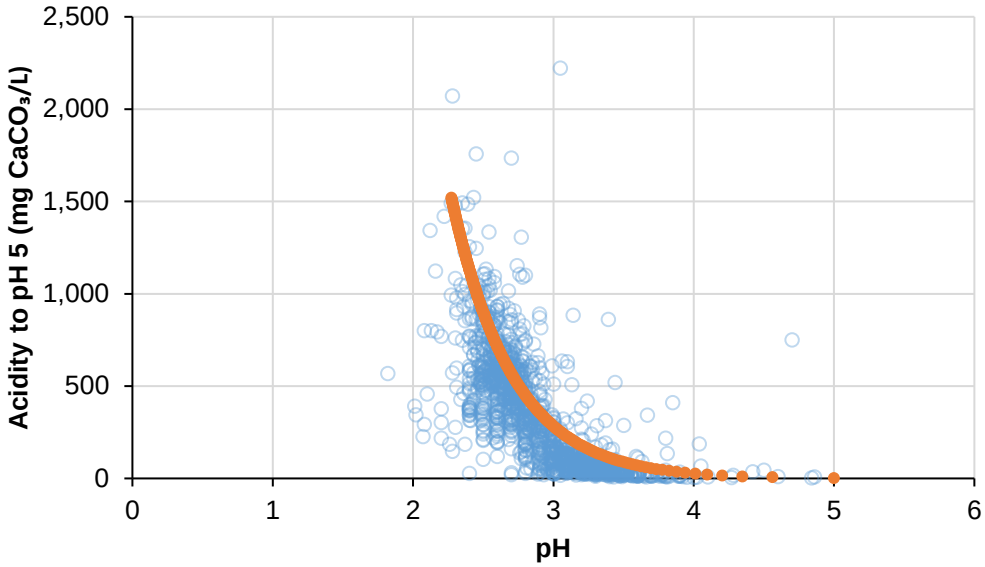


Figure 44: Correlation of the Acidity to pH 5 and pH in the Millerton Catchment and at NR

Orange circles-line represent the pH estimation of the correlation.

Blue circles represent data from the following monitoring points: Duncan's Sump, MC1, Millerton Pipe, MW05, NR, S23, S24A, S25, S6).

7.7 BPCP ELF basal sub-catchments

Table 13 provides a summary of ELF basal sub-catchments including:

Nomenclature for the basal ELF-sub-catchments (location maps for these ELFs are provided in MWM (2026f) for the ESE Project sub-area and MWM (2026g) for the MFS Project sub-area.

- Identification of basal ELF-sub-catchments that are NAF (NSUL, PPG, MDC1, MDC2)
- Average height – controls the duration of the Stabilisation Phase.
- Average sulfur content for total volume and values applied to10 m shell of each basal ELF-sub-catchment.
- Peak sulfate post Stabilisation Phase.
- Calculated peak acidity post Stabilisation Phase.

Table 13. BPCP ELF basal sub-catchments

PROJECT AREA	BASAL ELF SUB-CATCHMENT	AVERAGE HEIGHT (m)	ELF AVERAGE S (wt%)	10 m SHELL AVERAGE S (wt%)	SULFATE (mg/L)[1]	ACIDITY (mg $CaCO_3$/L)[2]
ESE	BV-ELF	10.71	0.18	n/a	271.8 [1]	129.4 [1]
ESE	BVE	35.1	0.43	0.13 [3]	203	118
ESE	CON	35.7	0.28	0.13 [3]	390	227
ESE	NSUL	21.1[4]	0.13	0.13	352	205
ESE	PPG	17.6	0.09	0.13 [3]	263	153
ESE	WWH	59.7	0.38	0.13 [3]	159	93
ESE	ESC	19.5	0.34	0.13 [3]	273	159

PROJECT AREA	BASAL ELF SUB-CATCHMENT	AVERAGE HEIGHT (m)	ELF AVERAGE S (wt%)	10 m SHELL AVERAGE S (wt%)	SULFATE (mg/L)[1]	ACIDITY (mg $CaCO_3$/L)[2]
MFS	MSR1	14.5	0.12	0.16	256	149
MFS	MSR2	12.6	0.12	0.164	230	134
MFS	MSR3	12.6	0.12	0.111	137	80
MFS	MSR4	12.6	0.12	0.057	354	206
MFS	MSR5	19.1	0.12	0.047	87	51
MFS	MSR6	10.1	0.12	0.047	81	47
MFS	MSR7	11.9	0.12	0.047	107	62
MFS	MDC1	9.0	0.049	0.047	73	43
MFS	MDC2	6.4	0.049	0.047	66	38
MFS	MSR8	18.4	0.14	0.052	91	53
MFS	MSR9	12.7	0.14	0.052	80	47
MFS	MSR10	8.4	0.14	0.052	75	44
MFS	MSR11	6.6	0.28	0.116	194	113
MFS	MSR12	7.8	0.28	0.116	201	117

Yellow: NAF ELF basal sub-catchments (NSUL, PPG, MDC1, and MDC2)

1. *Post stabilisation as calculated from the BV ELF load models.*
2. *As calculated from sulfate post stabilisation using the relationship SO_4:Acidity 1.7:1 (see Table 12)*
3. *Average S wt% of NAF ELF NSUL.*
4. *Average height during the operational phase has been applied as a conservative approach. Average height on closure is 15.49 m.*

The seepage from the larger PAF ELF basal sub-catchments will generally require active treatment during the operation phase of the project and passive treatment systems (e.g., mussel shell reactors [MSR]) in the closure phase.

Engineered landforms are also proposed as part of the Upper Waimangaroa Haul Road. These ELFs do not require treatment due to other engineering controls (e.g., the use of geosynthetic clay liners) and are discussed in a separate report (MWM, 2026e).

7.8 Empirical Dataset Model Development

The empirical dataset available for the BV ELF and wider BPCP were used in development of the ELF water quality load model. These data include:

- Water quality, flow and rainfall data for the BV ELF commencing from construction of the mine domain.
- Advective oxygen flux data.
- Material geochemistry data.
- Wider BPCP water quality data.
- Physical data for mine domains.
- Previous studies on the duration of draindown (i.e., the duration of the Stabilisation Phase).

The combination of site-specific empirical data with relevant literature provides the basis for the derivation of a water quality prediction model for BPCP basal ELF sub-catchments. The following interpretations have been applied to the available data sets during the model development:

- Scaling of sulfur content to derive sulfate concentrations in each ELF. This addresses AMD risk for higher and lower sulfur mine domains.

It is assumed that the BV ELF is not affected by gypsum precipitation (e.g., sulfate is < 1,000 mg/L) hence sulfate is conservative and likely a better representation of sulfide oxidation compared to acidity, as acidity is influenced by limestone addition and acid neutralisation capacity (ANC).

- Empirical data confirms that a sulfate to PCOC relationship (Table 12) is a reasonable approach to derive other water quality parameters for ELF water quality using sulfate concentration as the basis for model development.
- The BV ELF has limestone added. Acidities are lower than sulfate concentrations, which confirm that neutralisation is occurring and that the application of limestone is advantageous.
- The duration of the Stabilisation Phase is assumed to be a function of ELF height. Estimates are comparable to previous studies (e.g., O'Kane Consultants, 2014) demonstrating this approach is reasonable.
- Application of the SOX model to a 10 m ELF shell is considered appropriate from advective oxygen data for the BV ELF. Engineering controls will be needed to ensure the model remains a reliable forecasting tool (i.e., oxygen diffusion needs to be < 10 m).

8 LIMESTONE DOSING

This section discusses the benefits of limestone application to the BV ELF.

8.1.1 Background

Limestone dosing occurred during the construction of the BV ELF as shown in Figure 45. A total of 962.3 tonnes of limestone was added during the Construction Phase of the BV ELF. This is equivalent to the addition of 1.16 kg limestone/tonne of waste rock in the BV ELF[9]. In addition to this dosing process limestone was also introduced as the stemming material for blast holes. It was determined (BRL, 2015) that this equated to 0.045 – 0.135 kg/t of waste rock. Data derived from the BRL database for the materials placed in the BV ELF indicates that the ANC is ~ 3 kg $CaCO_3$/t.

Figure 45. Limestone dosing of the BV ELF.

8.1.2 Analysis

Based on the average flow rate for the BV ELF of 3.35 L/s and using the peak acidity (182 mg $CaCO_3$/L) and peak sulfate (386 mg/L) concentrations to normalise the data to a point in time, the following analyses were derived:

- Over a 1-year period the acidity based on the SO_4 load (where SO_4 is converted to $CaCO_3$ equivalence) was calculated as 42.5 t/yr.
- Over a 1-year period the acidity based on the measured acidity (as $CaCO_3$) was calculated as 19.2 t/yr.
- This suggests that during the Stabilisation Phase, half the acidity generated (42.5 t/yr) is neutralised by limestone and reactive ANC available to interact with porewater.

[9] *Note – this is based on the full ELF of 826,879 t rather than the 745,286 t that is within the BV ELF weir catchment.*

- An assessment of the water quality from 1 March 2017 to 4 July 2024 indicated that: the average measured acidity (to pH 8.3) was 117 mg $CaCO_3$/L; the acidity derived from average sulfate concentration was 184.9 mg $CaCO_3$/L; the neutralisation from calcium carbonate (based on average Ca in solution) was 74.6 mg $CaCO_3$/L; which indicates the average calculated acidity (184.9 – 74.6) is 110.3 mg $CaCO_3$/L, a close match to the measured acidity. Based on the assumption that ANC provides minor neutralisation, this suggests that the limestone is having a direct benefit to mitigating acidity loads by ~40%.
- Hence, if the limestone was not applied to the BV ELF, then acidity loads in the model should be doubled.
- The Escarpment AMD Management Plan (BRL, 2015) states that limestone should be applied at a rate of 2 -10 kg $CaCO_3$/ m^2 based on 2 m high lifts. Based on a loose cubic metre density of 2.09 this equates to 4.2 t/m^2 of waste rock. Records provided by BRL indicated that 1.16 kg/t of limestone was applied, which is equivalent to 4.86 kg $CaCO_3$/m^2.
- It is recommended that the application rate of ~5 kg limestone/m^2 per 2 m lift continue. However, this could be adjusted for ELFs that have lower sulfur content (i.e., scaling).

The calculated sulfate acidity and the calculated $CaCO_3$ neutralisation rates were compared to understand whether the ratio changed with time. If the ratio of sulfate acidity to $CaCO_3$ neutralisation was increasing this would indicate either increasing sulfide oxidation rates or exhaustion of limestone alkalinity. This time-series plot is provided in Figure 46 and suggests no change.

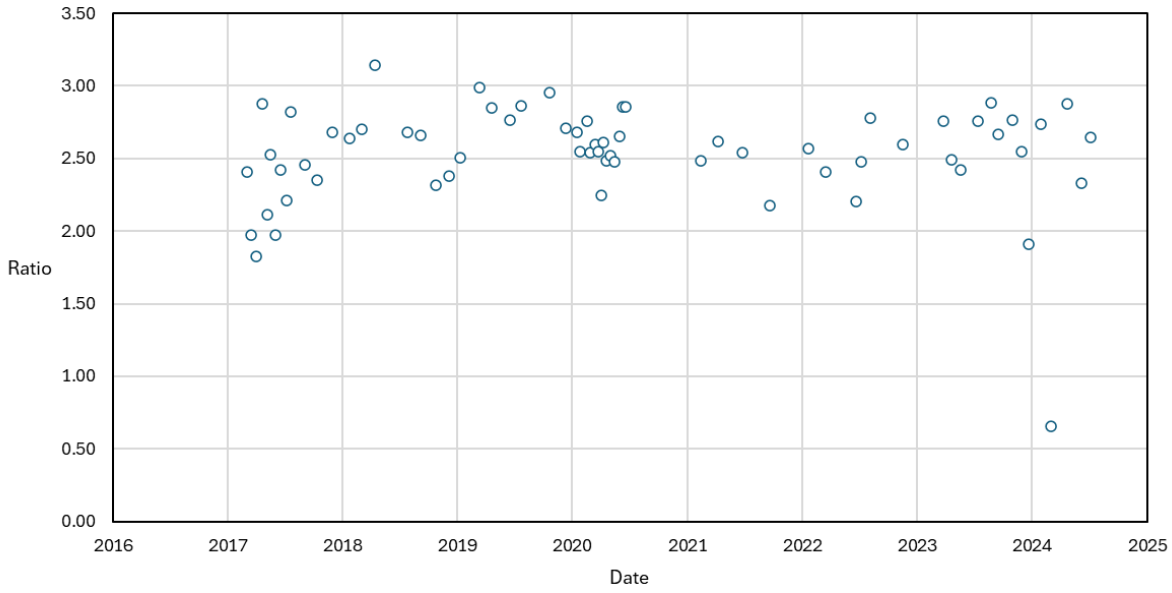


Figure 46. Ratio between acidity calculated from H_2SO_4 and the $CaCO_3$ neutralisation

Based on $CaCO_3$ neutralisation rate (74.6 mg $CaCO_3$/L) and using an average flow rate of 3.35 L/s, a total of 7.9 tonnes of limestone is consumed each year (of a total of 962.3 tonnes). However, it would be reasonable to assume the total amount of limestone won't be available for acidity neutralisation. For instance:

- In the sub-oxic parts of the ELF, more limestone will be available as no Fe-armouring of the limestone will be occurring – enabling ongoing neutralisation of H+ acidity.

- In oxic parts of the ELF, it is expected only ~10% of the limestone will be available (Weber et al., 2014) due to Fe-armouring of limestone surfaces preventing further neutralisation of H+ acidity.
- If the limestone is only 10% effective the neutralisation will be exhausted after ~12 years.

8.1.3 Review

The following comments are provided on the limestone application rate:

- Limestone is not needed in NAF ELFs.
- Limestone dose rates could be adjusted based on the expected acidity load, which is a function of the sulfur content of the proposed ELF.
- Lower sulfur ELFs with low modelled acidity could be treated more effectively using passive treatment technologies rather than dosing with limestone.

9 NITROGENOUS COMPOUNDS

This section discusses the risks for elevated nitrogenous compounds at the proposed BPCP due to the use of ammonium-nitrate fuel oil (ANFO) explosives that are used to blast overburden.

9.1 Stockton ANFO Usage

ANFO is used at Stockton for blasting of overburden. The following quantities of ANFO were used (as reported by BRL):

- FY2020 Blasting 3,620,321 bcm: ANFO 2,322,427 kg
- Fy2021 Blasting 3,046,979 bcm: ANFO 2,301,143 kg
- FY2022 Blasting 4,320,787 bcm: ANFO 3,345,759 kg
- FY2023 Blasting 4,765,259 bcm: ANFO 3,666,768 kg
- FY2024 Blasting 4,671,952 bcm: ANFO 3,453,694 kg

Data indicates that the amount of ANFO ranges from 0.64 – 0.77 kg ANFO/bcm of rock. BRL indicate that similar ratios are expected for ESE, MFS, and the UWHR.

9.2 Data Review

Literature indicates that the loss of nitrogenous compounds from ANFO-type products to surface and groundwaters can range from 1 – 28% (Pommen, 1983; Sidenko, 2018; Morin and Hutt, 2009) due to incomplete volatilisation of nitrogenous compounds during blasting and/or poor housekeeping (e.g., spillage of ANFO). Hence, significant quantities of nitrogen could be present in water discharge from mining operations if large quantities of ANFO are used.

Guidelines from the NPS[10] for Freshwater Management (MfE, 2020) for nitrate-N and ammoniacal-N are 2.4 mg/L and 0.24 mg/L respectively. These values were used in this report to determine if elevated nitrogenous compounds are present within current mining areas of the Buller Plateaux and whether this would be an issue for the BPCP. Results are provided for a range of different environments (active pits and seepage from ELFs) at the existing Stockton and Escarpment mines (Table 14), including:

- Cypress Pit S5 (now S9): This site is located at the Cypress Mine, adjacent to the blast area and collects runoff from blasted rock before it is excavated and placed in the ELF or backfill (Figure 47).
- Cypress Pit: Blasted rock from the blast area is moved to this pit for backfill, which therefore receives direct seepage from recently basted overburden (Figure 47).
- Barren Valley Engineered Landform (BV ELF): BV ELF is located at the existing Escarpment Mine and has been monitored since 2014. The empirical water quality data from BV ELF is considered a good analogue dataset for other ELFs proposed as part of the BPCP. Water samples for nitrogenous compounds from ELF seepage, were collected several years after rock placement.

[10] *National Policy Statement*

- Cypress ELFs (PAF and NAF): This includes the Cypress North ELF (NELF, which contains PAF materials) and the Cypress NAF NELF (which contains NAF materials). Two water samples were recently collected to assess the water quality (Table 14).

Table 14. Nitrate and ammoniacal-N data for various mine domains (Stockton and Escarpment)

SITE	SAMPLING DATE	NITRATE - N		AMMONIACAL - N	
		Count of Records	Concentration [1] (mg/L)	Count of Records	Concentration [1] (mg/L)
Cypress Pit S5	9/5/2024 to 27/3/2025	31	0.071 (0.001 – 0.434)	-	-
Cypress Pit	9/5/2024 to 27/3/2025	32	0.239 (0.029-0.990)	-	-
BV ELF	30/11/2017 to 11/12/2024	16	0.08 (0.01 – 0.10)	3 3	0.083 (0.05-0.11) < LOR of 1.0 [2]
NELF (sump inlet)	9/4/2025	1	0.16	1	0.21
NAF NELF (seepage)	9/4/2025	1	0.04	1	<0.01

Note: 1. for the site with more than 1 sample collected, the unbracketed numbers are the average and the bracketed numbers indicate the concentrations range (min and max).
2. Limit of Reporting, this has varied over the sampling period.

Figure 47. Cypress Pit showing the location of water samples to assess ANFO effects.

These data suggest that the risk of elevated nitrate from blasting activities is low for the BPCP (i.e., all nitrate-N data are < 1 mg/L for ELF seepage and within active pits (blasting and backfill)), which is likely associated with two key drivers:

- High rainfall environment leading to considerable flushing and dilution of any blasting residues.

- Nitrate reduction due to pyrite oxidation (biogeochemical processes), where often higher sulfur environments have a lower risk of elevated nitrogenous compounds (e.g., Weber et al., 2021).

9.3 Nitrate Reduction due to Pyrite

There is a pathway for conversion of nitrate through to nitrogen gas when sufficient reactive pyrite (i.e., framboidal pyrite) is available. This biogeochemical process may explain why nitrate concentrations are low in seepage from waste rock storage facilities on the Buller Plateaux. This pathway is explained by Equation 1 – 3 (anoxic conditions: Reid et al., 2016) as described by Hayakawa *et al.* (2013):

$$5FeS_2 + 14NO_3^- + 4H^+ \Rightarrow 5Fe^{2+} + 10SO_4^{2-} + 7N_{2(g)} + 2H_2O \quad \text{(Equation 1)}$$

$$5Fe^{2+} + NO_3^- + 12H_2O \Rightarrow 5Fe(OH)_3 + {}^1/_2N_{2(g)} + 9H^+ \quad \text{(Equation 2)}$$

Summarising the reactions in Equation 1 and 2, Hayakawa *et al.* (2013) notes:

$$5FeS_2 + 15NO_3^- + 10H_2O \Rightarrow {}^{15}/_2N_{2(g)} + 10SO_4^{2-} + 5Fe(OH)_3 + 5H^+ \quad \text{(Equation 3)}$$

Hence, based on Equation 3:

- Materials that have a higher reactive sulfide content will have lower nitrate concentrations in drainage waters as a higher proportion of nitrate is consumed through oxidation of sulfides.
- However, anoxic conditions and a moderate residence time is required (e.g., many months) for the pathway to occur (Reid et al., 2016).
- The acidity generated from the oxidation of pyrite by nitrate produces only 1 mole H^+ per mole of FeS_2 oxidised. This is significantly less acidity generation than the 4 mole of H^+ that is generated by the oxidation of pyrite by oxygen (Equation 4).

$$FeS_2 + {}^{15}/_4O_2 + {}^7/_2H_2O \Rightarrow Fe(OH)_3 + 2H_2SO_4 \quad \text{(Equation 4)}$$

These reaction pathways suggest that lower nitrate concentrations could occur within materials disturbed by the BPCP. As evidenced at other projects (e.g., Weber et al., 2021), seepage from waste rock storage facilities (e.g., ELFs) are likely to represent the greatest risk for elevated nitrogenous compounds.

9.4 Geochemical Modelling

A numerical model was established to estimate nitrate concentrations in ELF seepage to understand risk.

9.4.1 Data Review

The data available from the Barren Valley ELF was reviewed to understand the trends in nitrate and ammoniacal nitrogen in seepage from the ELF with time. Available nitrate-N and sulfate data for the BV ELF seepage was plotted (Figure 48). Results indicated there is an overall decreasing trend in nitrate-N concentration with time, which was also identified for other PCOC (Section 5). Sulfate data predominantly falls within the 100 to 200 mg/L range, and this was plotted against nitrate-N data (Figure

49) to understand any relationships. Data (Figure 49) suggest that there is a relationship (although this is skewed by two outliers[11]).

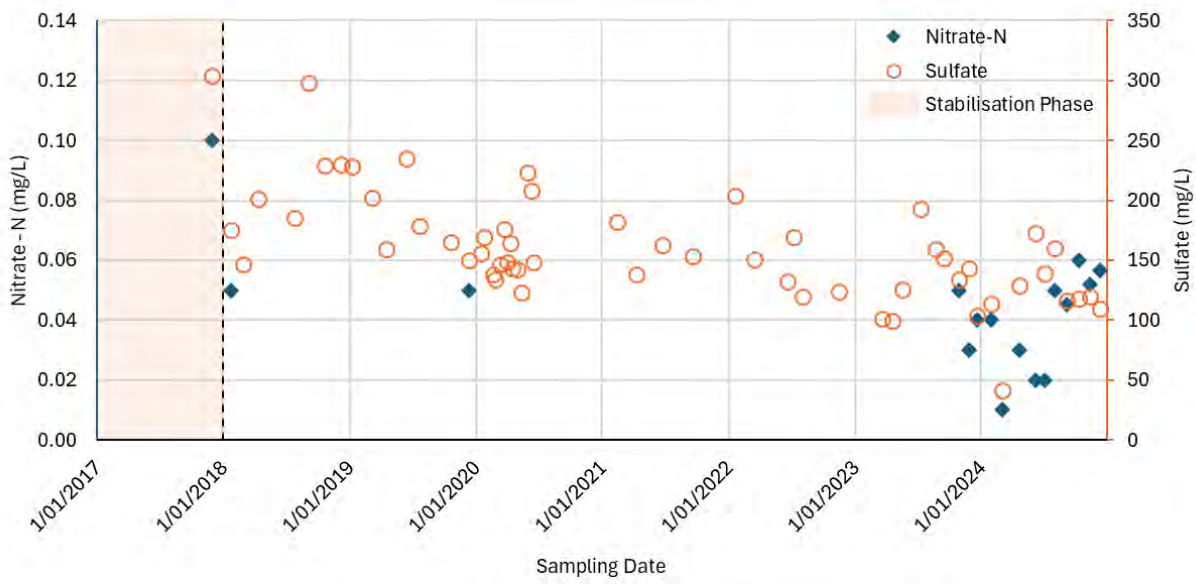


Figure 48. Time series plot of nitrate-N and sulfate data for the BV ELF.

Note: Sulfate data provided for the corresponding period of available nitrate-N water quality data. Higher concentrations are observed in the Stabilisation Phase.

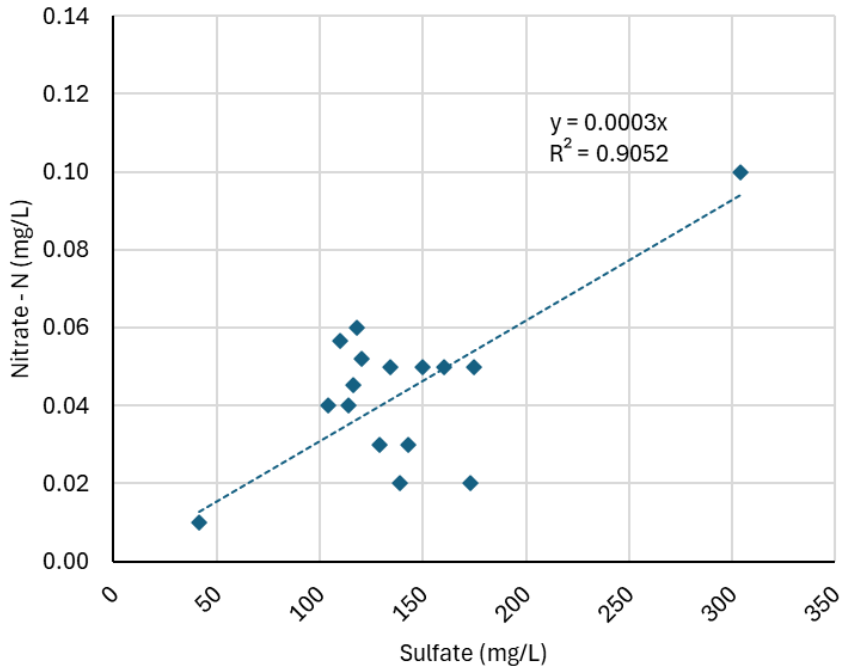


Figure 49. Relationship between nitrate-N and sulfate data for the BV ELF.

Note: the data cluster is generated by lots of datapoints in the decay phase when sulfate concentrations are very similar. The relationship is thus biased by the two outliers.

[11] *Further data are required to confirm this relationship is reliable. This is proposed (Section 9.6)*

Data quantity for ammoniacal nitrogen is low (see Table 14) with a maximum of 0.11 mg/L. This is below NPS water quality guidelines for Freshwater Management of 0.24 mg/L (MfE, 2020) (three additional samples are recorded as < LOR, however these samples have a higher LOR of 1.0 mg/L therefore do not provide reliable data). Additional monitoring of nitrogenous compounds will provide more certainty around ammoniacal nitrogen concentrations.

9.4.2 Nitrate Concentration Model Development

A nitrate water quality model was developed for the Barren Valley ELF using the sulfate:nitrate-N relationship observed in Figure 49 and applying this relationship to the SOX and SOP as modelled for the BV ELF. The resulting nitrate-N model is presented in Figure 50. This model is assumed to be suitable as water soluble SOP will be flushed from the overburden as a function of net percolation just like water soluble nitrate.

As a conservative approach, due to the low quantity of nitrate-N data during the Stabilisation and early Decay Phases, a scaling factor was applied to the derived nitrate-N model. A scaling factor of 1.4 was selected to increase the concentration of estimated water quality above all recorded nitrate-N data for the BV ELF. Therefore, the maximum predicted nitrate-N concentration during the Construction Phase is 0.16 mg/L (Figure 50).

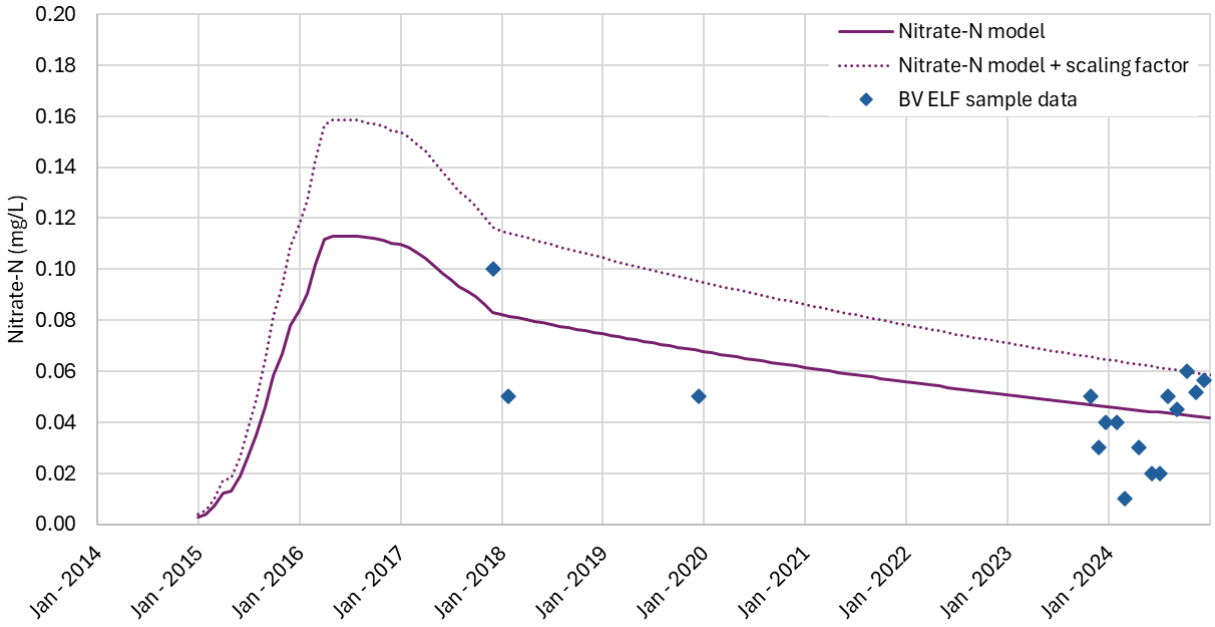


Figure 50. BV ELF nitrate-N model.

Note: Scaling factor of 1.4 applied.

9.4.3 BPCP ELF Nitrate Concentrations

The nitrate concentration model for the BV ELF was used to estimate the maximum concentration of nitrate in the ELFs associated with the BPCP. A height scaling factor[12] was applied to the maximum predicted nitrate-N from the BV ELF (0.16 mg/L see Figure 50) to predict maximum concentrations of the basal-ELF sub catchments (Table 15). Noting larger basal ELF sub-catchments areas (i.e., footprint) will have a larger flow/load.

[12] Average height of the basal ELF sub catchment / average height of the BV ELF (= 10.71 m)

It is expected nitrate concentration will decay over time in alignment with other PCOC (as observed in Figure 48). The highest modelled nitrate-N concentration is estimated at WWH for a concentration of 0.89 mg/L.

Table 15. Estimated maximum nitrate concentration of BPCP basal ELF sub catchments.

PROJECT AREA	BASAL ELF SUB-CATCHMENT	AVERAGE HEIGHT (m)	HEIGHT SCALING FACTOR[6]	MAXIMUM* NITRATE-N (mg/L)
ESE	BV-ELF	10.71	-	
ESE	BVE	35.1	3.3	0.52
ESE	CON	35.7	3.3	0.53
ESE	NSUL	21.1 [1]	1.4	0.23
ESE	PPG	17.6	1.6	0.26
ESE	WWH	59.7	5.6	0.89
ESE	ESC	19.5	1.8	0.29
MFS	MSR1	14.5	1.4	0.22
MFS	MSR2	12.6	1.2	0.19
MFS	MSR3	12.6	1.2	0.19
MFS	MSR4	12.6	1.2	0.19
MFS	MSR5	19.1	1.8	0.29
MFS	MSR6	10.1	0.9	0.15
MFS	MSR7	11.9	1.1	0.18
MFS	MDC1	9.0	0.8	0.13
MFS	MDC2	6.4	0.6	0.10
MFS	MSR8	18.4	1.7	0.27
MFS	MSR9	12.7	1.2	0.19
MFS	MSR10	8.4	0.8	0.13
MFS	MSR11	6.6	0.6	0.10
MFS	MSR12	7.8	0.7	0.12

** Peak modelled nitrate (occurs during the construction/stabilisation phases).*

[1] Average height during the operational phase has been applied as a conservative approach. Average height on closure is 15.49 m.

9.4.4 Brunner Coal Measures Baseline Nitrate Concentrations

Background nitrate levels within the BPCP area are expected to be low as indicated by data derived from non-mine affected watercourses draining BCM. For instance, water quality data for the upper reaches of catchments within BCM of the Te Kuha area (West Creek, Camp Creek, Landslide Creek and Coal Creek Northern) reported by CRL (2016) indicate background nitrate levels with maximum concentrations ranging from 0.014 to 0.75 mg/L (nitrate-N[13] 0.003 to 0.17 mg/L).

[13] Nitrate (mg/L)×0.226 = Nitrate Nitrogen (mg/L).

9.5 Summary

Based on the results presented in this section, elevated nitrate is not expected in drainage waters from the BPCP. However, ongoing performance monitoring is recommended to support this assessment as there is a risk that construction of the ELFs may generate sub-oxic conditions that may convert nitrate to ammoniacal nitrogen.

9.6 Performance Monitoring

The two areas of the Project likely to have the higher risk for nitrogenous compounds are pit sumps and ELFs. Data and modelling suggest the risks are low. However, to ensure this expectation remains valid, the following performance monitoring is recommended:

- Monitoring of pit sumps for nitrogenous compounds (including the ESE granite quarry that is within NAF materials).
- Monitoring of ELF seepage for nitrogenous compounds.

9.7 Adaptive Management

If the concentration of nitrogenous compounds in ELF seepage is high, then management activities may be required. This could include:

Methods to minimise the loss of ANFO:

ANFO may be lost to surface/ground waters for a number of reasons. For instance:

- During storage: Release of explosives residue may occur around storage facilities due to spillage when transferring the material for use, through seepage of damaged containers, or drips from valves not adequately sealed.
- During transport: Explosives material may be released during transport to the blasting location through damaged bins. Spills may also occur during unloading of explosives and during blending (Pommen, 1983).
- During loading: spillage may occur around the blasting location when loading the hole.
- During sleep time: in substantially wet conditions, leaching of undetonated explosive to groundwater may occur between loading and detonation if the explosive is not contained within a water-resistant casing, or within an emulsion or slurry.

The management of any spills should follow the procedures detailed in the Explosives Principal Hazard Management Plan (PHMP). Basic adaptive management options include:

- The storage of ANFO should be within a suitable lined facility with any surface run-off directed to the mine impacted water circuit for treatment.
- Ensure all systems used to transport ANFO do not have leaks and are not overfilled leading to spillage.
- Clean up any spills immediately using spill response kits. These facilities should be available at the storage location and during loading of blast holes.

- Avoid long sleep times that can lead to loss of ANFO to groundwater, or when necessary, use water-resistant casing or an emulsion/slurry.

Methods to treat nitrogenous compounds:

Elevated nitrogenous compounds in mine waters can be treated. This should be part of the adaptive management approach for elevated nitrogenous compounds:

- As demonstrated by numerous studies, anaerobic passive treatment systems can also convert nitrate to N_2 gas (e.g., Christenson et al., 2018). Nitrate can also be converted to ammoniacal nitrogen and secondary treatment (polishing ponds) are proposed for the BPCP passive treatment systems (MWM, 2026i).
- During the operational and active closure phases, nitrogenous compounds can be treated by fluidised bed reactors if this is required. Such technologies are common within the municipal wastewater treatment industry. The active treatment of combined operational phase waters for the BPCP is unlikely to require treatment for nitrogenous compounds.

10 SUMMARY AND RECOMMENDATIONS

The objectives of this report are:

- Update the BV ELF water quality model using new data to understand flow, water quality, and PCOC loads.
- Develop a model, based on empirical data, to estimate seepage water quality for engineered landforms associated with the MFS and ESE sub-areas of the BPCP.

10.1 Water Quality Model

Three distinct water quality phases are identified and will be applied to future engineered landforms that will be constructed as part of the BPCP.

Phase 1: Construction Phase

- Low PCOC concentrations that increase with an increasing amount of waste rock placement within the ELF and gradual wetting up of the ELF.
- Generally, peak concentrations coincide with maximum material placement.

Phase 2: Stabilisation Phase

- Flow rates are generally stable as the ELF wets up and then flushes stored oxidation products from the waste rock. For the BPCP, it is assumed the duration of the Stabilisation Phase for final rehabilitated areas of the ELF also aligns with the duration of the draindown phase (created by the installation of a lower permeability cover system).
- Concentrations of PCOC remain stable.
- The majority of stored oxidation products are flushed by the end of the Stabilisation Phase.

Phase 3: Decay Phase

- Phase 3 relates to the decrease in PCOC concentrations from peak concentrations observed in the Stabilisation Phase.
- During this phase, water infiltration rates remain steady, but the rate of solute generation declines (lesser oxidation of sulfides and minor flushing out of stored oxidation products).

10.2 ELF Seepage Water Quality Model

Two load models (SOX and SOP) and a water quality model were developed using empirical data from the BV ELF and other data sources to derive:

- Natural decay of acidity loads due to flushing out of stored oxidation products and oxidation of reactive sulfides.
- Predicted sulfate data throughout the three identified ELF phases.
- PCOC concentrations were derived from sulfate relationships.

- The duration of the Stabilisation Phase is based on the average height of the ELF and aligns with previous studies of the draindown phase duration for the original Escarpment ELF (e.g., Okane Consultants 2015).
- The Decay Phase uses a 9.6% annual decrease based on BV ELF data.
- ELF design where rocks > 10 m depth are within a sub-oxic zone and are not generating further acidity.

These models are used to forecast the water quality from the six engineered landforms at the proposed ESE sub-area and the fourteen engineered landforms at the proposed MFS sub-area.

10.3 Sensitivity Modelling

Sensitivity modelling was undertaken during the development of the ELF seepage water quality model. Table 16 summarises sensitivity modelling completed, and details the conservative approach applied during the decision process.

Table 16. Sensitivity modelling.

MODEL	DESCRIPTION	MODELLING	DECISION
SOX	Estimation of SOX load through investigation of a range of sulfate water quality statistical data from the BV ELF Stabilisation Phase.	• Average • 75th percentile • 95th percentile • Maximum	75th percentile. Result is a close match to peak empirical data in the Decay Phase and did not overestimate loads.
	Application of the oxidation load to varying BV ELF volumes.	• Total ELF • 20 m shell • 15 m shell	15 m shell [1] Conservative approach based on measured data for the BV ELF. Using a 20 m shell or total ELF volume reduces the oxidation load per m3.
SOP	Investigation of relationship of wt% sulfur and sulfate decay rates over various column leach test cycles for MFS and Escarpment Mine material to estimate SOP load.	• Month 1 • Month 1-3 Average • Month 1-4 Average	Relationship not used. Overestimated results compared to empirical data.
	Estimation of SOP from the difference between sulfate water quality data from the Stabilisation Phase and one year post stabilisation from the BV ELF.	Difference between: • Average peaks • Maximum peaks	Maximum peak values selected as a conservative approach (greatest difference) and best match to empirical data (i.e., data fitting).

1. *Sensitivity modelling was done for 15 and 20 m shells to test the model and potential effects. For the modelling of ELFs associated with the BPCP, a 10m shell was used.*

One model scenario was chosen to represent BV ELF seepage, which was fitted to empirical data, and this was used to forecast the water quality from the six engineered landforms at the proposed ESE sub-area and the fourteen engineered landforms at the proposed MFS sub-area. This provided a deterministic estimate for water quality, based on empirical data and trends that was adjusted for varying ELF sulfur content. Given the reliance on these deterministic model values, the water and load balance models that were undertaken for ESE and MFS (MWM, 2026f,g) were stress tested with metal loads in ELF seepage being run at ±30% of the Base Case scenario.

10.4 Key Components for ELF Seepage Water Quality Forecasting

A number of datasets and assumptions were used to develop the model to derive the BPCP ELF seepage water quality:

- The BV ELF was used as a suitable project specific structure to provide analogue data to create an ELF water quality model.
- The BPCP ELF water quality model was developed through scaling water quality based on sulfate derived from ELF load models, sulfur ratios, and material movement to determine AMD risks for each ELF basal sub-catchment.
- A net percolation rate of 40% of rainfall (MWM, 2026c) is applied to the ELF water quality model to forecast long term acidity loads.
- The estimated ELF water quality model is conservative as not all water will flow through the entire ELF from top to bottom and a proportion will report as lateral seepage to the ELF batter slopes (NAF layer).
- The duration of the Stabilisation Phase is derived as a function of ELF height. Estimates are comparable to previous studies (e.g., O'Kane Consultants, 2014).
- Limiting the SOX to the final 10 m shell volume is appropriate if ELF construction practices ensure that design criteria are met, and that oxygen is limited to diffusion.
- A rate of 9.6% was applied to the water quality (e.g., sulfate) at the end of the Stabilisation Phase and thence ongoing (as shown in Figure 40).
- Limestone was applied to the BV ELF at a rate of ~1.16 kg/t of waste rock. Limestone should be applied to the proposed ELFs.

10.5 Risk Management

The overarching objectives of the water quality modelling is to ensure the risks for BPCP ELF seepage are understood and that appropriate engineering controls are in place to minimise AMD effects on the receiving environment. The following comments are provided on the conceptual model and model construct:

- The use of upper quartile sulfate concentration data from the BV ELF for construction of the model provides conservatism to ensure potential effects are understood and managed.
- Lateral flow along running surfaces leading to seepage on the batters of an ELF is a risk for closure ((i.e., Not all seepage will drain to the toe of the ELF, some may percolate sub-horizontally surfacing along batter slopes), as it will have poor water quality, and if this flow generates surface seepage this could affect surface rehabilitation outcomes and surface water quality. The NAF cover system needs to ensure this lateral drainage discharges to the toe of the ELF for treatment (i.e., runs down the PAF/NAF boundary – achieved by permeability contrast).
- The duration of the Stabilisation Phase will be a function of stored oxidation products, material properties (e.g., grainsize, porosity, etc), and the time to wet up and draindown. Results are in

in alignment with other studies (e.g., O'Kane, 2014) but could be longer. A longer duration could result in a longer time frame for active treatment.

- Load will be driven by flow rate. This is currently set at 40% of rainfall in the model. This could be higher or lower and performance monitoring is required to confirm flows at closure. This may extend / shorten the active treatment phase.
- The decay rate of 9.6% assumes that the ELF is built to exclude oxygen at depth within the ELF (> 10 m horizontally). If performance monitoring during the operational phase of the BPCP determines that this is not achieved and there is advective oxygen ingress, then the most appropriate model to use for ongoing water quality projections would be the Stockton AMD Liability Model (Gandy and Younger, 2007; Treasury, 2017) as explained in Section 2.6.2.

10.6 Recommendations

The ELF water quality model should be refined and updated as the earthworks are undertaken. Areas of focus should include:

- Confirmation of the effect of multiple compacted lifts on lateral flow and further quantification of the effect on net percolation rates through the total ELF height. This may reduce net percolation rates.
- Lateral flow along compacted lifts to batter slopes will require the construction of a low permeability NAF layer to drain this water to the ELF toe for AMD control and management. Continual assessment on constructability and geotechnical risks (e.g., slumping) need to be considered. A management process should be developed if this water becomes a surface seep that could impact rehabilitation efforts.
- Continue monitoring of the BV ELF seepage for flow and quality to validate the 9.6% decay trends.
- Validation of the duration of the Stabilisation Phase, which is currently based on the BV ELF Stabilisation Phase of 20 months for an ELF with an average height of 10.71 m and the O'Kane (2014) study.
- Monitoring for nitrogenous compounds in pit sumps and ELF seepage.
- Ongoing monitoring of the ratio for H_2SO_4 acidity: $CaCO_3$ neutralisation to confirm the ratio is not increasing, which would suggest limestone / ANC is being exhausted. This will be important to validate limestone dose rates and longevity of its benefits.
- Limestone will not be needed in NAF ELFs and variable dose rates may be suitable for differing sulfur content, for instance:
    - Limestone dose rates could be adjusted based on the expected acidity load, which is a function of the sulfur content of the proposed ELF.
    - Lower sulfur ELFs with low modelled acidity could be treated more effectively using passive treatment technologies rather than dosing with limestone.

11 REFERENCES

Australian and New Zealand Environment and Conservation Council (ANZG) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Canberra.

BRL (Bathurst Resources Limited), 2015. Escarpment Mine: Acid Mine Drainage Management Plan. Document number: ESC-ENV-PLN-025-AMD V2.0. 201 pp.

BRL (Bathurst Resources Limited), 2018. Escarpment Mine: Annual Work Plan for Care and Maintenance. Document number: ESC-ENV-PLN-026-AWP-2017-18-v1.0. 78 pp.

Christenson, H., Weber, P., Pope, J., Newman, N., Trumm, D., 2018. Enhanced passive treatment systems: addition of nutrients to bioreactors. New Zealand Annual AusIMM Branch Conference, Tauranga, 10 - 13 September, p 97 -104.

Connor, L., 2005. Managing Adverse Effects of Acid Mine Drainage at Stockton Opencast Coalmine: A geotechnical and geochemical approach. A thesis submitted in partial fulfilment of the requirements for the Degree of Master of Science in Engineering Geology at the University of Canterbury.

CRL, 2012. Geochemistry of rocks at the Escarpment mine site. CRL reference 12-41093. Dated 15 August 2012, 88 pp.

CRL, 2016. Te Kuha Mine – Water Management Plan – Information Report (Update to December 2015). CRL reference 15-41213. Dated January 2016, 61 pp.

Diloreto, Z., 2016. Biogeochemical Investigations of a Full-Scale Mussel Shell Bioreactor for the Treatment of Acid Mine Drainage (AMD), the Stockton Mine, New Zealand. Master's Thesis. University of Canterbury.

Demchak, J., J. Skousen, and L.M. McDonald. 2001. Water quality improvements over time and longevity of acid mine discharges from underground mines in northern West Virginia. p. 174–182. In 18th Annual National Meeting of the Am. Soc. of Mining and Reclamation. 3–7 June 2001. Albuquerque, NM.

Demchak, J., J. Skousen, and L.M. McDonald. 2004. Longevity of Acid Discharges from Underground Mines Located above the Regional Water Table. J. Environ. Qual. 33:656-668.

Gandy, C.J., Younger, P.L., 2007. Predictive Modelling of Waste Rock Leaching at Stockton Mine. Report to Solid Energy New Zealand Ltd by the Hydrogeochemical Engineering Research and Outreach Institute for Research on Environment and Sustainability, Newcastle University, UK.

Hayakawa, A., Hatakeyama, M., Asano, R., Ishikawa, U., Hidaka, S., 2013. Nitrate reduction coupled with pyrite oxidation in the surface sediments of a sulfide-rich ecosystem. Journal of Geophysical Research: Biogeosciences, Vol. 118, 639–649.

Hughes, J.B., 2004. Environmental evaluation of Cypress mine proposed overburden, West Coast, New Zealand. MSc Thesis, University of Otago.

Mack, B., McDonald, L.M., Skousen, J., 2010. Acidity Decay of Above-Drainage Underground Mines in West Virginia. J. Environ. Qual. 39:1–8.

Mack, B., and J. Skousen. 2008. Acidity decay curves of 40 above drainage mines in West Virginia. p. 612–627. In Proceedings, 2008 American Society of Mining and Reclamation, June 14–19, 2008, Richmond, VA.

Mackenzie, A., 2010. Characterization of Drainage Chemistry in Fanny Creek Catchment and Optimal Passive AMD Treatment Options for Fanny Creek. A thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Geology, University of Canterbury.

Ministry for Environment, 2020. National Policy Statement for Freshwater Management 2020 (amended February 2023). New Zealand. 77 pp.

Morin, K.A., Hutt, N.M. 2009. Mine-water leaching of nitrogen species from explosive residues. Proceedings of GeoHalifax2009 Conference: p 1549-1553.

MWM (Mine Waste Management), 2026a. Factual Report: Geoenvironmental Hazards – Mount Frederick South Project. Mine Waste Management Report J-NZ0377-001-R-FINAL.

MWM (Mine Waste Management), 2026b. Column Leach Test Factual Report – Mount Frederick South Project. Mine Waste Management Report J-NZ0377-005-R-FINAL.

MWM (Mine Waste Management), 2026c. Cover System Technical Report - Buller Coal Plateaux Continuation Project. Mine Waste Management Report J-NZ0349-013-R-FINAL.

MWM (Mine Waste Management), 2026d. ELF Water Quality and MSR Design - Buller Coal Plateaux Continuation Project. Mine Waste Management Report J-NZ0453-006-R-FINAL.

MWM (Mine Waste Management), 2026e. Upper Waimangaroa Haul Road – Water Studies. Buller Plateaux Continuation Project. Mine Waste Management Report J-NZ0453-0070R-FINAL.

MWM (Mine Waste Management), 2026f. Escarpment Extension Water and Load Balance Model. MWM Report J-NZ0433-003-FINAL.

MWM (Mine Waste Management), 2026g. Mount Frederick South Extension Water and Load Balance Model. MWM Report J-NZ0377-003-FINAL.

MWM (Mine Waste Management), 2026h. Water and Load Balance Model - Source Term Definition - Buller Plateaux Continuation Project. Mine Waste Management Report J-NZ0433-004-R- FINAL.

MWM (Mine Waste Management), 2026i. Passive Treatment System Design Toolkit - Buller Plateaux Continuation Project. Mine Waste Management Report J-NZ0453-005-R- FINAL.

O'Kane Consultants Ltd, 2014. Escarpment Mine Project – Estimation of Draindown Seepage for Engineered Landform (ELF). Okane Consultants Memorandum dated 17 January 2014.

O'Kane Consultants Ltd, 2015. Acid Mine Drainage Liabilities – Stockton and Cypress Operations. Technical report prepared for Solid Energy New Zealand Ltd. Report No. 949/01-01. Dated July 2015.

Pommen, L.W., 1983. The effect on Water Quality of Explosives use in Surface Mining. Vol. 1 Nitrogen Sources, Water Quality, and Prediction and Management of Impacts. British Columbia Ministry of the Environment, Victoria, British Columbia, MOE, Tech. Rep. 4.

Pope. J., Rait. R., Newman. N., Hay. S., Rogers. M., McCraken. L. 2011. Geochemical studies of waste rock at proposed Escarpment open cast mine, Denniston Plateau West Coast. AusIMM New Zealand Branch Conference 2011, Queenstown, pp. 369-380.

Pope, J., Weber, P., Olds, W., 2016. Control of acid mine drainage by managing oxygen ingress into waste rock dumps at bituminous coal mines in New Zealand. Proceedings of the Mining Meets Water—Conflicts and Solutions, Leipzig, Germany, pp.11-15.

Pope, J., Christenson, H., Gordon, K., Newman, N., Trumm, D., 2018a. Decrease in acid mine drainage release rate from mine pit walls in Brunner Coal Measures. New Zealand Journal of Geology and Geophysics, Vol. 61, No. 2, 195–206.

Pope, J., Christenson, H., Gordon, K., Newman, N., Trumm, D., 2018b. Decrease in acid mine drainage release rate from mine pit walls in Brunner Coal Measures. New Zealand Journal of Geology and Geophysics, Vol 61, No. 4, page 578.

Process Flow 2026. Active Water Treatment Testing Report - Summary of Water Quality Testing. Process Flow Report PFL-2408-PRO-RPT-00002.

Reid, N., Boxall, N., Donn, M.J., Gray, D.J., Kaksonen, A.H., Meakin, R., Robson, T., Shiers, D., 2016. Low acid sulfide leaching project review. CSIRO Report EP163134, pp 69.

Ritchie, A.I.M., 1994. The Waste Rock Environment, Chapter 5 in The Environmental Geochemistry of Sulfide Mine-Wastes, Short Course Handbook, Volume 22, May 1994, Waterloo, Ontario, Editors: D.W. Blowes and J.L. Jambor (Mineralogical Association of Canada) 133 – 161.

Sidenko, N., 2018. Nitrogen leaching from explosives into mine water of an underground mine. Paper presented at IMWA/ICARD 2018. Wolkersdorfer, Ch.; Sartz, L.; Weber, A.; Burgess, J.; Tremblay, G. (Editors).

Treasury, 2017. AMD Liability Model. New Zealand Government

Weber, P.A., Skinner, W.M., Hughes, J.B., Lindsay, P., Moore, T.A., 2006. Source of Ni in coal mine drainage, West Coast, New Zealand. International Journal of Coal Geology 67: 214-220.

Weber, P.A., Olds, W.E., Pizey, M.H., 2014. Geochemical and Geotechnical Investigations at the Reddale Coal Mine, Reefton, New Zealand. Paper submitted and to be presented at the 8th Australian Workshop on Acid and Metalliferous Drainage, 28 April – 2 May 2014, Adelaide 2014. JK Tech Pty Ltd, pp 455-466.

Weber, P.A., Olds, W.E., Bird, B., Pearce, J., 2015. Forecasting long term water quality at closure for current mining operations. New Zealand Annual AusIMM Branch Conference, Dunedin, 31 August – 2 September 2015, pp 495-505.

Weber, P., Reid, N., Robson, T., 2021. Nitrate and AMD: An opportunity to innovate. Virtual ICARD 2021, 21 – 23 September 2021. https://www.icard2021.com

Wood, S.C., P.L. Younger, and N.S. Robins., 1999. Long-term changes in the quality of polluted minewater discharges from abandoned underground coal workings in Scotland. Q. J. Eng. Geol. 32:69–79.

Younger, 1997. The longevity of minewater pollution: a basis for decision-making. Science of the Total Environment. 194/195:457-466.

Ziemkiewicz, P. 1994. AMD/time: A simple spreadsheet for predicting acid mine drainage. p. 395–400. In Proc. Int. Land Reclamation and Mine Drainage Conf. and the Third Int. Conf. of the Abatement of Acid Mine Drainage. Vol. 2. Mine Drainage. U.S. Bureau of Mines Spec. Publ. SP06B-94. 24–29 Apr. 1994, Pittsburgh, PA.

12 LIMITATIONS

Attention is drawn to the document “Limitations”, which is included in Appendix B of this report. The statements presented in this document are intended to provide advice on what the realistic expectations of this report should be, and to present recommendations on how to minimise the risks associated with this project. The document is not intended to reduce the level of responsibility accepted by Mine Waste Management, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in doing so.

APPENDIX A ABBREVIATIONS

ABBREVIATION	DEFINITION
AEE	Assessment of environmental effects
AMD	Acid and metalliferous drainage
ANC	Acid neutralisation capacity
BCM	Brunner Coal Measures
BPCP	Buller Plateaux Continuation Project
BRL	Bathurst Resources Limited
BV	Barren Valley
CLT	Column leach test
CSM	Conceptual site model
EDD	Eastern Diversion Drain
ELF	Engineered landform
ESE	Escarpment Extended project area
FTAA	Fast-track Approvals Act 2024
FY	Financial year
kbcm	1000 bank cubic metres
LCM	Loose cubic metres
LOR	Limit of reporting
LR	Low Risk
MGIU	Mangatini sump inlet (untreated)
MSR	Mussel shell reactor
MFS	Mount Fred South project area
MWM	Mine Waste Management Limited
NAF	Non-acid forming
NP	Net percolation
NPS	National Policy Statement
PAF	Potentially acid forming
PCOC	Potential constituent of concern
PHMP	Principal Hazard Management Plan
PLUTO	Pipeline under the overburden
pXRF	Portable X-ray Fluorescence
RSPP	Red Shed Pit Pond
SOP	Stored Oxidation Product Load Model
SOX	Stored Oxidation Load Model
UG	Underground

ABBREVIATION	DEFINITION
UWHR	Upper Waimangaroa Haul Road
WLBM	Water and load balance model
WRS	Waste rock stack

APPENDIX B LIMITATIONS

This Document has been provided by Mine Waste Management Ltd (MWM) subject to the following limitations:

This Document has been prepared for the particular purpose outlined in MWM's proposal and no responsibility is accepted for the use of this Document, in whole or in part, in other contexts or for any other purpose.

The scope and the period of MWM's services are as described in MWM's proposal, and are subject to restrictions and limitations. MWM did not perform a complete assessment of all possible conditions or circumstances that may exist at the site referenced in this Document. If a service is not expressly indicated, do not assume it has been provided. If a matter is not addressed, do not assume that any determination has been made by MWM in regards to it.

Conditions may exist which were undetectable given the limited nature of the enquiry MWM was retained to undertake with respect to the site. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account in the Document. Accordingly, additional studies and actions may be required.

In addition, it is recognised that the passage of time affects the information and assessment provided in this Document. MWM's opinions are based upon information that existed at the time of the production of this Document. It is understood that the services provided allowed MWM to form no more than an opinion of the actual conditions of the site at the time the site was reviewed and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings, or any laws or regulations.

Any assessments made in this Document are based on the conditions indicated from published sources and the investigation described. No warranty is included, either express or implied, that the actual conditions will conform exactly to the assessments contained in this Document.

Where data supplied by the client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by MWM for incomplete or inaccurate data supplied by others.

MWM may have retained subconsultants affiliated with MWM to provide services for the benefit of MWM. To the maximum extent allowed by law, the Client acknowledges and agrees it will not have any direct legal recourse to, and waives any claim, demand, or cause of action against, MWM's affiliated companies, and their employees, officers and directors.

This Document is provided for sole use by Bathurst Resources Limited and is confidential to it and its professional advisers. No responsibility whatsoever for the contents of this Document will be accepted to any person other than the Client. Any use which a third party makes of this Document, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. MWM accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this Document.

MWM acknowledges that this report will be relied on by a Panel appointed under the Fast-track Approvals Act 2024 and these disclaimers do not prevent that reliance.

MINE WASTE MANAGEMENT

GREENROAD GROUP

APPENDIX J WATER AND LOAD BALANCE MODEL - SOURCE TERM DEFINITION

Water and Load Balance Model - Source Term Definition

Buller Plateaux Continuation Project

21 July 2026

J-NZ0433-004-R-FINAL

MINE WASTE MANAGEMENT
GREENROAD GROUP

BATHURST RESOURCES LIMITED

Water and Load Balance Model – Source Term Definition

Buller Plateaux Continuation Project

Document Number: J-NZ0433-004-R-FINAL

Document Date: 21 July 2026

Prepared for:

Bathurst Resources Limited

[redacted]

Prepared by:

Mine Waste Management Limited

[redacted] New Zealand

[redacted]

www.minewaste.com.au

REVISION	DATE	AUTHOR	RECORD OF REVIEW
J-NZ0433-004-R-FINAL	21/07/2026	PW	PW

EXECUTIVE SUMMARY

Bathurst Resources Limited (BRL) is seeking to obtain authorisation through the Fast-track Approvals Act 2024 (FTAA) to progress development and mining of the coal resources across the wider Buller Coal Plateaux. This project is referred to as the Buller Plateaux Continuation Project (BPCP or Project).

The purpose of the BPCP is to reconsent the existing infrastructure and mining operations associated with the existing Stockton Mine and provide access to additional coal mining areas across the Buller Plateaux, as the coal resource in the current Stockton Mine is close to depletion, and further coal resources for blending are required. There are five key project sub-areas:

- Stockton mining area (Stockton)
- Mount Frederick South (MFS)
- Escarpment Extended (ESE)
- Upper Waimangaroa Haul Road (UWHR)
- Cypress mining area (Cypress)

Background

Mine Waste Management Limited (MWM) has developed this report to support BRL with the assessment of environmental effects for the BPCP. This report relates to the development of source terms for the water and load balance models (WLBM) that have been created for MFS, ESE, and UWHR sub-areas. Stockton and Cypress sub-areas are covered in other reports.

A WLBM that contains water flow and water quality data is required for the BPCP to understand the potential effects of acid and metalliferous drainage (AMD) and sediment on surrounding waterways. The WLBM has been developed using the GoldSim modelling platform [1]. These WLBMs are discussed in separate reports for ESE sub-area (MWM, 2026b) and MFS sub-area (MWM, 2026c). Key water quality inputs (source terms) are required for the WLBM that include:

Background streams within the Project sub-areas.

- PAF [2] Engineered Landform (ELF) seepage.
- NAF [3] ELF seepage.
- Active Treatment Plant discharge.
- Mussel Shell Bioreactor (MSR) effluent (treated ELF seepage).
- Runoff from pit walls, pit floors, and clean water diversion through acid-forming materials.
- Active pits and active PAF ELF running surfaces.

[1] *https://www.goldsim.com*

[2] *Potentially acid forming*

[3] *Non-acid forming*

- ELF surface run-off (NAF ELF surfaces, unrehabilitated NAF batter slopes, and rehabilitated surfaces).
- Hardstand areas runoff.
- Underground adit discharge.

A number of source terms are also used for the WLBM for the UWHR, although this was created numerically using Microsoft Excel rather than GoldSim (MWM, 2026g).

Derivation of Source Terms

Water quality source terms were developed from a variety of sources including analogue data sources, background water quality studies, and laboratory derived data from environmental geochemistry testing. This report provides an explanation of how the source terms for modelling were developed for the WLBMs.

- Water quality limits have been derived by an independent subject matter expert (Hickey, 2026). These are used to understand the effects to the receiving environment for each Project sub-area.
- Background water quality data for streams in the BPCP area have used:
    - Average concentration data for dissolved parameters (e.g., potential constituents of concern (PCOC))
    - TSS has been derived from available W-M2 monitoring site data.
    - These data are assigned in the WLBM to background catchments within the model bounds. These data are summarised in this report.
- ELF seepage water quality has been developed from analogue datasets (Barren Valley ELF). These data are summarised in this report, and the process is applied to:
    - ELF seepage from PAF materials
    - ELF seepage from NAF materials.
- Water quality for other mine impacted waters (MIW) has been derived from a variety of sources. These data are summarised in this report and include:
    - Highwall run-off derived from empirical datasets, scaled for sulfur content to consider higher and lower AMD risk surfaces where constant load models are developed (kg/ha/day) and are applied to the WLBM to account for variation in flow rates/rainfall. PAF, NAF, and granite highwall surfaces are assessed using different methods. Similar data are used for drains cut into bedrock materials that are acid forming (e.g., Brunner Coal Measures).
    - Active pit water quality and active ELF surfaces, which is derived from:
        - Empirical TSS datasets from the Stockton Coal Mine.

        - The existing Escarpment Mine, Pit 3 empirical water quality during the early stages of filling to be representative of the dissolved parameters (e.g., PCOC). Two datasets are used to represent lower and higher rainfall periods with a gradational change introduced into the WLBM between the two datasets.
    - Coal floor run-off, which uses the highwall constant load model approach, scaled for sulfur content and concentration as a function of rainfall.
    - Unrehabilitated ELF surface runoff, which uses NAF water quality data derived from the column leach testing. Noting that due to progressive rehabilitation only 2-3 lifts containing PAF rock will be exposed before they are recontoured and capped with NAF rock. A constant source term is applied.
    - Rehabilitated ELF surfaces, which uses:
        - Background stream water quality data based on W-M2 data.
        - In the absence of representative empirical data, source terms were adopted from previous studies on the Buller Plateaux.
    - Hardstand runoff, which uses a constant load model approach for PAF surfaces (same as highwall source terms).
    - Underground workings / adit discharge that use empirical average data from the Escarpment Adit. Constant data are used in the WLBM
- Water treatment efficiency assumptions have been developed for both active and passive treatment technologies. These efficiencies are summarised in this report and include:
    - Passive treatment efficiencies using MSRs, which are based on empirical field data and laboratory trials.
    - Active treatment performance is based on laboratory water treatability trials.

A number of interpretations were needed in the derivation of these source terms, which are documented in this report together with performance monitoring.

TABLE OF CONTENTS

1 Introduction 1
1.1 Project Background 1
1.2 Water and Load Balance Models 1
1.3 Mine Plan 1
1.3.1 ESE Sub-area 2
1.3.2 MFS Sub-area 2
1.4 Engineered Landforms 3
1.5 Purpose and Scope 4
1.6 Source Term Components 5
1.7 Modelling Approach 5
2 Project Sub-Area Description 6
2.1 Introduction 6
2.2 Escarpment Extended Sub-area 8
2.2.1 Catchments 8
2.3 Mount Frederick South Sub-area 10
2.3.1 Catchments 10
2.4 Upper Waimangaroa Haul Road Sub-area 10
2.4.1 Catchments 10
3 Proposed Compliance Monitoring 13
3.1 Source Hazards 13
3.1.1 AMD 13
3.1.2 TSS 13
3.1.3 ANFO 13
3.2 Proposed Water Quality Limits 13
4 Source Term - Climate 14
4.1 Data Sources 14
4.2 Monthly Climate Data 14
4.3 Rainfall Quality 14
5 Source Term - Background Water Quality 15
5.1 ESE Background Water Quality 15
5.2 Mount Frederick South Background Water Quality 16
5.3 Upper Waimangaroa Haul Road Water Quality 17
5.4 Groundwater 19
5.5 Assumptions 19
5.6 Opportunities 19
6 Source Term: ELF Toe Seepage 20
6.1 ELF Seepage Water Quality Phases 20
6.2 Derivation of ELF Water Quality 21
6.3 NAF ELF Seepage Water Quality 21

6.3.1 Adjustments Required for NAF Materials 21
6.3.2 Assumptions and Clarifications for NAF ELF Seepage 22
6.3.3 Model Effects 22
6.4 Performance Monitoring 23
6.5 ELF Seepage Source Terms - Summary 23
7 Mine Impacted Surfaces 24
7.1 Highwall Run-off and Surface Drains 24
7.1.1 Source Term - Granite Highwall Runoff 25
7.1.2 Background: Dilution through Increased flow 26
7.1.3 Run-off from Brunner Coal Measures and Kaiata Mudstone Highwalls 27
7.1.4 Source Term Derivation for Surfaces – PAF Materials 29
7.1.5 Decay of acidity and PCOC – PAF Surfaces 35
7.1.5.1 ESE Borrow Pit 37
7.1.6 Assumptions 37
7.1.7 Model Effects 38
7.1.8 Performance Monitoring 38
7.2 Active Pits 38
7.2.1 Methodology 39
7.2.2 Source Term 41
7.2.3 Active ELF Running Surfaces 43
7.2.4 Assumptions 43
7.2.5 Model Effects 43
7.2.6 Performance Monitoring 44
7.3 Coal Floor - Closure 44
7.3.1 Source Term: ESE Coal Floor - Closure 44
7.3.2 Source Term: MFS Coal Floor - Closure 46
7.3.3 Decay of acidity and PCOC 49
7.3.4 Summary 49
7.3.5 Assumptions 50
7.3.6 Performance Monitoring 50
7.4 ELF Surface Runoff: Uncovered and Revegetated 50
7.4.1 Source Term 50
7.4.2 Risk 51
7.4.3 Performance Monitoring 51
7.5 Hardstand Runoff 52
7.5.1 Source Term 52
7.5.2 Summary 53
8 Adits 54
8.1.1 Escarpment Adit 54
8.1.2 Sullivan Adit: Source Term 55
8.1.3 Source Term 55

8.1.4 Assumptions 55
8.1.5 Model Effects 55
8.1.6 Performance Monitoring 56
9 TSS Source Terms 57
9.1 Background Water Quality 57
9.2 Mine Impacted Water Quality 57
9.3 Rehabilitated Surfaces 61
9.3.1 ELF Runoff 61
9.3.2 Coal Floor, Highwalls, and Hardstand 62
9.4 ELF Seepage 62
9.5 Post Passive Treatment 62
10 Source Terms - Treated Water 63
10.1 Active Water Treatment 63
10.1.1 Source Terms – Treated Water Quality 63
10.2 MSR Treated Water 64
10.3 MSR and WTP Effluent Alkalinity 66
10.3.1 Introduction 66
10.3.2 Alkalinity Modelling 66
11 Closing 68
11.1 Report Overview 68
11.2 Adaptive Management 68
12 References 69
13 Limitations 71
Appendix A Limitations 72

LIST OF TABLES

Table 1: ESE overburden quantities 2
Table 2: MFS overburden quantities 3
Table 3: ELF physical properties - ESE 4
Table 4: ELF physical properties - MFS 4
Table 5: Monthly Climate Source Term Data 14
Table 6: Surface water quality source terms for Whareatea River area (W-M2). 15
Table 7: Surface water quality source terms for MFS. 16
Table 8: Water quality data from site 2W (Smokestack). 18
Table 9: Summary of Mine Impacted Surfaces 24
Table 10: Source term for ESE6.2 highwall (derived from the Cypress Highwall dataset). 25
Table 11: PAF surface domain acidity loads 27
Table 12: ESE Highwall Sulfur Content 30
Table 13: Source terms for highwalls and drains 32
Table 14: ESE specific source terms for highwalls 34
Table 15: MFS Column Leach Test ABA Data 41
Table 16: Active pit surface runoff water quality. 41
Table 17: ABA Data for ESE Coal Floor 44
Table 18: Source term for ESE coal floor runoff. 45
Table 19: ABA Data for MFS Coal Floors 47
Table 20: Source term for MFS coal floor runoff. 48
Table 21: ELF Runoff – Uncovered and Rehabilitated 51
Table 22: Waste rock runoff – NAF Hardstand 52
Table 23: Escarpment Adit water quality data (2008 and 2022). 54
Table 24: Sullivan Mine Adit Water Quality. 55
Table 25: Mine impacted area TSS source term derivation. 58
Table 26: TSS load change before and after installation of the Mangatini Quarry Sump. 60
Table 27: Rehabilitated ELF surface TSS source term. 61
Table 28: Water Quality Source Term – WTP Effluent 63
Table 29: MSR Treatment + Polishing Pond Efficiencies 65

LIST OF FIGURES

Figure 1: Proposed Disturbance and Proposed Consent Areas for the Project 7
Figure 2: Catchments for the ESE sub-area with proposed monitoring locations and ESE footprint. 9
Figure 3: Catchments at MFS. 11
Figure 4: Upper Waimangaroa Haul Road Catchments 12
Figure 5: BV ELF acidity concentration data. 21
Figure 6: Cypress Pit and the Cypress Pit highwall, cut into the Mount William granite. 26

Figure 7: Flow versus acidity – St Patricks Stream (S16), Stockton Coal Mine 26
Figure 8: Grand Canyon (Millerton Road Cutting) water sampling locations 28
Figure 9: Site 3 – UWHR 29
Figure 10: ESE closure highwall (Year 13). 31
Figure 11: Daily rainfall events versus acidity (mg $CaCO_3$/L) for highwall and drain surfaces. 35
Figure 12: Average acidity data for highwall surfaces versus time, fitted with a power trendline. 35
Figure 13: Derived decay rate for highwalls 36
Figure 14: Pit 3 Pit Lake sulfate concentration timeseries. 39
Figure 15: Pit 3 Pit Lake zinc concentration timeseries. 39
Figure 16: Pit 3 Pit Lake acidity concentration timeseries. 40
Figure 17: Pit 3 Pit Lake iron concentration timeseries. 40
Figure 18: Pit 3 Pit Lake aluminium concentration timeseries. 40
Figure 19: Pit 3 Pit Lake mixing model for high flow and low flow scenarios. 43
Figure 20: ESE closure coal floor. 45
Figure 21: Daily rainfall events versus acidity (mg $CaCO_3$/L) for CON Coal Floor. 46
Figure 22: MFS Closure Coal Floor in relation to other project infrastructure. 47
Figure 23: MFS Closure Coal Floors showing areal extent. 48
Figure 24: Daily rainfall events versus acidity (mg $CaCO_3$/L) for MFS Coal Floor 2. 49
Figure 25: Mine impacted TSS relationship for use in WLBMs. 59
Figure 26: TSS reduction factor relationship applied to sumps 61
Figure 27: MSR influent sulfate versus MSR effluent Ca 64
Figure 28: MSR influent sulfate versus MSR effluent Mg. 65
Figure 29: Alkalinity (mg $CaCO_3$/L) of Mangatini Stream after treatment 66
Figure 30: Net Alkalinity versus pH for laboratory test data: 67

1 INTRODUCTION

Bathurst Resources Limited (BRL) is seeking to obtain authorisation through the Fast-track Approvals Act 2024 (FTAA) to progress development and mining of the coal resources across the wider Buller Coal Plateaux. This project is referred to as the Buller Plateaux Continuation Project (BPCP or Project).

1.1 Project Background

The purpose of the BPCP is to reconsent the existing infrastructure and mining operations associated with the existing Stockton Mine and provide access to additional coal mining areas across the Buller Plateaux, as the coal resource in the current Stockton Mine is close to depletion, and further coal resources for blending are required. There are five key project sub-areas:

- Stockton mining area (Stockton)
- Mount Frederick South (MFS)
- Escarpment Extended (ESE)
- Upper Waimangaroa Haul Road (UWHR)
- Cypress mining area (Cypress)

This report relates to MFS, ESE, and UWHR. Stockton and Cypress are covered in other reports.

1.2 Water and Load Balance Models

As part of the assessment of effects, the Project sub-areas require the development of water and load balance models (WLBM models) that will simulate flow and key water quality parameters associated with acid and metalliferous drainage (AMD) and sediment on surrounding waterways. This WLBM is used to support water management and treatment planning/design; and to forecast water quality at downstream compliance monitoring sites. The WLBM is a tool to understand potential risks to the receiving environment.

WLBMs have previously been developed for the Mangatini, Millerton, St Pats, and Cypress catchments at Stockton Coal Mine. For the BPCP, WLBMs have been developed for the ESE sub-area (MWM, 2026b), MFS sub-area (MWM, 2026c), and the proposed UWHR transport corridor sub-area (MWM, 2026g).

A critical component of developing a robust WLBM is the development of appropriate source terms to define the water quality of each model domain. A source term is a unique water quality concentration (mg/L) or load (e.g., mg/s) that is applied to the flow from a specific pathway (point source or diffuse source) in a water and load balance model. Source terms can be static or can change with time. Some of these source terms will share commonality between models, others will be unique to the model domain.

1.3 Mine Plan

Material schedules have been developed by BRL for the BPCP, with the specific sub-area AMD classification criteria being applied to the material quantities.

1.3.1 ESE Sub-area

A materials schedule for ESE has been provided by BRL for Stage -1 to Stage 14 of the ESE. The dataset is split into potentially acid forming (PAF) non- acid forming (NAF), Low Risk, and High Acid Forming (HAF). Estimated extraction volumes are summarised in Table 1.

Table 1: ESE overburden quantities

INDICATIVE YEAR	PROJECT STAGE	NAF	LOW RISK	PAF	HAF	TOTAL OVERBURDEN [1]
[redacted]	STAGE -1	83,800	23,000	503,500	48,900	659,200
	STAGE 0	258,700	403,800	2,428,700	1,257,100	4,348,200
	STAGE 1	820,400	679,500	3,888,400	2,041,700	7,429,800
	STAGE 2	610,200	294,000	4,935,700	1,763,300	7,603,100
	STAGE 3	1,591,700	694,800	5,957,300	1,560,500	9,804,100
	STAGE 4	2,421,200	482,500	4,202,500	2,819,600	9,925,600
	STAGE 5	3,779,500	378,400	2,958,200	2,822,500	9,938,500
	STAGE 6	3,536,300	481,300	5,185,700	636,600	9,839,800
	STAGE 7	3,123,300	1,798,600	3,105,600	1,886,100	9,913,400
	STAGE 8	2,670,100	2,446,800	3,882,200	803,700	9,802,600
	STAGE 9	3,862,300	1,615,500	3,250,200	1,195,200	9,923,000
	STAGE 10	4,403,500	1,131,400	3,013,400	983,700	9,531,900
	STAGE 11	3,126,900	514,100	4,659,400	1,146,900	9,447,200
	STAGE 12	1,862,300	432,800	5,672,800	1,062,500	9,030,200
	STAGE 13	3,260,800	540,200	4,040,300	962,600	8,803,800
	STAGE 14	1,418,800	27,600	720,200	19,400	2,185,800
Grand Total [1]		36,828,900	11,943,600	58,403,500	21,009,600	128,185,500

All results in bcm (bank cubic meters)

[1] Total overburden and grand totals are calculated and rounded from source data; therefore, may not equal the sum of the rounded figures shown.

[2] Green cells represent the Construction Phase.

1.3.2 MFS Sub-area

A materials schedule for MFS has been provided by BRL for Stage -1 to Stage 14 of the MFS. Overburden quantity, split into NAF, Low Risk, PAF, and HAF are provided in Table 2 for the MFS sub-area.

Table 2: MFS overburden quantities

INDICATIVE YEAR	PROJECT STAGE	NAF	LOW RISK	PAF	HAF	TOTAL OVERBURDEN [1]
[redacted]	Stage -1	-	365,500	30,100	-	395,600
	Stage 0	599,300	210,800	414,100	169,900	1,394,100
	Stage 1	724,100	87,000	38,100	1,700	850,700
	Stage 2	529,300	80,200	17,000	300	626,600
	Stage 3	149,100	154,700	150,300	5,700	459,700
	Stage 4	413,400	107,800	39,800	500	561,400
	Stage 5	130,800	64,100	61,700	-	256,600
	Stage 6	1,023,500	55,600	25,200	5,700	1,109,800
	Stage 7	1,108,300	143,500	198,800	9,300	1,459,700
	Stage 8	771,900	239,200	499,900	1,500	1,512,400
	Stage 9	1,845,900	108,200	154,700	4,500	2,113,100
	Stage 10	980,000	216,100	181,400	44,900	1,422,200
	Stage 11	367,700	125,100	227,800	151,300	871,900
	Stage 12	1,809,000	255,300	202,700	66,800	2,333,600
	Stage 13	405,000	170,000	200,200	2,300	777,300
	Stage 14	8,300	14,400	41,300	1,500	65,400
Grand Total [1]		10,865,600	2,397,500	2,483,100	465,900	16,212,100

All results measured in bcm (bank cubic meters), - indicates no volume to be extracted during this Stage.

[1] Total overburden and grand total are calculated and rounded from source data; therefore, may not equal the sum of the rounded figures shown.

[2] Green cells represent the Construction Phase.

1.4 Engineered Landforms

The overburden removed as part of the mining process (as shown in Table 1and Table 2) will be placed in Engineered Landforms (ELFs). The physical properties of these landforms, divided into ELF basal sub-catchments are shown in Table 3 for the ESE sub-area and in Table 4for the MFS sub-area.

Table 3: ELF physical properties - ESE

BASAL ELF SUB-CATCHMENT	LCM (m^3) [3]	TONNES	PLAN AREA (m^2) [3]	AVERAGE HEIGHT (m)	AVERAGE S (wt%)	MINIMUM NAF THICKNESS (m)
BVE	7,017,463	14,537,200	200,171	35.1	0.43	1
CON	38,784,258	80,344,498	1,086,249	35.7	0.28	3
NSUL	4,022,469 [2]	8,332,846 [2]	259,753	15.49 [1]	0.13	15.49
PPG	698,196	1,446,366	39,774	17.6	0.09	17.6
WWH	100,987,674	209,203,536	1,692,122	59.7	0.38	2.39
ESC	621,386	1,287,248	31,849	19.5	0.34	1
Total	**153,580,780**	**318,154,097**	**3,309,917**	**-**	**-**	**-**

Green cells indicate the ELF is non-acid forming (NAF), hence NAF = ELF average height.

[1] The maximum height during operations is 21.07 m before NAF is removed for PAF ELF capping towards the end of mining.

[2] Closure quantities.[3] Note volumes and areas are based on the mine model, rather than the rehab model, which means the surface area and volumes are slightly different (<3%).

Table 4: ELF physical properties - MFS

BASAL ELF SUB-CATCHMENT	LCM (m^3)	TONNES	PLAN AREA (m^2)	AVERAGE HEIGHT (m)	AVERAGE S (wt%)	MINIMUM NAF THICKNESS (m)
MSR1	898,896	1,828,840	61,571	14.5	0.12	12
MSR2	126,918	258,219	15,328	12.6	0.12	12
MSR3	503,500	1,024,392	41,472	12.6	0.12	12
MSR4	503,525	1,024,443	41,472	12.6	0.12	12
MSR5	4,003,925	8,146,147	190,019	19.1	0.12	15
MSR6	605,378	1,231,666	45,097	10.1	0.12	12
MSR7	2,714,959	5,523,694	202,212	11.9	0.12	10
MDC1	52,933	107,694	6,033	9.0	0.049	9.0
MDC2	35,151	71,516	5,319	6.4	0.049	6.4
MSR8	7,438,945	15,141,903	317,705	18.4	0.14	20
MSR9	498,743	1,015,186	39,758	12.7	0.14	10
MSR10	152,503	310,419	24,523	8.4	0.14	8
MSR11	281,450	582,236	29,323	6.6	0.28	4
MSR12	328,342	679,243	29,350	7.8	0.28	4
Total	**18,145,167**	**36,945,599**	**1,049,181**	**-**	**-**	**-**

Green cells indicate the ELF is wholly NAF, hence NAF = ELF average height.

1.5 Purpose and Scope

The purpose of this report is to define and present the relevant data that have been used to derive the key source terms to be used in the WLBM for the BPCP. Hydrological aspects such as run-off coefficients, water management infrastructure, and sizing of infrastructure are not considered in this report. Details are provided in WLBM as documented by MWM (2026b; 2026c).

With respect to the definition of the source terms, the objectives of this report are to:

- Define the sources of data used for source term definition.

- Define the rationale applied in deriving the source terms.
- Identify the applicability and limitations associated with the data used to derive the source terms.

1.6 Source Term Components

Models that assess the effects on water quality generally require flow rates and water quality estimates. Source terms are created to represent the water quality of each component of the model. Source terms are derived from empirical site data and analogue data, which may be from the compilation of monitoring data (e.g., average data) or from geochemical relationships (e.g., sulfate versus constituents of potential concern (PCOC)). Source terms that require definition for BPCP include:

- Background water quality of streams within the Project sub-areas.
- PAF [4] ELF seepage.
- NAF [5] ELF stockpile seepage.
- Active treatment plant discharge water quality.
- Mussel Shell Bioreactor (MSR) effluent (treated ELF seepage).
- Runoff from pit walls, pit floors, and clean water diversion through acid-forming materials.
- Active pits and active PAF ELF running surfaces.
- ELF surface run-off (NAF ELF surfaces, unrehabilitated NAF batter slopes, and rehabilitated surfaces).
- Hardstand areas runoff.
- Underground adit discharge.

Total suspended solids (TSS) source terms have been developed in MWM (2026k) and are discussed in Section 9.

1.7 Modelling Approach

Modelling is undertaken using GoldSim modelling platform [6] to develop a WLBM. Further details of the WLBM are contained in:

- MWM (2026b) for the ESE sub-area.
- MWM (2026c) for the MFS sub-area.

The WLBM for the UWHR does not use GoldSim for modelling as the amount of material disturbance and effects are expected to be lesser. Instead, a Microsoft Excel based numerical analysis is undertaken:

- MWM (2026g) for the UWHR sub-area

[4] *Potentially acid forming*

[5] *Non-acid forming*

[6] *https://www.goldsim.com*

2 PROJECT SUB-AREA DESCRIPTION

This section provides an explanation of the Project sub-areas.

2.1 Introduction

The BPCP covers areas on both the Stockton Plateau and the Denniston Plateau (collectively referred to as the Buller Plateaux). The purpose of the BPCP is to reconsent the existing infrastructure and mining operations associated with the Stockton Mine and provide access to additional coal mining areas across the Buller Plateaux, as the coal resource in the current Stockton operations are close to depletion, and further coal resources for blending are required.

The BPCP comprises five key sub-areas (Figure 1), each with defined project scopes and site-specific geoenvironmental hazards:

- Stockton: Completion of mining of existing pits and remaining coal resources. Ongoing utilisation of existing infrastructure.
- MFS: A new opencast mining area with initial mining through existing historical underground workings, and extension into unmined areas to the northwest along with the extension of the UWHR road into the MFS mine area. Coal will be transported to Stockton via the UWHR
- ESE: Mining is a combination of an existing pit (Escarpment), mining through existing historical underground workings (Whareatea, Escarpment), and an extension into unworked areas (West Whareatea). Coal will be transported to Stockton via the UWHR. The ESE sub-area includes the Waimangaroa Storage Yard, located at the bottom of the Denniston Road which will be used as a laydown area.
- UWHR: Road connecting Stockton with MFS and ESE operations. The UWHR is a combination of upgrades to existing roads and the development of a new section through the Waimangaroa Valley. This will be used for transport of coal from MFS and ESE to Stockton.
- Cypress: the BPCP will interact with Cypress, but for the purposes of AMD and water management, Cypress has existing consents and water management plans and procedures in place and therefore, is not considered further in this assessment.

The report provides source terms for water and load balance modelling of the ESE, MFS, and UWHR sub-areas.

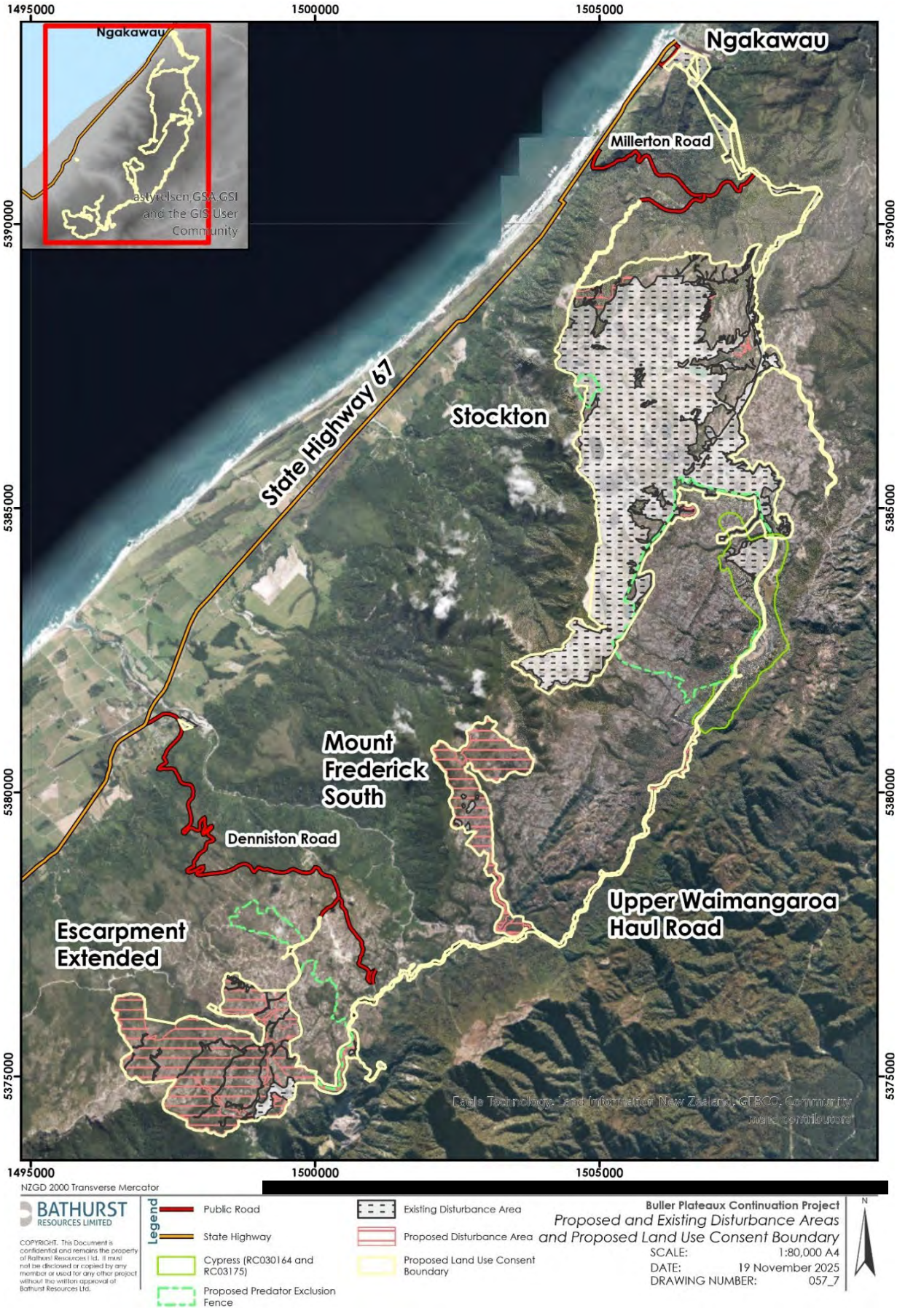


Figure 1: Proposed Disturbance and Proposed Consent Areas for the Project

2.2 Escarpment Extended Sub-area

The ESE sub-area is located on the Denniston Plateau, which is typically elevated at 600 – 1,100 m above sea level and hosts several current and former coal mining operations. The area is located within moderately sloping, hilly terrain with deeply incised gullies. The site has an overall slope to the northwest and has several watercourses draining the site either to the north, or southeast via a steep topographical drop into the Cascade Creek catchment. Cascade Creek ultimately drains into the Buller River.

The main drainage feature within the ESE Area is the Whareatea River. The Whareatea River becomes deeply incised to the north and receives flows from numerous tributaries on the Denniston Plateau. Ultimately, the river drains in a north-westerly direction towards the coast and discharges into the Tasman Sea approximately 10 km east of Westport.

2.2.1 Catchments

As shown in Figure 2, numerous streams flow through and around the ESE sub-area with the Whareatea River, Rapid Stream, and Cascade Creek representing the major catchment streams with the potential to receive impacted water from the historic and proposed mining operations. Specifically:

- Cascade Creek: Cascade Creek flows to the south of the Escarpment Mine and receives flow from Hagan Creek, V8 Creek and V37 Creek. There are underground workings beneath the proposed ESE workings that drain AMD impacted water into the Cascade Creek Valley via numerous adits.
- Rapid Stream: Rapid Stream and its tributaries flow in a north-westerly direction and would contain runoff from the proposed Ex-Pit Sullivan ELF. Adit discharge to Rapid Stream from the Sullivan underground mine is known and evident.
- Whareatea River: The Whareatea River flows from the southeast to northwest to the north of the Escarpment pit and receives flow from Trent Stream, Conglomerate Stream, V40 Stream, South Creek, V62 Stream and several other lesser tributaries that intersect the Escarpment Pit.

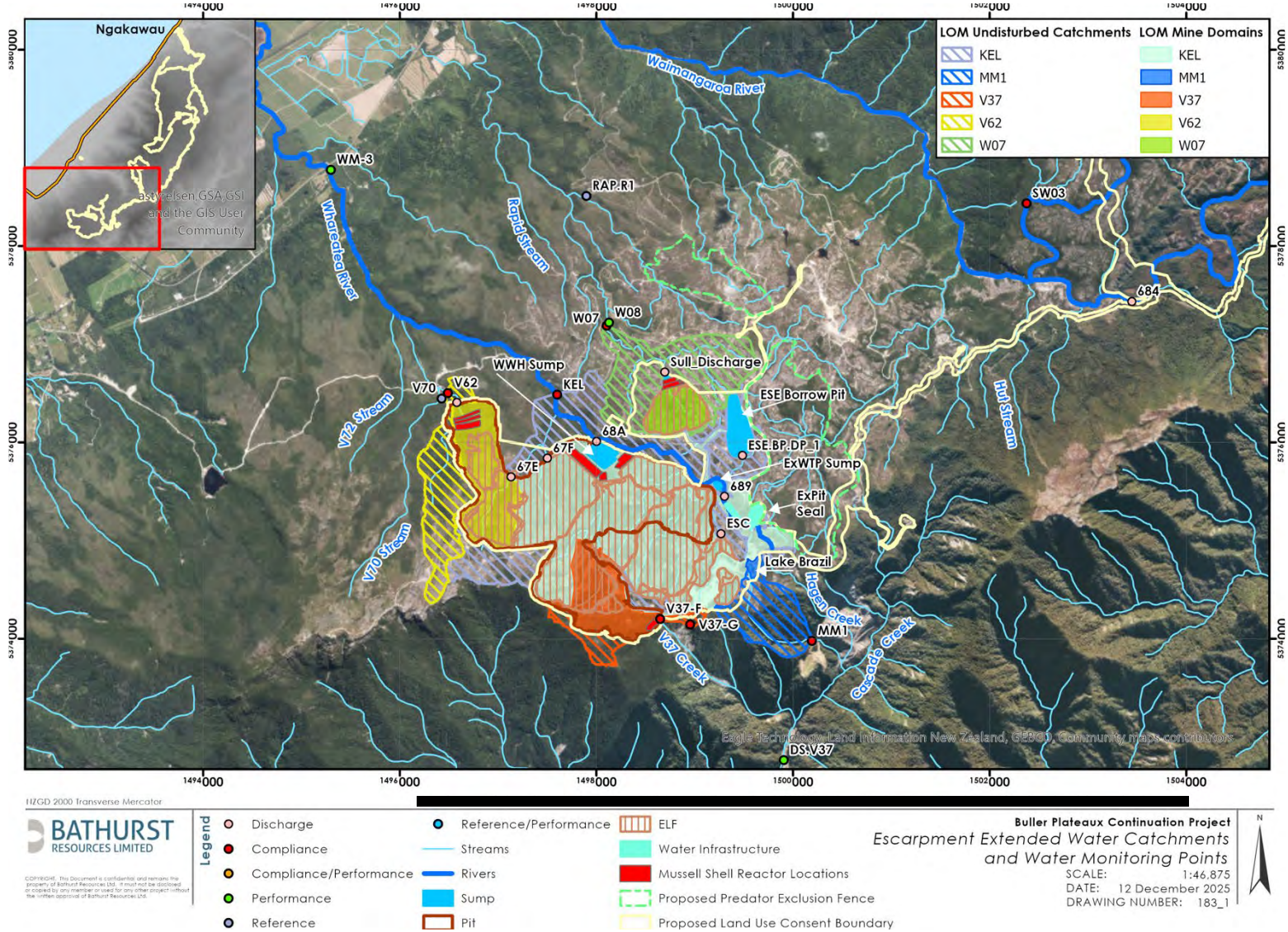


Figure 2: Catchments for the ESE sub-area with proposed monitoring locations and ESE footprint.

2.3 Mount Frederick South Sub-area

The MFS sub-area is bounded by Webb Stream in the north, the coastal ridgeline south of Mount Frederick in the west, the steep scarp of the Waimangaroa River Gorge in the south, and the Waimangaroa River valley / headwaters in the east. It is deeply incised by a number of streams including Billo and Deep Stream in the south, L75 Stream in the north, which flow east or southeast.

2.3.1 Catchments

As shown in Figure 3 major drainage feature at MFS is Deep Stream, which is deeply incised and flows from the north of the operations along the eastern project area boundary and discharges into Waimangaroa River to the south. Billo Stream has the potential to transport mine-impacted waters because it runs through and between the mine features. Billo Creek converges with Deep Stream to the east. The remainder of the waterways appear unnamed.

2.4 Upper Waimangaroa Haul Road Sub-area

Compliance monitoring is needed to confirm any effects of the UWHR on water quality within the Waimangaroa River.

Monitoring point, 2W (Smokestack), has been chosen for this purpose, due to its:

- Proximity to the proposed haul road and accessibility for sampling.
- Limited historic workings upstream of this site; the concern being historic workings having the potential to conceal AMD effects from the haul road.
- Historic water sampling and river gauging data.
- A location downstream of the proposed MFS water treatment plant.

2.4.1 Catchments

Figure 4 provides the location of water quality compliance monitoring location 2W (Smokestack), which will also be the monitoring location for discharge from the MFS Water Treatment Plant (MFS-WTP).

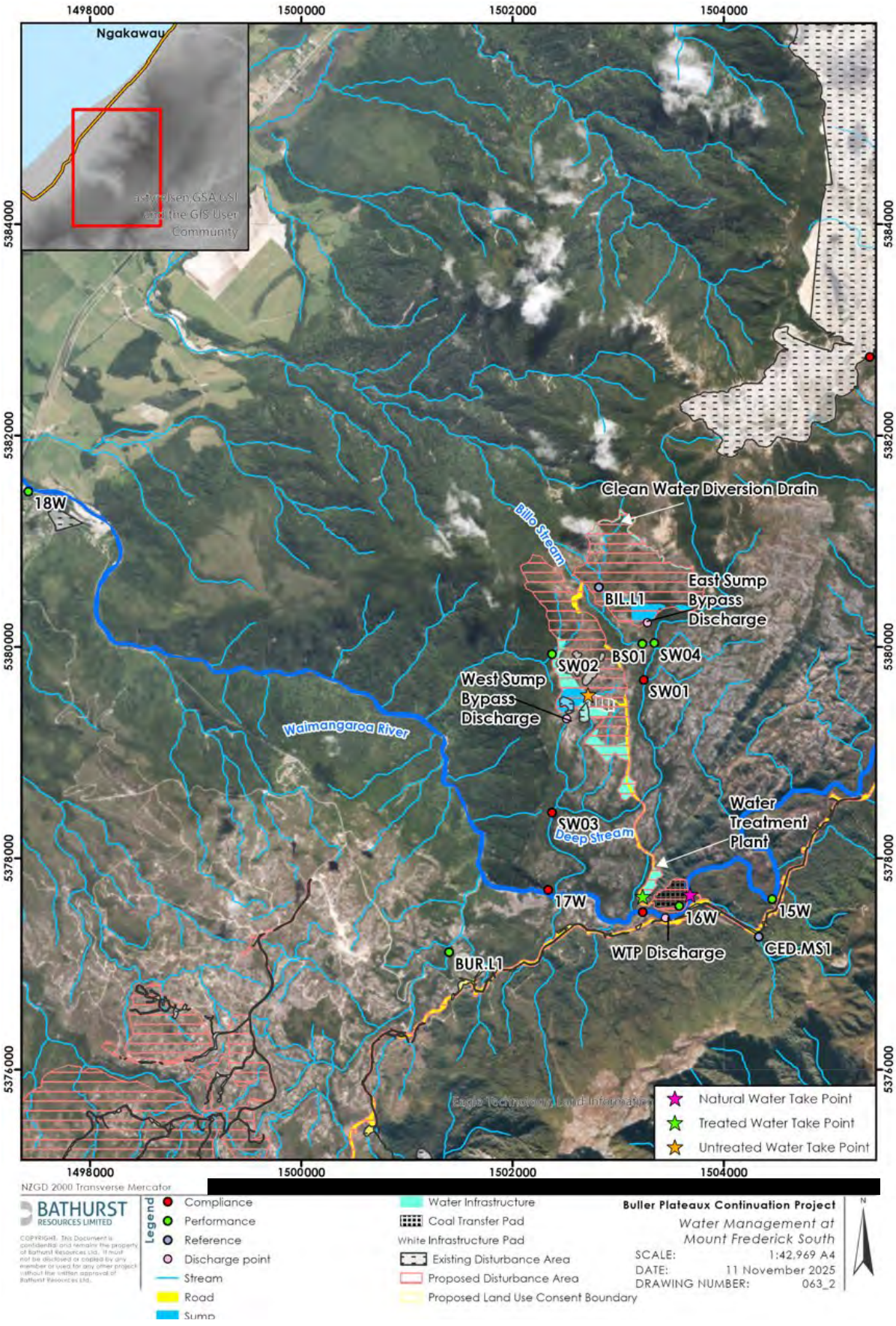


Figure 3: Catchments at MFS.

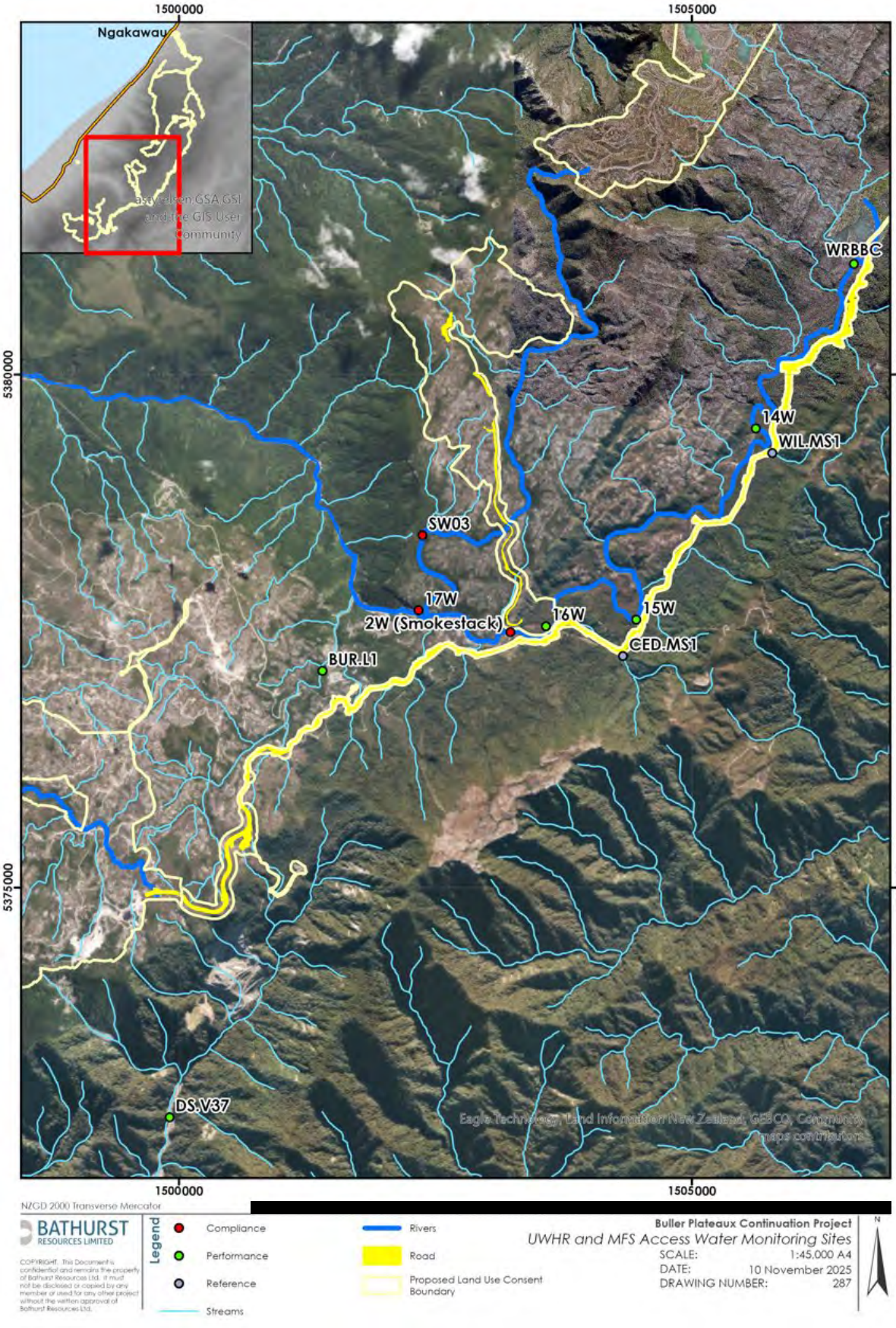


Figure 4: Upper Waimangaroa Haul Road Catchments

3 PROPOSED COMPLIANCE MONITORING

This section summarises the proposed compliance monitoring requirements for water quality to aid in understanding and providing context for the source terms developed in this report. These limits apply to MFS, ESE, and the UWHR sub-areas of the BPCP.

3.1 Source Hazards

The following section discusses potential source hazards for the BPCP including AMD, total suspended solids (TSS) and the effects of blasting using ammonium nitrate-based explosives (e.g., ANFO [7]).

3.1.1 AMD

AMD is expected from the Brunner Coal Measures (BCM) and Kaiata Mudstone (KMS). Source terms need to reflect these effects. Further discussion is provided in this report.

3.1.2 TSS

Mining can create elevated TSS and NTU, which has been documented at the Stockon Coal Mine (e.g., Elder et al., (2011)). Elevated TSS and NTU are expected as part of the BPCP and source terms need to be developed. Source terms for TSS are discussed in MWM (2026k,t) and are summarised in Section 9.

3.1.3 ANFO

Nitrogenous compounds associated with the use of ANFO are not expected to be elevated (MWM, 2026i). However, performance monitoring is recommended (pit sumps and ELF seepage).

3.2 Proposed Water Quality Limits

Water quality limits have been developed for the identified PCOC/ for the BPCP. Water quality limits are provided by (Hickey, 2026).

[7] *Ammonium Nitrate Fuel Oil (ANFO) based explosives where ANFO is 94% NH_4NO_3 and 6% fuel oil.*

4 SOURCE TERM - CLIMATE

This section summarises the climatic data for the sub-areas.

4.1 Data Sources

Climatic conditions within the ESE sub-area have been derived utilising the data collected from Lake Brazil weather station, located on-site at an elevation of 640 m. The weather record contains data from 2010 – 2023. The data records lack continuity and contain numerous data gaps. In such cases, data has been estimated using climatic data from the Stockton Office Met station which is located at the Stockon mine at a similar elevation (Chater, 2024). The patched dataset is henceforth referred to as the project climate dataset.

4.2 Monthly Climate Data

The West Coast of the South Island is characterised by high rainfall and is the wettest region in New Zealand. High rainfall is attributed to the region's exposure to moisture laden air masses passing over the Tasman Sea, with typical annual rainfall in coastal areas of 2,000 – 3,000 mm/year (Macara, 2016). However, rainfall is significantly higher in elevated areas such as on the Denniston Plateau.

Table 7 presents the climate records between 2011 to 2023 from the project climate dataset. The following is noted regarding the derivation of the source term data:

- Average monthly rainfall has been adjusted for Mount Frederick South (MFS) to account for the higher elevation compared to the Escarpment area.
- Potential evaporation has been calculated from the available data using the Penman formulation.

Table 5: Monthly Climate Source Term Data

SOURCE TERM	UNIT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Rainfall (Brazil - ESE)	mm	423	366	341	448	548	410	476	408	481	591	471	505	5,468
Rainfall[1] (MFS)	mm	458	397	370	486	594	444	516	442	522	641	511	547	5,928
Monthly Air Temp	°C	13.5	13.9	12.7	10.3	8.4	6.5	5.2	5.7	6.8	8.0	9.9	12.3	-
Potential Evaporation	mm	139	117	91	49	23	10	15	34	64	101	128	151	922

[1]Rainfall adjusted based on rainfall-altitude relationship for the Denniston Plateau derived by Chater (2024), assuming a mean site elevation of 812 mRL.

Further details are provided in MWM (2026b,e).

4.3 Rainfall Quality

No information is available regarding rainfall quality in the sub-areas. As a result, rainfall concentrations were assigned a null value.

5 SOURCE TERM - BACKGROUND WATER QUALITY

This section reviews background water quality for the BPCP area. The following source terms are derived:

- MFS Background Water Quality: used as background water quality for the MFS sub-area.
- ESE Background Water Quality: used as background water quality for the ESE sub-area.
- Upper Waimangaroa River (Smokestack) Background water quality: used as background water quality for the UWHR sub-area.

Source terms for background water quality have been derived from surface water quality data from the ESE, MFS, and UWHR sub-areas, with monitoring data covering multiple locations from 2002 to 2025. Further information on these data is provided in MWM (2026l).

Surface water quality source terms for compliance monitoring locations have been defined using the average concentration from the monitoring records. The source terms are provided in Table 6.

The purpose of the source term is to allocate a water quality to a catchment that reports to the compliance monitoring location. The use of average water quality means:

- the model will generate average water quality at the compliance monitoring location when no mining activities are present.
- This provides a source of dilution in the model but may not account for the dynamic changes in water quality with higher and lower flow.

It is likely the data are representative of low/median flows, when it is safe and possible to collect water samples. Higher flows are unlikely to have been obtained on a regular basis; however further assessment has been undertaken using flow samplers for higher rainfall events.

5.1 ESE Background Water Quality

Water quality from monitoring site W-M2 in the Whareatea River, located upstream of monitoring site KEL is used as background water quality for the ESE sub-area (Table 6).

Table 6: Surface water quality source terms for Whareatea River area (W-M2).

PARAMETER[1,2]	**W-M2**
DATA CONFIDENCE	
Number of Samples	164
Monitoring Period	2010-2024
MEAN CONCENTRATION	
pH	4.9
EC (mS/m)	2.9
Acidity (mg $CaCO_3$/L)	4.2
Alkalinity (mg $CaCO_3$/L)	1.2
TSS (mg/L)	7
Turbidity (NTU)	1
Total Hardness (mg $CaCO_3$/L)	3.2

PARAMETER[1,2]	W-M2
Dissolved Organic Carbon (DOC)	3.7
Ammonia (as N)	0.02
Nitrite (as N)	0.01
Nitrate (as N)	0.05
Total nitrogen	0.13
Sulfate	1.8
Chloride	4.2
Silicon dioxide	1.9
Aluminium	0.15
Arsenic	0.001
Boron	0.15
Cadmium	0.0001
Calcium	0.5
Chromium	0.001
Cobalt	0.0004
Copper	0.001
Iron	0.15
Lead	0.0002
Magnesium	0.5
Manganese	0.01
Mercury	0.00025
Nickel	0.0006
Potassium	0.29
Selenium	0.0025
Sodium	2.66
Thallium	0.0004
Tin	0.00025
Zinc	0.005

1. *Units reported in mg/L unless otherwise noted*
2. *Dissolved concentrations are reported*

Further details on the W-M2 site are provided in MWM (2026l).

5.2 Mount Frederick South Background Water Quality

Surface water data within Deep Stream (SW01) are provided in Table 7, which is used as the source term for the MFS sub-area catchment.

Table 7: Surface water quality source terms for MFS.

PARAMETER[1, 2]	SW01
DATA CONFIDENCE	
Max Number of Samples	6
Monitoring Period	06/2024 to 12/2024
MEAN CONCENTRATION	
pH	5.9
EC (mS/m)	3.1

PARAMETER[1, 2]	SW01
Acidity (mg $CaCO_3$/L)	3.6
Alkalinity (mg $CaCO_3$/L)	1.0
TSS	2.9
TDS	17.7
Turbidity (NTU)	0.3
Dissolved Organic Carbon (DOC)	2.5
Ammonia (as N)	0.026
Nitrite (as N)	0.005
Nitrate (as N)	0.021
Total nitrogen	0.074
Sulfate	4.0
Chloride	3.33
Silicon dioxide	3.9
Aluminium	0.09
Antimony	0.0005
Arsenic	0.0005
Boron	0.01
Cadmium	0.0001
Calcium	0.90
Chromium	0.0005
Cobalt	0.00025
Copper	0.00025
Iron	0.06
Lead	0.00025
Magnesium	1.00
Manganese	0.002
Mercury	0.00025
Nickel	0.0005
Potassium	0.32
Selenium	0.0025
Sodium	2.63
Thallium	0.00025
Tin	0.00025
Zinc	0.0020
Iron + Manganese	0.24

1. *Units reported in mg/L unless otherwise noted*
2. *Dissolved concentrations are reported*
3. *No Sonde data used – although these data are available for SW01.*

5.3 Upper Waimangaroa Haul Road Water Quality

Surface water source terms for the proposed compliance monitoring location Smokestack (2W) have been defined using the mean concentration from 2025 monitoring records. The source terms for Smokestack are provided in Table 12 and mean data are used.

Table 8: Water quality data from site 2W (Smokestack).

PARAMETER[1, 2]	Smokestack (2W)
DATA CONFIDENCE	
Max Number of Samples	3
Monitoring Period	10/04/2025 to 02/05/2025
MEAN CONCENTRATION	
pH	5.4
Conductivity (mS/m)	7.2
Acidity to pH 8.3 (mg $CaCO_3$/L)	7.7
Total Alkalinity (mg $CaCO_3$/L)	0.5
Hardness (mg $CaCO_3$/L)	19.3
TSS	3.2
TDS	45.0
Turbidity (NTU)	1.6
Dissolved Organic Carbon (DOC)	2.1
Nitrite (as N)	0.005
Nitrate (as N)	0.005
Sulfate	21.9
Chloride	3.6
Silica	5.8
Aluminium	0.35
Antimony	0.0005
Arsenic	0.0005
Boron	0.0025
Cadmium	0.0001
Calcium	4.9
Chromium	0.0005
Cobalt	0.0062
Copper	0.00025
Iron	0.035
Lead	0.00025
Magnesium	1.74
Manganese	0.14
Mercury	0.00025
Nickel	0.0070
Potassium	1.0
Selenium	0.0025
Sodium	0
Thallium	0.00025
Tin	0.00025
Zinc	0.023

[1] Units reported in mg/L unless otherwise noted

[2] dissolved concentrations

5.4 Groundwater

Groundwater is implicitly included within the WLBM through the use of background surface water quality data for streams (just like rainfall water quality) within the sub-areas. Derivation of groundwater source terms is therefore not required.

5.5 Assumptions

The following assumptions are presented for the source term for the background streams:

- It is assumed that the average water quality data provides a reasonable dataset to create a source term for the sub-area for non-impacted catchments (TSS excluded). Average data are commonly used for background streams where variance is minor compared to the potential effects from PCOC derived from AMD. Higher flows may not be represented fairly.
- TSS source term water quality data needs to be adjusted for different flow regimes. This is discussed further in Section 9.
- Average data may underestimate dissolved organic carbon (DOC) during higher flow events where DOC is flushed from soils to streams and overestimate PCOC during high flow events where dilution effects are not incorporated. Higher flows may not be represented fairly.
- It is assumed that SW01 data are suitable as the source term for the MFS sub-area catchment as this is one of the proposed compliance monitoring locations. This source term is applied to all unimpacted surfaces in the model.
- It is assumed that W-M2 data are suitable as the source term for the ESE sub-area catchment. W-M2 data is the most comprehensive dataset for the area and is applied to compliance monitoring location KEL. This source term is applied to all unimpacted surfaces in the catchment and is used for rehabilitated surfaces.
- It is assumed 2W (Smokestack) is a suitable dataset to generate a source term for the UWHR sub-area catchment being the proposed compliance monitoring location.
- It is noted that the data in this section does not include the full dataset that is used in the WLBM due to ongoing sampling. Refer to MWM (2026l) for full datasets for W-M2, SW01, and 2W.

5.6 Opportunities

Waterways degraded by historic AMD such as the Cascade Creek may be improved by the diversion and / or treatment of mine-impacted water from the catchment and the addition of alkalinity and hardness to the Cascade Stream from MSR. The BPCP may represent an opportunity to improve waterways impacted by historical mining activities (i.e., betterment).

6 SOURCE TERM: ELF TOE SEEPAGE

This section summarises how the source terms for ELF seepage water quality were derived for the BPCP ELFs (as shown in Table 3 and Table 4).

6.1 ELF Seepage Water Quality Phases

Three distinct water quality phases were identified for BPCP ELFs. These phases are based on materials (overburden / rock) movement associated with the Barren Valley ELF and subsequent changes in water quality, which is presented in Figure 5. Further details are provided in MWM (2026i) where:

Phase 1: Construction Phase

- Low PCOC concentrations that increase with an increasing amount of waste rock placement within the ELF and gradual wetting up of the ELF.
- Generally, peak concentrations coincide with maximum material placement.

Phase 2: Stabilisation Phase

- Flow rates are generally stable as the ELF wets up and then flushes stored oxidation products from the waste rock. For the proposed BPCP Project, it is assumed the duration of the Stabilisation Phase for final rehabilitated areas of the ELF also aligns with the duration of the draindown phase (created by the installation of a lower permeability cover system).
- The duration of the stabilisation phase is based on the average height of the ELF and aligns with previous studies of the draindown phase duration for the original Escarpment ELF (e.g., Okane Consultants (2014)).
- Concentrations of PCOC remain stable.
- The majority of stored oxidation products are flushed by the end of the Stabilisation Phase.

Phase 3: Decay Phase

- Phase 3 relates to the decrease in PCOC concentrations from peak concentrations observed in the Stabilisation Phase.
- During this phase, water infiltration rates remain steady, but the rate of solute generation declines (lesser oxidation of sulfides and minor flushing out of stored oxidation products).

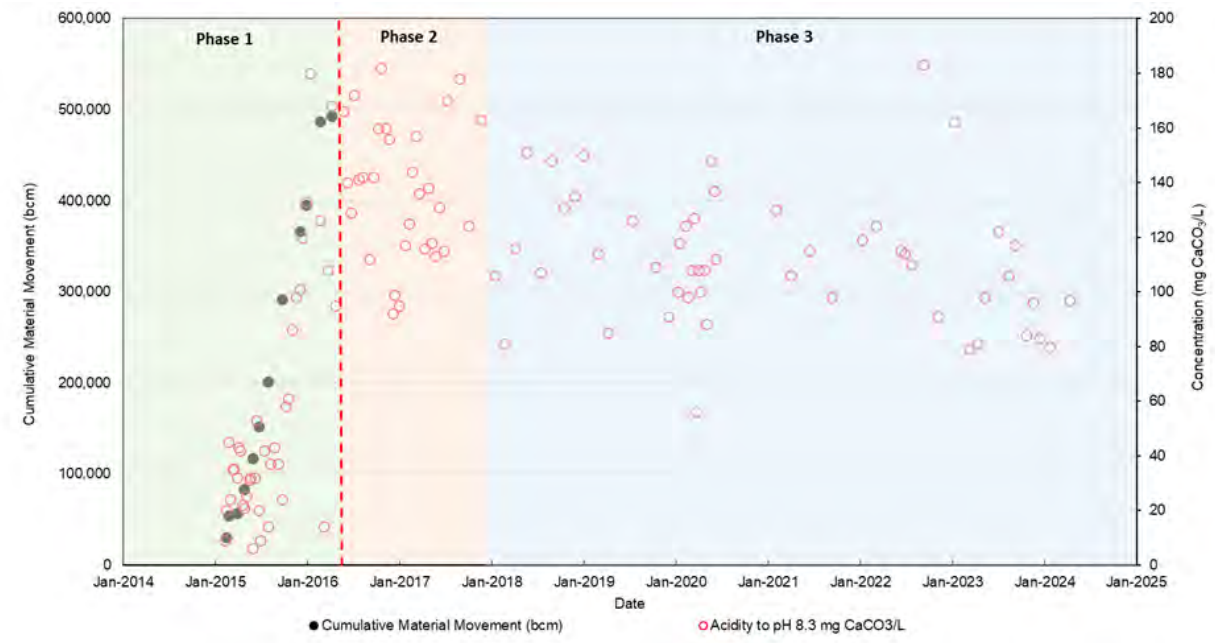


Figure 5: BV ELF acidity concentration data.

Source: BRL 51279_RPT_Water (water quality excel database).

The red line indicates when the BV ELF underdrain flooded in ~ April 2016.

Green shading indicates Phase 1: Construction Phase.

Yellow shading indicates Phase 2: Stabilisation Phase.

Blue shading indicates Phase 3: Decay Phase.

6.2 Derivation of ELF Water Quality

Further details of how the PAF ELF water quality were determined are provided in MWM (2026i) and MWM (2026j).

6.3 NAF ELF Seepage Water Quality

NAF stockpiles are proposed for the BPCP, some of which may be temporary, and some may be left, in part, as final landforms (e.g., NSUL ELF). This section summarises the approach to derive water quality for NAF ELF Seepage. Further details of how the NAF ELF water quality were determined are provided in MWM (2026j).

6.3.1 Adjustments Required for NAF Materials

The source terms for ELFs are provided in MWM (2026j). It is based on the ELF water quality model used to derive water quality (MWM, 2026i) for the key PCOC. However, the approach does not consider circum-neutral drainage water quality from NAF materials. Hence, several adjustments were required to the model using laboratory derived data from column leach tests (MWM, 2026d) to provide reasonable source terms:

<u>The PAF ELF water quality model generates a pH that is too low for NAF materials:</u>

- In the PAF ELF model the pH is derived from pH:acidity relationships. The relationship is not reliable above pH 5.5. Hence an adjustment is needed.

pH uses the average pH obtained from the existing Escarpment Mine Column Leach Test (CLT 7) assessed by Pope et al. (2011) and CRL (2012) of pH 5.81 that had a sulfur content of 0.25 wt% and a NAG[8] pH of 6.8 (MWM, 2026d). It is classified as NAF by the Process Flow Classification Scheme for ESE and MFS sub-areas (MWM, 2026h), although the sulfur content is elevated compared to other BPCP materials, which thus provides a conservative dataset to consider acidity and alkalinity for NAF materials.

The PAF ELF water quality model does not generate alkalinity:

- BV ELF seepage is < pH 4.5 hence there is no alkalinity. NAG materials will have a small amount of alkalinity.
- Average alkalinity for CLT 7 was 6.18 mg $CaCO_3$/L over 15 months; acidity was 11.1 mg $CaCO_3$/L over 15 months; (Pope et al., 2011; CRL, 2012). Alkalinity data of 6.18 mg $CaCO_3$/L and pH of 5.81 was used in the NAF ELF seepage source term.

Acidity needs to be considered for sub-oxic NAF ELFs:

- The construction of sub-oxic dumps will mean Fe will be present in solution. This will contribute to acidity.
- Acidity is assumed to be related to pH and Fe only, with Al being removed from solution due to hydrolysis at pH 5.81 in the model.
- An average aluminium concentration of 0.02 mg/L is used (derived from the average of CLT 7 data) and was applied in the model.

6.3.2 Assumptions and Clarifications for NAF ELF Seepage

The following assumptions are provided on the derivation of this source term:

- Oxidation is still expected in these materials, hence secondary oxidation products are expected (e.g., Cu, Ni, Zn, etc). The concentrations of these metals are based on the ELF water quality model. This is conservative as the release of these metals will be lesser at a higher pH.
- The adjustments to pH, acidity, alkalinity, Fe, and Al are assumed to be reasonable to account for drainage from materials that are non-acid forming.

6.3.3 Model Effects

It is noted that for NAF ELFs, the sulfate and PCOC concentrations scaled from sulfate may be conservative as the data are from a PAF landform (low pH increases reaction/oxidation rates of sulfides) and concentrations may not be comparably elevated

The ELF water quality model generates elevated metals such as Zn, however, given zinc's ubiquitous nature, this may be a reasonable assumption.

[8] *Non Acid Generating*

6.4 Performance Monitoring

Performance monitoring of ELF seepage is recommended once the BPCP commences. Data should be used to validate the model is suitable to determine water management requirements during the operational and closure phases of the BPCP.

6.5 ELF Seepage Source Terms - Summary

Two ELF load models were developed including the stored oxidation product (SOP) load model and the sulfide oxidation (SOX) load model, which were developed using empirical data from the BV ELF and other supplementary data sources to derive:

- Sulfate concentration over the three water quality phases considering two processes:
    - Dissolution of stored oxidation products: This relates to the release of solutes in the short term due to flushing of readily available soluble minerals by net percolation through the ELF. This was assessed using the SOP load model.
    - Oxidation of sulfides: This relates to ongoing generation of sulfate and associated solutes over the long term due to oxygen ingress and the oxidation of sulfide minerals. This was assessed using the SOX load model.
- PCOC concentrations were derived from sulfate relationships, observed in the BV ELF Drainage and other empirical datasets (e.g., Stockton Mine AMD and column leach tests).
- The duration of the Stabilisation Phase is based on the average height of the ELF and aligns with previous studies of the draindown phase duration for the original Escarpment ELF (e.g., Okane Consultants (2015)).
- The Decay Phase is due to:
    - Natural decay of acidity loads due to flushing out of stored oxidation products and decreasing oxidation rates of reactive sulfides.
    - ELF design where rocks > 10 m depth are within a sub-oxic zone and are not generally generating further acidity.
- The load model uses a 9.6% annual decrease per year to align with BV-ELF empirical data before transitioning to a long-term acidity load decay 0.62% per year.

Further details on the model development are contained in MWM (2026i). Application of this model to the BPCP ELFs is provided in MWM (2026j).

7 MINE IMPACTED SURFACES

This section of the report discusses water quality source terms for mine-impacted surfaces. This includes the surfaces as explained in Table 9. TSS is managed separately as discussed in Section 9.

Table 9: Summary of Mine Impacted Surfaces

PROJECT AREA	EXPLANATION	SURFACE AREA	NOTES
Highwall Runoff and Surface Drains: Section 1			
ESE sub-area	Granite Surfaces	ESE6.2	Surface NAPP = 6.9 kg H_2SO_4/t. Uses Cypress Highwall cleanwater runoff data.
	PAF Surfaces	ESE highwalls and drains	0.35 wt% S – average [1]
MFS sub-area	PAF Surfaces	MFS highwalls and drains	0.13 wt% S – average [1]
ESE Borrow Pit	PAF Surfaces	Borrow Pit highwall	0.584 wt% S [1]
	Granite Surfaces	Borrow Pit highwall	Uses Cypress Highwall cleanwater runoff data.
UWHR sub-area	PAF Surfaces	UWHR road cuttings	0.932 wt% S – average [2]
Active Pits: Section 7.2			
All	Active Pits + highwalls + Active ELF running surfaces	Active pit voids + ELF surfaces	Operational water quality
	Active Pits + highwalls + Active ELF running surfaces	Active pit voids + ELF surfaces	Spill water quality (diluted)
Coal Floor - Closure: Section 7.3			
ESE sub-area	PAF Surfaces	CON, WWH	0.23 and 0.26 wt% S [1]
	NAF Surfaces	ESC	0.04 wt% S [1]
MFS sub-area	PAF Surfaces	CF2, CF4, CF5	0.906, 0.151, 0.157 wt% S [1]
	What goes here, NAF?	CF1, CF3	0.113, 0.084 wt% S [1]
ELF Surfaces: Section 7.4			
All	NAF Cover	ELF cover	NAF Column Leach test data
	Rehabilitated	Rehab surfaces	Background water quality
Hardstand surfaces: Section 7.5			
All	PAF		WWH Coal floor runoff (ESE) – 0.26 wt% S [1]
	NAF		CF3 runoff (MFS) – 0.084 wt% S [1]

1. *Sulfur data provided by BRL from the BRL ABA database*
2. *Average sulfur data from the UWHR Site visit (MWM, 2026a).*

7.1 Highwall Run-off and Surface Drains

Source terms are required for highwalls and surface drains to understand the effects of PAF and NAF surfaces and the contribution of these surfaces to contaminant loads. Source terms are required for:

- Granite materials (NAF).
- PAF materials associated with Brunner Coal Measures.

7.1.1 Source Term - Granite Highwall Runoff

Data are available for runoff from the Cypress highwall (Figure 6) that is dominated by granite to generate a source term for modelling. Samples were obtained from the Cleanwater Diversion Drain, which included runoff from the natural catchment above the highwall and also the highwall surface. This is comparable to what will occur above the ESE6.2 highwall, hence it is considered a suitable analogue to provide empirical data for modelling. A constant concentration model was developed using average data (Table 10).

Part of the ESE pit void is cut into Berlins Quartz Porphyry (granite), with a final granite highwall left at closure. This is identified as Highwall ESE6.2 in Table 12 and Figure 10. ABA data (Table 12) indicates that the granite highwall ESE 6.2 is NAF with a net acid producing potential (NAPP) of -6.9 kg H_2SO_4/t.

Table 10: Source term for ESE6.2 highwall (derived from the Cypress Highwall dataset).

PARAMETER	UNIT	COUNT OF RECORDS	SOURCE TERM
pH	pH unit	89	6.0
Acidity (to pH 7.0)	mg/L $CaCO_3$	64	1.1
Alkalinity	mg/L $CaCO_3$	20	41
Ca	mg/L	5	33.2
Mg	mg/L	5	2.2
Na	mg/L	5	4.65
K	mg/L	5	1.2
SO_4	mg/L	78	27.6
Al	mg/L	79	0.33
Fe	mg/L	79	0.402
Ni	mg/L	5	0.0025
Mn	mg/L	5	0.072
Cr	mg/L	5	0.00032
Cd	mg/L	5	0.00008
Co	mg/L	5	0.00084
Cu	mg/L	5	0.00075
Pb	mg/L	5	0.0025
Tl	mg/L	2	0.00025
Zn	mg/L	5	0.00395
TSS	mg/L	78	4.6
DOC	mg/L		n/a

Note: The values presented in the table are the average of highwall runoff water quality data from June 2022 to April 2025 (n = 89). pH based on average [H^+].

Figure 6: Cypress Pit and the Cypress Pit highwall, cut into the Mount William granite.

7.1.2 Background: Dilution through Increased flow

Generally, with increasing flow rates there is a decreasing concentration for surface domains (e.g., highwalls, hardstand areas, coal floor surfaces) due to dilution by rainfall. This has been observed previously (Weber et al., 2015) for the St Patricks Stream, Stockton Coal Mine (Figure 7) where the decrease in acidity concentration with increasing flow is due to dilution of AMD sources (e.g., waste rock dump toe seepage; mine impacted surfaces) by surface runoff.

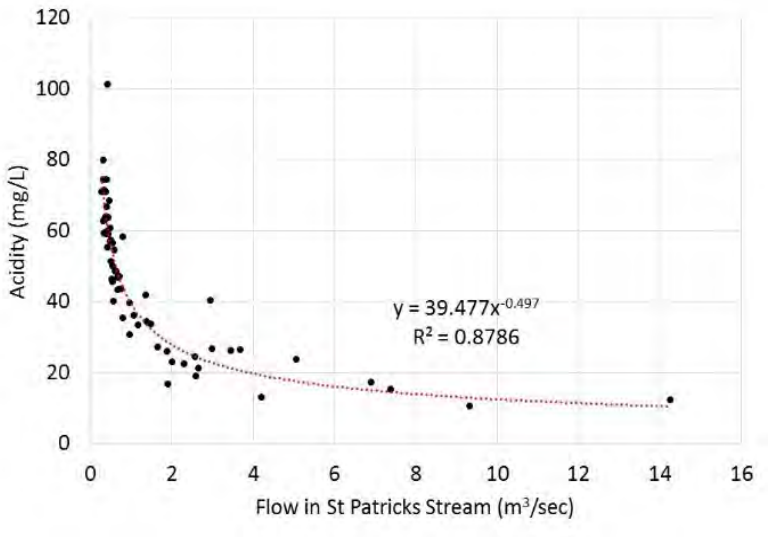


Figure 7: Flow versus acidity – St Patricks Stream (S16), Stockton Coal Mine

Source: Weber et al., 2015

Hence dilution of surface domains influenced by rainfall is required in the model to ensure the model provides reasonable data and is not overly conservative at higher flows. This was done by developing a constant contaminant load (kg/ha/day) based on empirical data, which is therefore diluted by higher rainfall events.

7.1.3 Run-off from Brunner Coal Measures and Kaiata Mudstone Highwalls

Source terms are needed for PAF highwalls and other surfaces such as excavated drains to generate a term that is responsive to rainfall generating higher concentrations in lower rainfall periods and lower concentrations in high rainfall periods. To develop source terms for the WLBM, a PCOC load model approach was developed based on PCOC loads generated per unit time (i.e., kg/ha/day) to align with the daily time steps of the WLBM.

BRL (and its predecessor Solid Energy) have been collecting runoff water quality data from highwalls for a number of years. Other data are available from Pope et al. (2018a,b) and this has been provided for the Grand Canyon sampling location (Figure 8). These data are presented in Table 11.

Table 11: PAF surface domain acidity loads

DOMAIN	LITH.	APPROX. AGE (yrs)	SO_4 (mg/L)	ACIDITY (mg/L)	ACIDITY LOAD (t/ha/yr)	RELIAB. [2]	REF
Roadside Ditch (Site 3) - UWHR	BCM	>20	17.2	15	9.5 [1]	Low	MWM (2026a)
Mount Frederick Ribs – Stockton	BCM	-	23	19	-	-	BRL (2024)
Mount Frederick Coal Floor Top – Stockton	BCM	-	2.3		-	-	BRL (2024)
A13 Pond – Stockton	BCM	-	3.4	<5	-	-	BRL (2024)
Cypress North Box Cut – Cypress Mine [4]	KMS	~2		Average: 93 (10-220)	9.2	Med	BRL (2018)
Grand Canyon – access road to Stockton (Sites MRC1, MRC2, MRC3) [3]	BCM	1-2		Average: 22 (10-40)	Average: 13.1 (12.3-19.2)	High	Mackenzie (2008)
Grand Canyon – access road to Stockton [4]	BCM	12		Average: 40 (17-73)	1.3	High	BRL (2018)
Grand Canyon – access road to Stockton (Site MRC5)	KMS	1-2		Average: 15 (10-20)	7.2	High	Mackenzie (2008)
Grand Canyon – access road to Stockton [4]	KMS	12		9	0.8	High	BRL (2018)
Grand Canyon – access road to Stockton [4]	BCM	10		Average: 76 (1 - 199			Pope et al. (2018a,b)
Grand Canyon – MRC3 [5]	BCM	2		40	4.02	High	Mackenzie (2008)
Fly Creek Quarry – access road to Stockton [4]	KMS	20-40		Average: 41 (20-80)	2.3	Med	BRL (2018)

BCM = Brunner Coal Measures; KMS = Kaiata Mudstone. Numbers in brackets represent acidity range.

1. *Based on a flow rate of ~ 1 L/s and a catchment area of 500 m^2.*
2. *Reliability (RELIAB) is based on professional judgement of Dr Paul Weber (who was involved in the 2008 study) as to its applicability to a load model. Noting that whilst wall wash data are accurate, the results do not provide an average result for a catchment.*
3. *Site MRC4: – up dip location. Generally, low flow rates (BRL (2018) report 0.09 L/s compared to the downdip (south side of the road) of 0.64 L/s. Mackenzie (2008) reported acidities of 150-360 mg/L (annual acidity loads of 16 – 388 t/ha/yr)*
4. *Wall wash data*
5. *Data from 10 January 2008.*
6. *Data shown in red are used for modelling purposes as a reasonable representation of acidity load at closure of the pit.*

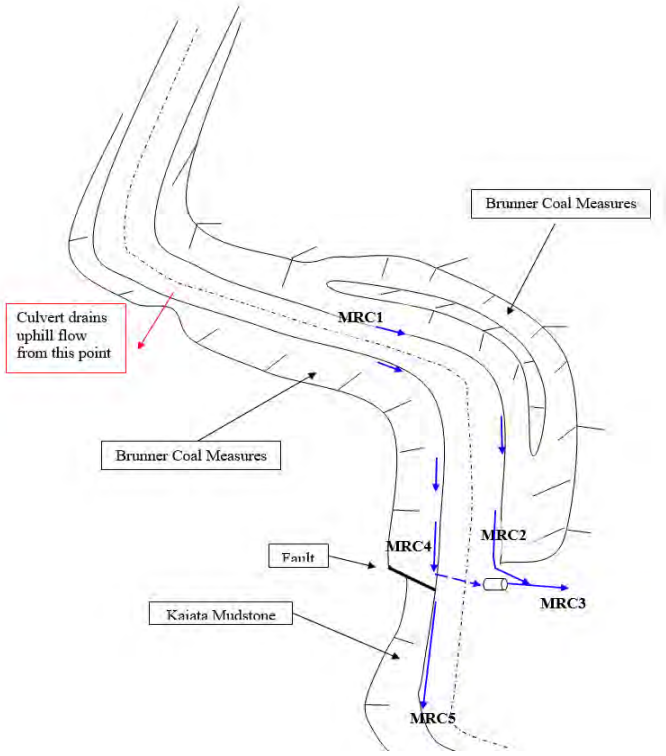


Figure 8: Grand Canyon (Millerton Road Cutting) water sampling locations

Source: Mackenzie (2008)

Data were available for monitoring site MRC3 from the BCM within the Grand Canyon (Mackenzie, 2008) that had a measured flow of 3 L/s; a pH of 3.08; an acidity of 40 mg $CaCO_3$/L; a catchment area of 0.94 ha, which generated an annual acidity load of 4.02 t/ha/yr (assuming constant flow). This dataset (highlighted red in Table 11) was considered the most reasonable to use to derive the source term for PAF highwalls for the following reasons:

- Cleary defined catchment area.
- Accurate flow rates.
- Multi-decade sampling program.
- Higher sulfur materials (providing a conservative approach), which were reported as an MPA of 57.3 kg H_2SO_4/t for the BCM (i.e., 1.87 wt% S) by Mackenzie (2008).
- MRC3 included flows within a drain from both sides of the road, which therefore includes up-dip and down-dip surfaces (e.g., average data) and a potential difference in acidities
- An acidity load of 4.02 t/ha/yr is approximately mid-way between fresh surfaces (15.2 t/ha/yr) and surfaces that are ~10 years old (1.3 t/ha/yr) as shown in Table 13.
- Flow rates were low, so it is assumed that measurements into a 20 L container are more reliable and would be reflective of dryer conditions.
- The data provided by Mackenzie (2008) was from a well-mapped catchment area.
- Prolonged dry conditions are infrequent in the BPCP area, so the accumulation of significant stored oxidation products is unlikely (noting performance monitoring needs to validate this).

An average acidity concentration of 40 mg $CaCO_3$/L was used to derive the source term for highwalls and drains. This is comparable to the acidity concentrations measured by Pope et al. (2018a,b) who reported calculated acidities of 1 – 199 mg $CaCO_3$/L and an average of 76 mg $CaCO_3$/L for the Grand Canyon surfaces (~10 years old). Noting the Pope et al. (2018a,b) data are discrete wall wash data (~ equivalent to a 2-3 mm [9] rainfall event) and the Mackenzie (2008) data are for both up-dip and down-dip surfaces (catchment scale runoff).

7.1.4 Source Term Derivation for Surfaces – PAF Materials

The acidity data provided by Mackenzie (2008) did not include results for other water quality parameters. Hence runoff data from the Upper Waimangaroa Haul Road (Site 3: Figure 9) having a sulfate concentration of 17.2 mg/L and an acidity of 15 mg $CaCO_3$/L was used to derive a source term for PAF surface water quality (MWM, 2026a). Site 3 was selected for the following reasons:

- Drainage was from a relatively clean BCM surface exposure (Figure 9).
- BCM in this area has an average sulfur content of 0.932 wt% S (MWM, 2026a), which is closer to the Grand Canyon sulfur (i.e., 1.87 wt%) than other parts of the BPCP.
- Runoff was from a PAF catchment that was not affected by seepage from waste rock, which would bias results to higher concentrations of metals.
- pH was 3.8 so introduced a modest amount of Fe and Al into solution
- The water quality data for Site 3 was also elevated in trace metals such as Co, Cu, and Zn which are key PCOC for the project. Data are presented in Table 14.
- Sulfate and acidity were comparable suggesting minimal neutralisation of acidity.

Site 3: Sampling location
(ABA[1] + Water)

Site 3: Upper catchment
(road cutting and very minor fill)

Figure 9: Site 3 – UWHR

Source (MWM, 2026a).

1. -ABA = Acid base accounting

[9] *Variable as a function of the highwall overall angle*

The approach to derive an acidity load included:

- The raw water quality data for Site 3 was increased by a factor of 2.67 to account for the higher acidities (40 mg/L $CaCO_3$/L) measured at site MRC3 in the Grand Canyon compared to site 3 (15 mg/L $CaCO_3$/L) to generate a water quality source term for site MRC3.
- MRC3 data were then converted into kg/ha/yr based on the flow rate (3 L/s) and catchment area for MRC3 of 9,415 m^2 provided by Mackenzie (2008). These data are provided in Table 13.
- The load data were then used to derive the average PCOC loads (kg/ha/day) for other PAF surfaces associated with the BPCP areas based on the sulfur content ratio for materials within the sub-areas (Table 14):
    - ESE: Average sulfur of 0.35 wt% based on material properties and quantities provided by BRL (Section 1.3)
    - MFS: Average sulfur of 0.13 wt% based on material properties and quantities provided by BRL (Section 1.3)
    - Upper Waimangaroa Haul Road sulfur content of 0.932 wt% (MWM, 2026a).
    - ESE Borrow Pit BCM PAF materials average sulfur of 0.584 wt% [10]

Sulfur content is a key driver of AMD. Hence multiplication by the sulfur content ratio acknowledges this risk and ensures other geochemical processes are implicitly included in the scaling (e.g., acidity and trace metals).

Acid Base Accounting (ABA) data were available in the block model for final ESE highwall surfaces (Figure 10). A load was developed for these surfaces based on the sulfur content (kg/ha/day). These data are shown in Table 14. One highwall at ESE (ESE6.2) is granite, has a negative NAPP, and has a moderate ANC compared ot the other highwall surfaces that are PAF. As discussed in Section 7.1.2 the source term is based on analogue data from the Cypress Mine.

Table 12: ESE Highwall Sulfur Content

EXPOSED HIGHWALL NAME (CLOSURE)	SURFACE AREA (m^2)	S (wt%)	ANC (kg H_2SO_4/t)	NAPP (kg H_2SO_4/t)
ESE2.1	62,519	0.21	4.91	1.5
ESE2.2	90,922	0.20	5.36	0.8
ESE5	12,439	0.32	0.23	9.6
ESE6.1	21,949	0.49	2.59	12.4
ESE6.2	117,063	0.19	12.78	-6.9
ESE6.3	52,928	0.34	2.84	7.6
ESE9	30,594	0.33	6.35	3.7

1. *Data provided by BRL*
2. *Green cells indicate a Granite (NAF) highwall surface*

[redacted]

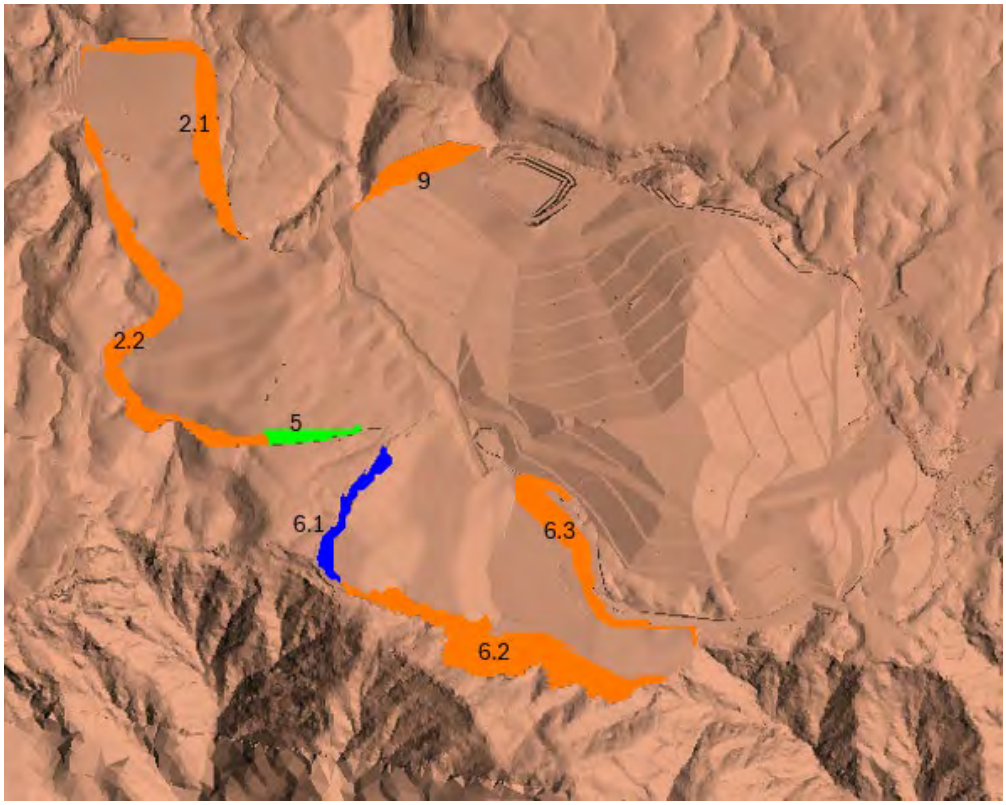


Figure 10: ESE closure highwall (Year 13).

Note: Colour coding of highwalls is used to delineate different adjoining highwalls for visual clarity. Names relate to catchment area.

The current waste rock block model required further development to confirm the sulfur content of the various highwalls. For the MFS Model an average sulfur content is used (0.13 wt%), with the conservative assumption all surfaces are PAF.

Table 13: Source terms for highwalls and drains

PARAMETER	Site 3 [3, 4] (mg/L)	GRAND CANYON MRC3 (kg/ha/day)	ESE (kg/ha/day)	MFS (kg/ha/day)	UWH ROAD[1] (kg/ha/day)	ESE BORROW PIT PAF SURFACES (kg/ha/day)
Average wt% S	-	1.87	0.35	0.13	0.932	0.584
pH[2]	3.8	-	-	-	-	
Acidity to pH 8.3	15	11.01	2.06	0.76	5.48	3.44
Chloride	3.57	2.62	0.49	0.18	1.30	0.82
Sulfate	17.2	12.63	2.36	0.88	6.28	3.94
Aluminium	0.844	0.62	0.12	0.04	0.31	0.19
Antimony	<0.001	0.0004	0.00007	0.00003	0.00018	0.00011
Boron	<0.03	0.0110	0.002	0.001	0.005	0.003
Cadmium	<0.0002	0.0001	0.00001	0.00001	0.00004	0.00002
Calcium	0.3	0.22	0.041	0.015	0.110	0.069
Chromium	<0.001	0.0004	0.00007	0.00003	0.00018	0.00011
Cobalt	0.0012	0.0009	0.00016	0.00006	0.00044	0.00028
Copper	0.0030	0.0022	0.0004	0.0002	0.0011	0.0007
Iron	1.06	0.78	0.15	0.05	0.39	0.24
Lead	0.0007	0.0005	0.00010	0.00004	0.00026	0.00016
Magnesium	0.44	0.32	0.060	0.022	0.161	0.101
Manganese	0.0238	0.0175	0.003	0.001	0.009	0.005
Mercury	<0.0005	0.0002	0.00003	0.00001	0.00009	0.00006
Nickel	0.0058	0.0043	0.001	0.000	0.002	0.0013
Potassium	0.52	0.38	0.07	0.03	0.19	0.12
Selenium	<0.005	0.0018	0.0003	0.0001	0.0009	0.0006
Sodium	3.05	2.24	0.419	0.155	1.114	0.70
Tin	<0.0005	0.0002	0.00003	0.00001	0.00009	0.00006
Zinc	0.022	0.016	0.003	0.001	0.008	0.005
Silica	4.99	3.66	0.68	0.25	1.82	1.14
Arsenic	<0.001	0.0004	0.00007	0.00003	0.00018	0.00011

PARAMETER	Site 3 [3, 4] (mg/L)	GRAND CANYON MRC3 (kg/ha/day)	ESE (kg/ha/day)	MFS (kg/ha/day)	UWH ROAD[1] (kg/ha/day)	ESE BORROW PIT PAF SURFACES (kg/ha/day)
Thallium	<0.0005	0.0002	0.00003	0.00001	0.00009	0.00006

1 – Upper Waimangaroa Haul Road = which uses the average sulfur for the area as the road cut through multiple lithologies.

2 – pH is not converted into a load due to the complexity of assignment to variable flow rates. A pH of 3.8 has been used for modelling, which is for a high sulfur content (0.932 wt% S) compared to other project areas and is considered conservative.

3 - With the exception of pH (unitless), all concentrations are reported in mg/L

4. - Source: MWM, 2024c.

Red data uses ½ LOR concentrations to determine load.

Table 14: ESE specific source terms for highwalls

PARAMETER	ESE2.1	ESE2.2	ESE5	ESE6.1	ESE6.3	ESE9
Units	(kg/ha/day)	(kg/ha/day)	(kg/ha/day)	(kg/ha/day)	(kg/ha/day)	(kg/ha/day)
Average wt% S	0.21	0.2	0.32	0.49	0.34	0.33
pH[2]	3.8	3.8	3.8	3.8	3.8	3.8
Acidity (as $CaCO_3$)	1.24	1.18	1.88	2.89	2.00	1.94
Ca	0.025	0.024	0.038	0.058	0.040	0.039
Mg	0.036	0.035	0.055	0.085	0.059	0.057
Na	0.251	0.239	0.383	0.587	0.407	0.251
K	0.043	0.041	0.065	0.100	0.069	0.043
SO_4	1.42	1.35	2.16	3.31	2.30	1.42
Al	0.070	0.066	0.106	0.162	0.113	0.070
Fe	0.087	0.083	0.133	0.204	0.141	0.087
Ni	0.00048	0.00046	0.00074	0.00113	0.00078	0.00048
Mn	0.0020	0.0019	0.0030	0.0046	0.0032	0.0020
Cr	0.000045	0.000043	0.000068	0.000105	0.000073	0.000045
Cd	0.000011	0.000011	0.000017	0.000026	0.000018	0.000011
Co	0.00010	0.00010	0.00015	0.00024	0.00016	0.00010
Cu	0.00025	0.00024	0.00038	0.00058	0.00040	0.00025
Pb	0.00006	0.00005	0.00009	0.00013	0.00009	0.00006
Tl	0.00002	0.00002	0.00003	0.00005	0.00004	0.00002
Zn	0.0018	0.0017	0.0028	0.0042	0.0029	0.0018
DOC	0	0	0	0	0	0

1, - pH is not converted into a load due to the complexity of assignment to variable flow rates. A pH of 3.8 has been used for modelling, which is for a high sulfur content (0.932 wt% S) compared to other project areas and is considered conservative.

Highwall ESE6.2 is not included as the surface is granite and represented by the source term for granite highwall runoff (see Section 7.1.1)

The PCOC load (kg/ha/day) is then applied on a daily basis to the rainfall to that surface to derive the water quality (mg/L). Higher rainfall generates lower concentrations. The relationship between daily rainfall and acidity (mg $CaCO_3$/L) of related runoff in the WLBM is shown in Figure 11 demonstrating that dilution in higher rainfall events occurs in the model, and conversely low rainfall events generate higher acidities.

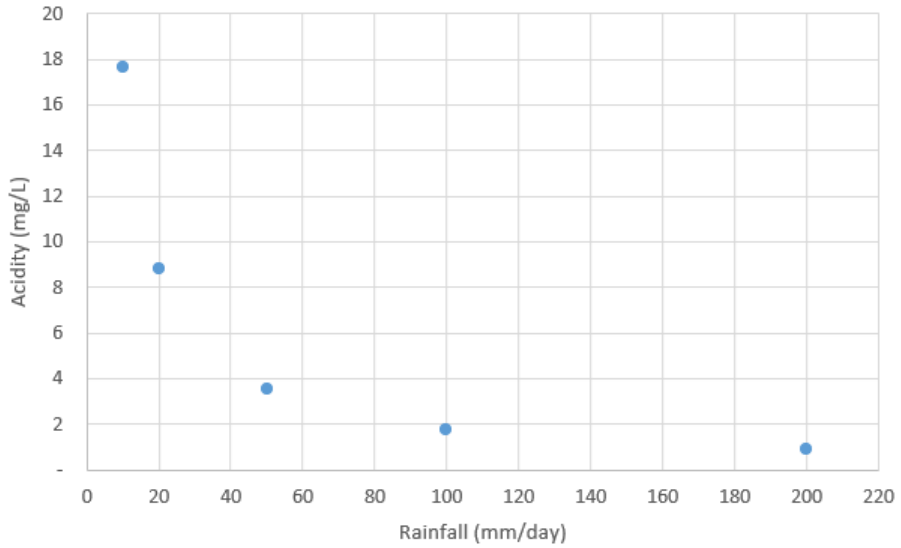


Figure 11: Daily rainfall events versus acidity (mg $CaCO_3$/L) for highwall and drain surfaces.

Based on a catchment sulfur content of 0.3 wt%.

7.1.5 Decay of acidity and PCOC – PAF Surfaces

As shown in Table 11 acidity loads for the BCM have decreased to 1.3 t/ha/yr after 10 years (BRL, 2018). To account for a long-term decrease in acidity loads, the data presented by Pope et al. (2018) has been utilised for highwall surfaces (Figure 12). This is applied at the end of mine life to all PAF surfaces for all PCOC as shown in Table 13 and Table 14.

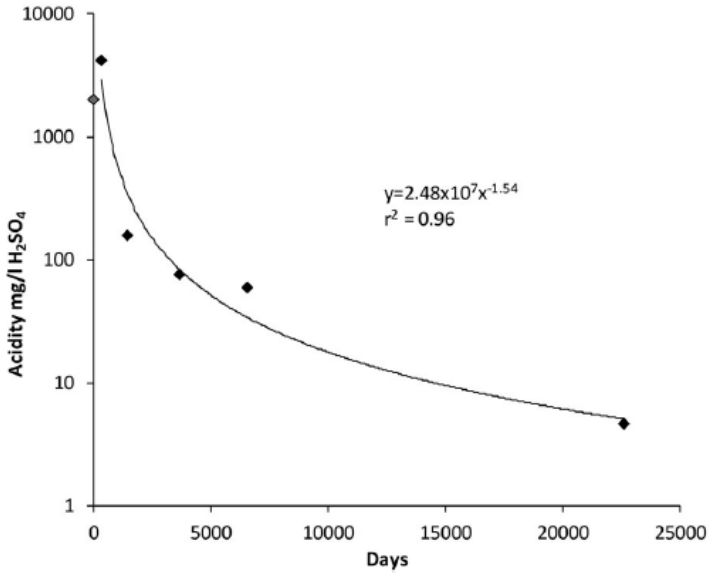


Figure 12: Average acidity data for highwall surfaces versus time, fitted with a power trendline.

Source: Pope et al. (2018a) for surfaces ranging in age from 1 to 62 years.

The equation provided by Pope et al. (2018) is a power trend that fits the observed data well overall but becomes unrealistic for the first ~12 months. As days approach zero, the equation predicts values that tend towards infinity, which is not meaningful from a load balance perspective. To address this, a second order decay equation was defined allowing an initial rapid decay (i.e., the decay rates also decays over time (at a constant rate) represented by the red line in Figure 13). This provides a reasonable fit to the empirical data derived by Pope et al. (2018) and is used in the WLBM however it underestimates decrease with time compared to Pope et al. (2018) and is thus conservative.

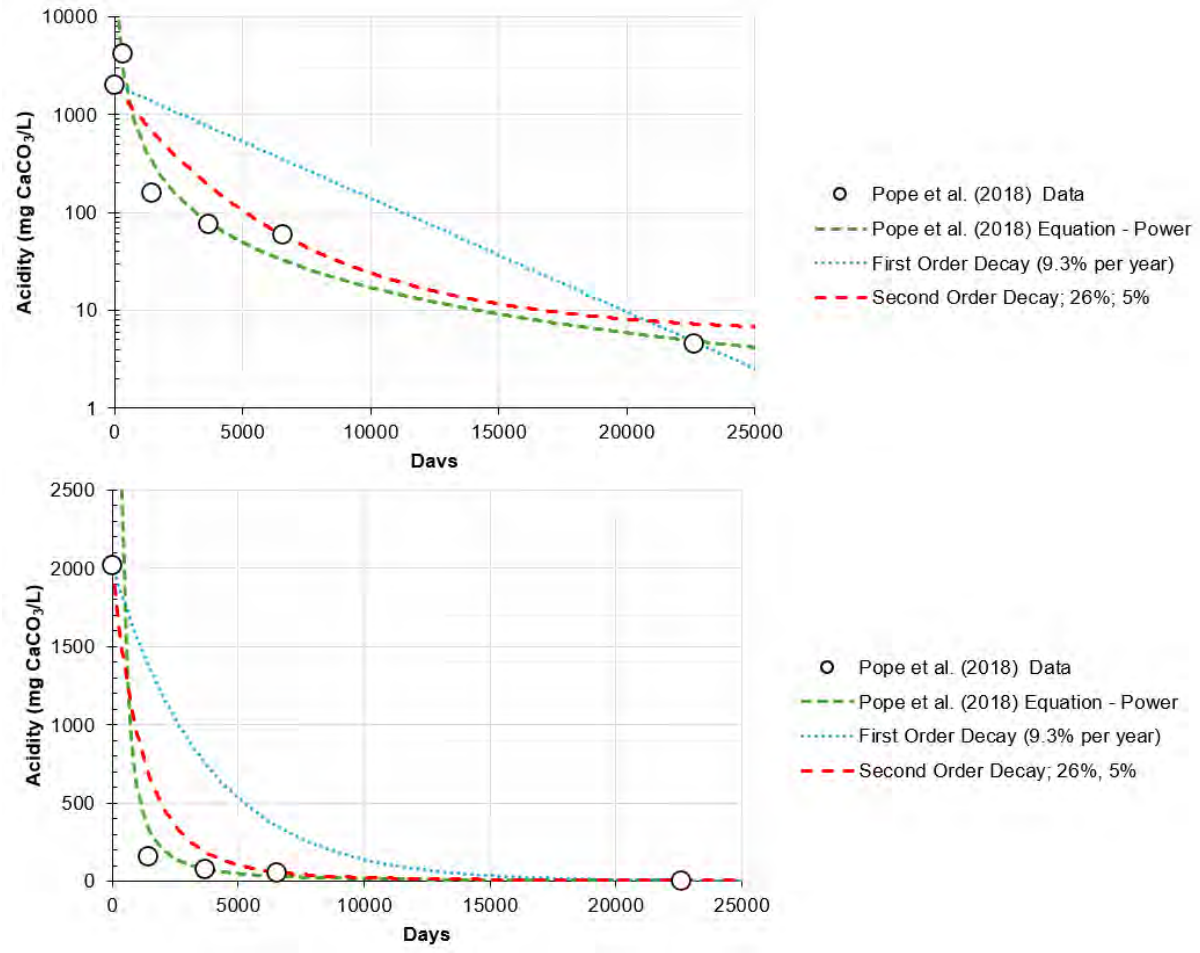


Figure 13: Derived decay rate for highwalls

The long term highwall load decay is modelled using the following process:

Highwall contaminant loads are assumed to be constant (at the rates derived in Table 13 and Table 14) through the operational phase to end of mine life.

- Long term load decay assumes the previous constant concentration as the “initial load”. The process of decaying commences with a rapid decay rate of 26% per year.
- Unlike a simple decay model (first-order decay) where this rate would be constant, this model includes a factor that reduces the decay rate itself by 5% each year.
- This results in a curve that shows a steep, rapid decline in concentration at the beginning, which then gradually levels off over the long-term.

The equation used can be written as:

$$C\ (t) = C_0 \exp\left(\frac{F1}{F2}(1 - \exp(F2 * t)\right)$$

Where:

C(t) = Concentration at year t

C_0 = Initial concentration (prior to decay)

F1 = ln (1-0.26) (represents a 26% yearly decay)

F2 = ln (1-0.05) (represents a 5% yearly decay applied to the 26%)

t = time in years

7.1.5.1 ESE Borrow Pit

The ESE Borrow Pit will be established to provide granite for infrastructure areas. It will be operational throughout the BPCP mine life and at closure will be rehabilitated to form a waterbody. Surficial BCM materials need to be mined to access the underlying granite basement. At closure there will be PAF and granite surfaces exposed above the final water level. Average sulfur content for the BCM is 0.584 wt%.

Two source terms have been used for the WLBM:

- 3.56 ha of granite highwall runoff (mg/L) – as shown in Table 10.
- 1.78 ha of BCM (PAF) highwall runoff using 0.584 wt% S to derive loads (kg/ha/day) – as shown in Table 11.

During operations the ESE Borrow Pit sump will pump to the water treatment plant. The source term will include 1.78 ha of PAF water runoff, and the remainder of the surface area (e.g., the difference) will be assigned granite highwall water quality run-off.

7.1.6 Assumptions

The following assumptions are provided for the derivation of the source terms for highwalls:

- It is assumed that the Grand Canyon PAF BCM data is suitable empirical data, coupled with BCM runoff data from the UWHR to derive the water quality for highwalls and drains. Noting the dataset used includes the Grand Canyon load from both up-dip and down-dip surfaces to provide an average value and hence a more reliable number.
- It is assumed that the water sample from Site 3, on the proposed Upper Waimangaroa Haul Road is appropriate to scale relationship from acidity / sulfate to other PCOC. The ratio of acidity (15 mg $CaCO_3$/L) to sulfate (17.2 mg/L) is close to 1:1, indicating little neutralisation of sulfide derived acidity. It is assumed that scaling, based on sulfur content will address the AMD risk for these PAF highwall surfaces.
- It is assumed that an average sulfur value is suitable for each of the Project areas to derive run-off from highwalls and drains that are likely to be a mixture of PAF and NAF material types.

BRL have provided average sulfur content for the ESE highwalls as shown in Table 15 and Figure 10. Data suggest they are not too dissimilar to the average of 0.35 wt% S.

- The WLBM assumes the PCOC load for highwalls is only available each day and does not accumulate. In very low flow conditions (i.e., very low rainfall) the model can generate very high concentrations. Noting that the daily load remains the same.
- It is assumed the work completed by Pope et al. (2018a) is suitable to derive the long-term decrease in acidity and PCOC from PAF surfaces such as highwalls and drains even though sulfur content varies for the data presented. This is considered reasonable as the data were collected from exposed highwall sites located near the BPCP (similar climate and weathering conditions) and the same lithologies.
- The model is scaled from the Grand Canyon data using an acidity of 40 mg $CaCO_3$/L. Data from Pope et al. (2018a) suggests that acidity (average) from such surfaces (~ 10 years old) could be 76 mg $CaCO_3$/L (equivalent to a 2-3 mm rainfall event). However, the Mackenzie (2018) is based on a total catchment approach to generate a load, which is a more representative dataset. Other data from BRL (2018) as shown in Table 11 suggest acidities are 9 mg $CaCO_3$/L (after 12 years). There remains uncertainty in the data and hence 40 $CaCO_3$/L is used as a reasonable estimate, mid-way between these datapoints. This may overestimate long term loads, however due to relaxation of materials and fretting (providing additional surface area for oxidation of sulfides) it is assumed to be reasonable. Noting that if 76 mg $CaCO_3$/L (after 10 years) is plotted on Figure 13, it is in reasonable agreement with the model, so any error is considered acceptable.
- Water quality for granite highwalls with natural catchment above the wall is based on average concentration data (mg/L) and does not consider higher rainfall effects (e.g., dilution). Further work is required to improve this source term for higher flow events.

7.1.7 Model Effects

A decrease in acidity load for PAF highwalls is applied at the end of mining. Hence, the highwall run-off model may over-estimate water quality at closure as the surfaces may have been ageing for a number of years prior to the acidity decay rate (Pope et al., 2018a,b) commencing.

7.1.8 Performance Monitoring

The following performance monitoring is recommended to validate the source term for highwalls and surface drains:

- Further monitoring of drainage from surfaces that are only influenced by surface runoff is recommended to ensure the model is accurate.
- Monitoring of such surfaces to improve confidence in the data for wetter periods and dryer periods.

7.2 Active Pits

Active pits are likely to be a significant source of contaminants due to the blasting and exposure of overburden and acid-forming materials, generating a large reactive surface area on a regular basis.

7.2.1 Methodology

Data from Pit 3 at the existing Escarpment mine were used to derive source terms for active pits that will be developed at the proposed MFS and ESE sub-areas, which provides empirical analogue data for the source term. Data was obtained from the early stages of pit lake filling. As shown in Figure 5, the movement of mine materials ceased in early 2016. Water quality monitoring of Pit 3 commenced in February 2016 so provides data on active pit water quality. Two source terms were developed from the Pit 3 water quality before commencement of discharge from the BV-ELF MSR, which influences water quality in the pit:

- 90th%ile data to represent active pit surface runoff water quality (i.e., highly impacted mine water) – low flow conditions.
- Average data to represent significant rainfall periods where pit water is diluted and can be used for active pit surface runoff water quality – high flow conditions.

These data are shown in Figure 14 to Figure 18. Sulfate data shows a steady decrease in concentration following cessation of mining and dilution of the pit by rainfall (noting surface water was directed away from the pit void). Hence the data provide a good analogue for storm events.

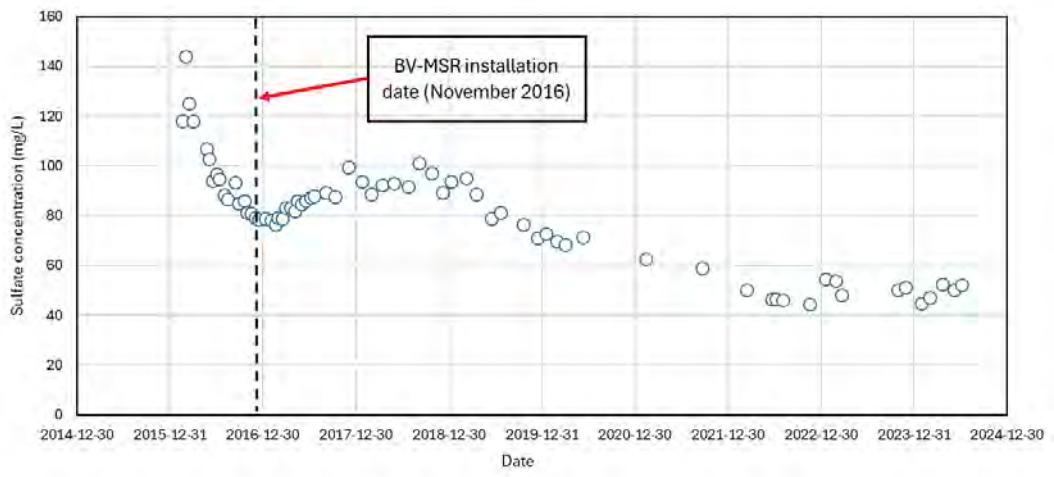


Figure 14: Pit 3 Pit Lake sulfate concentration timeseries.

Note: Sulfate increases after the MSR installation once BV-ELF water is introduced to the Pit 3 Pit Lake.

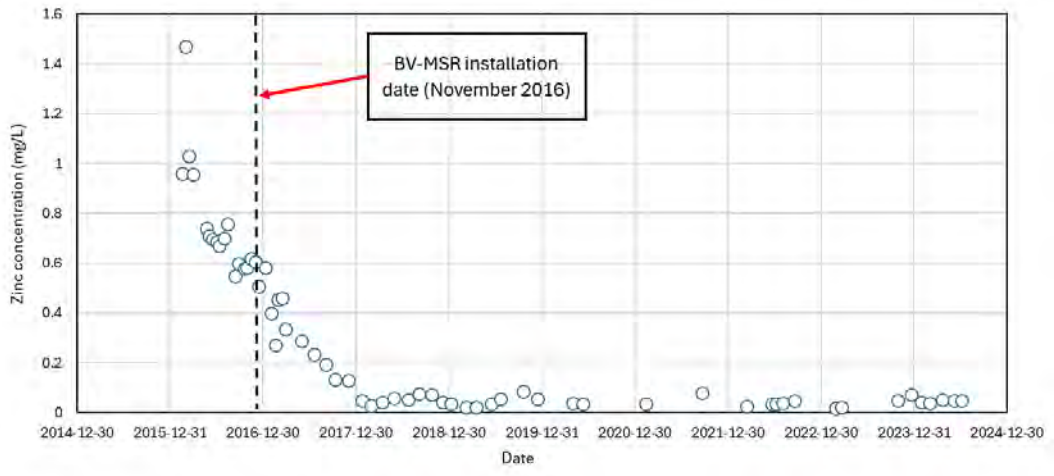


Figure 15: Pit 3 Pit Lake zinc concentration timeseries.

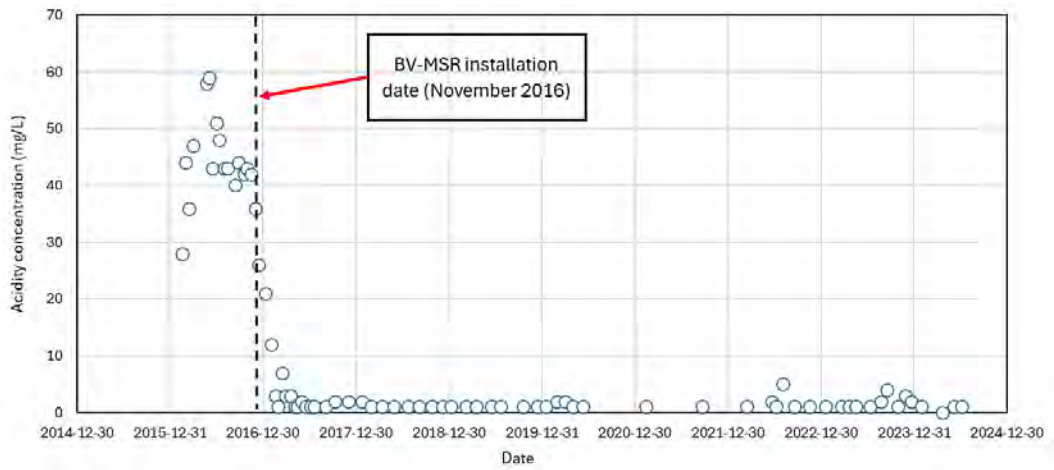


Figure 16: Pit 3 Pit Lake acidity concentration timeseries.

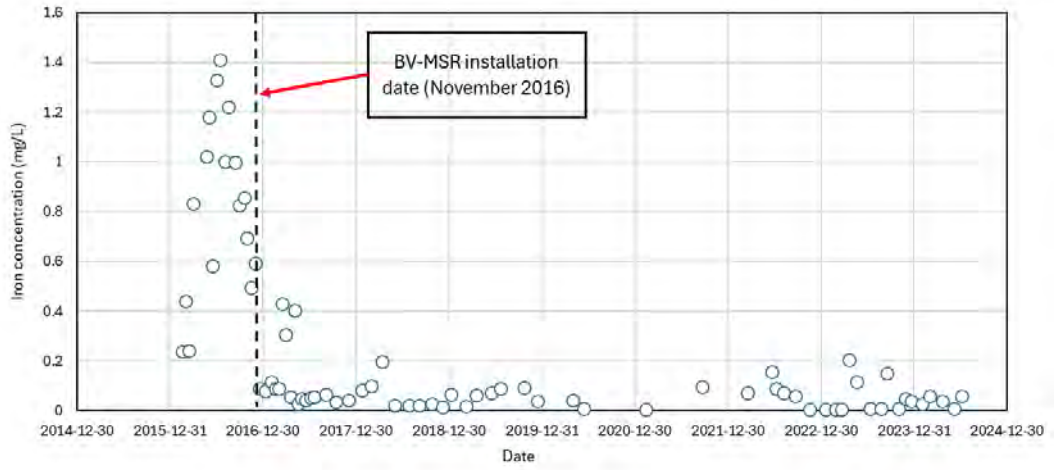


Figure 17: Pit 3 Pit Lake iron concentration timeseries.

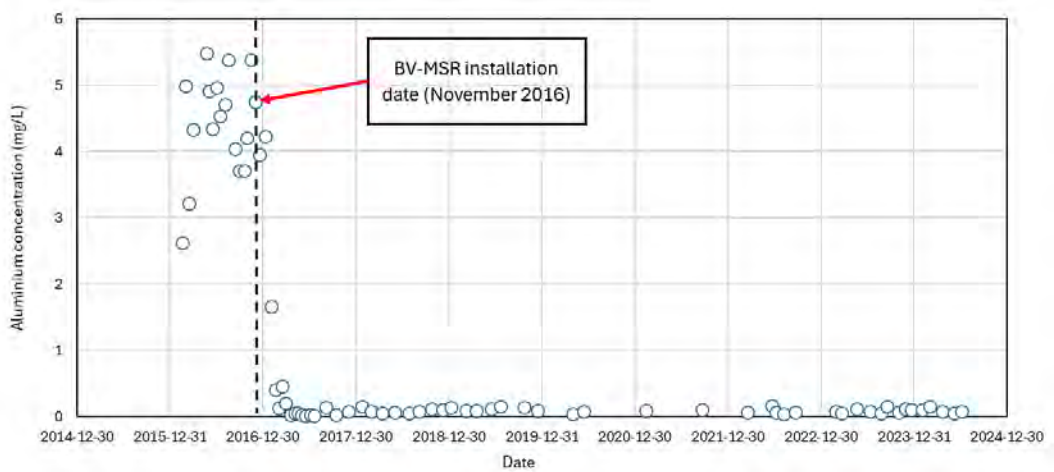


Figure 18: Pit 3 Pit Lake aluminium concentration timeseries.

7.2.2 Source Term

Table 16 provides the source terms for active pit runoff. The Pit 3 data are from February 2016 – November 2016 prior to the installation of the Barren Valley ELF Mussel Shell Bioreactor (BV-ELF MSR) at the existing Escarpment mine.

The dataset available for Pit 3 was limited for Cd, Cu, Cr, and Mn. These data were obtained from relationships between sulfate and the associated PCOC for water monitoring site S23 at Stockton Mine. This relationship has been discussed in MWM (2026i) that derives the ELF water quality model.

Some data required for source terms was absent from the initial Pit 3 water quality monitoring programme (As, B, K, Na, Si, Cl). To address this data gap, shake-flask test data was used. Data are available from MFS studies and have been reported in MWM (2024f). Sample AMD-DC16-007-MSS was used (ABA data provided in Table 16) that is PAF, and was validated as generating acidity (MWM, 2026d). These shake-flask test data were obtained from drillcore 13 months after drilling (that had been crushed 1 month after drilling) so the data is considered conservative.

Table 15: MFS Column Leach Test ABA Data

SAMPLE	PASTE pH	S (wt%)	MPA	ANC	NAPP	NAG pH	CLASSIFICATION (MFS PROCESS FLOW)
AMD-DC16-005-GRCG B	6.1	0.011	0.3	1	-0.7	5.9	NAF
AMD-DC16-007-MSS	5	0.587	18.0	-1	18.0	3.8	PAF
AMD-DC16-010-GRBX	5.2	0.148	4.5	0	4.5	4.5	LOW RISK
AMD-DC16-013-HCM	6.1	0.089	2.7	1	1.7	4.1	LOW RISK

Where MPA, ANC, and NAPP are in kg H_2SO_4/t equivalent

Table 16: Active pit surface runoff water quality.

ANALYTE[1]	AVERAGE PIT 3 WATER QUALITY[2]	90TH%ILE PIT 3 WATER QUALITY
SOURCE TERM	PIT SURFACE RUNOFF WATER – HIGH FLOW	PIT SURFACE RUNOFF WATER – LOW FLOW
pH	3.70	3.60
Total Alkalinity as $CaCO_3$	-	-
Acidity pH 8.3	44.4	54.5
Aluminium	4.41	5.39
Arsenic	0.007	0.007
Boron	0.015	0.015
Cadmium	0.00011[3]	0.00013[3]
Calcium	19.0	29.0
Chromium	0.0036[3]	0.0044[3]
Cobalt	0.010[3]	0.013[3]
Copper	0.0029[3]	0.0035[3]
Iron	0.835	1.28
Lead	0.00025	0.00025
Magnesium	2.63	3.11
Manganese	0.21[3]	0.26[3]
Nickel	0.116	0.139

ANALYTE[1]	AVERAGE PIT 3 WATER QUALITY[2]	90TH%ILE PIT 3 WATER QUALITY
Potassium	10.2	10.2
Selenium	0.0025	0.0025
Sodium	0.25	0.25
Thallium	0.00019	0.00023
Zinc	0.769	0.995
Silicon	2.1	2.1
Sulfate	100.1	121.5
Chloride	0.25	0.25

A hyphen (-) indicates no data are available. Purple = ½ LOR.

Red text is from shake flask data

Average Pit 3 metals and metalloids are presented as dissolved.

1. *With the exception of pH (unitless), all concentrations are reported in mg/L.*
2. *Average Pit 3 water quality data was derived from February 2016 – November 2016 prior to the installation of the BV-ELF MSR.*
3. *Water quality data derived relationship with sulfate (MWM, 2026i).*

The data presented in Table 16 provides the water quality end members for the WLBM. To avoid a step change in the WLBM a mixing model was developed (Figure 19). The following model development process was undertaken:

- Step 1: Calculate the exceedance probability of the flow rates. This is done for each day and expressed as a percentage.
- Step 2: A mixing factor is applied to determine the water composition:
    - At high exceedance probabilities (very low flows), the composition is entirely from the low-flow end member (e.g., SO_4= 121.5 mg/L).
    - At near-zero exceedance probability (very high flows), the composition reflects only the high-flow end member (e.g., SO_4 = 100.1 mg/L (diluted)).
    - At 50% exceedance probability, the composition is an equal mix of the two end members (50% low-flow, 50% high-flow) (e.g., SO_4 = 110.8 mg/L).
- For values between 0–50% and 50–100%, the transition between high-flow and low-flow compositions is smoothed using a cumulative normal distribution with a mean of 0.5 and a standard deviation of 0.15, as shown in Figure 19.

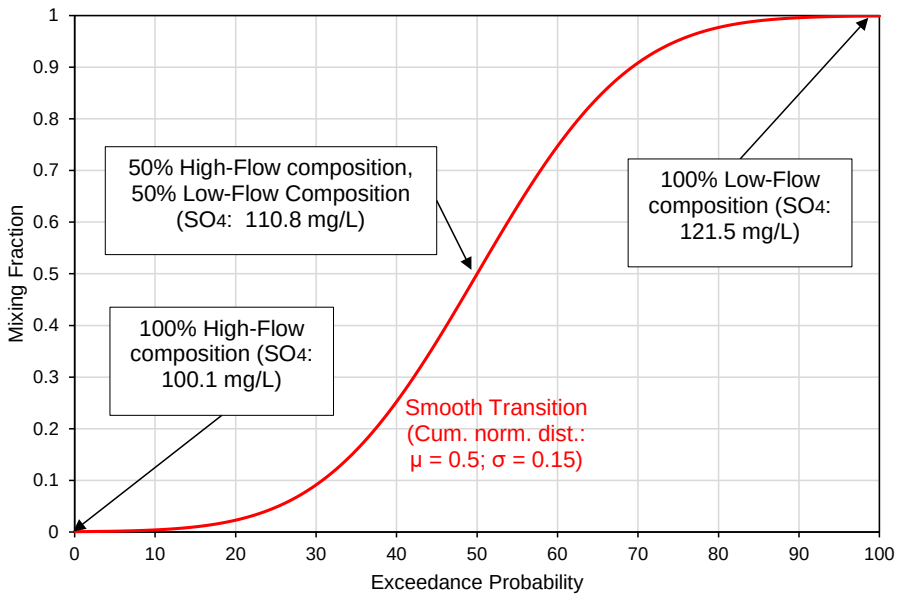


Figure 19: Pit 3 Pit Lake mixing model for high flow and low flow scenarios.

7.2.3 Active ELF Running Surfaces

Active ELF Running surfaces use the same source terms as the source term for active pit runoff water quality – high flow (Table 16) and those adjustments for high and lower flow periods. This provides a reasonable dataset for water quality, reflective of the risks for AMD.

7.2.4 Assumptions

The following assumptions are provided for the derivation of these source terms:

- It is assumed that the use of empirical data from Pit 3 at Escarpment provides suitable data for deriving a source term for active pits and ELF running surfaces.

7.2.5 Model Effects

No adjustment has been undertaken for varying sulfur content across the BPCP area, and it is assumed the source term is suitable for the following reasons:

- The sulfur content of Pit 3 at the existing Escarpment Mine is 0.22 wt% S (data provided by BRL for the final pit shell), which is reasonable when compared to average sulfur content of ESE (0.35 wt%) and MFS (0.13 wt%) [11].
- During the Operational Phase pit sump water is a mixture of other water sources including ELF seepage water quality with water being transferred to the water treatment plant, although periodic spills do occur.
- Pit voids do not remain after closure. In the closure phase run-off is a function of the final coal floor sulfur content, which has been determined by catchment (Section 7.3).

[11] *The average sulfur content is determined from the weighted average of data provided in Table 31 and Table 42.*

7.2.6 Performance Monitoring

The following performance monitoring is recommended to validate the source term for Active Pits:

- Regular monitoring of water quality from active pits areas to confirm the model source terms are appropriate. This should be undertaken during higher and lower rainfall periods.

7.3 Coal Floor - Closure

BRL propose to leave some areas of coal floor in place at mine closure to mimic natural pavement areas. This has been undertaken previously at the Stockton Coal Mine. During operations coal floor will be treated as an active pit area in the water and load balance models.

7.3.1 Source Term: ESE Coal Floor - Closure

Three coal floor areas will be left at closure as part of the ESE sub-area (Figure 11). ABA estimates from the Denniston ABA model are provided in Table 17 and indicates that the net acid producing potential (NAPP) is low (e.g., low AMD risk) and that the ESE coal floor is modelled as NAF. CON and WWH coal floors are modelled as PAF. These ABA data are comparable to the MFS ABA data (Table 19).

Table 17: ABA Data for ESE Coal Floor

COAL FLOOR	SURFACE AREA (m^2)	S (wt%)	ANC ($kg/H_2SO_4/t$)	NAPP ($kg/H_2SO_4/t$)
CON	167,437	0.23	3.61	3.4
ESC	180,666	0.04	3.41	-2.2
WWH	182,962	0.26	3.59	4.4

[redacted]

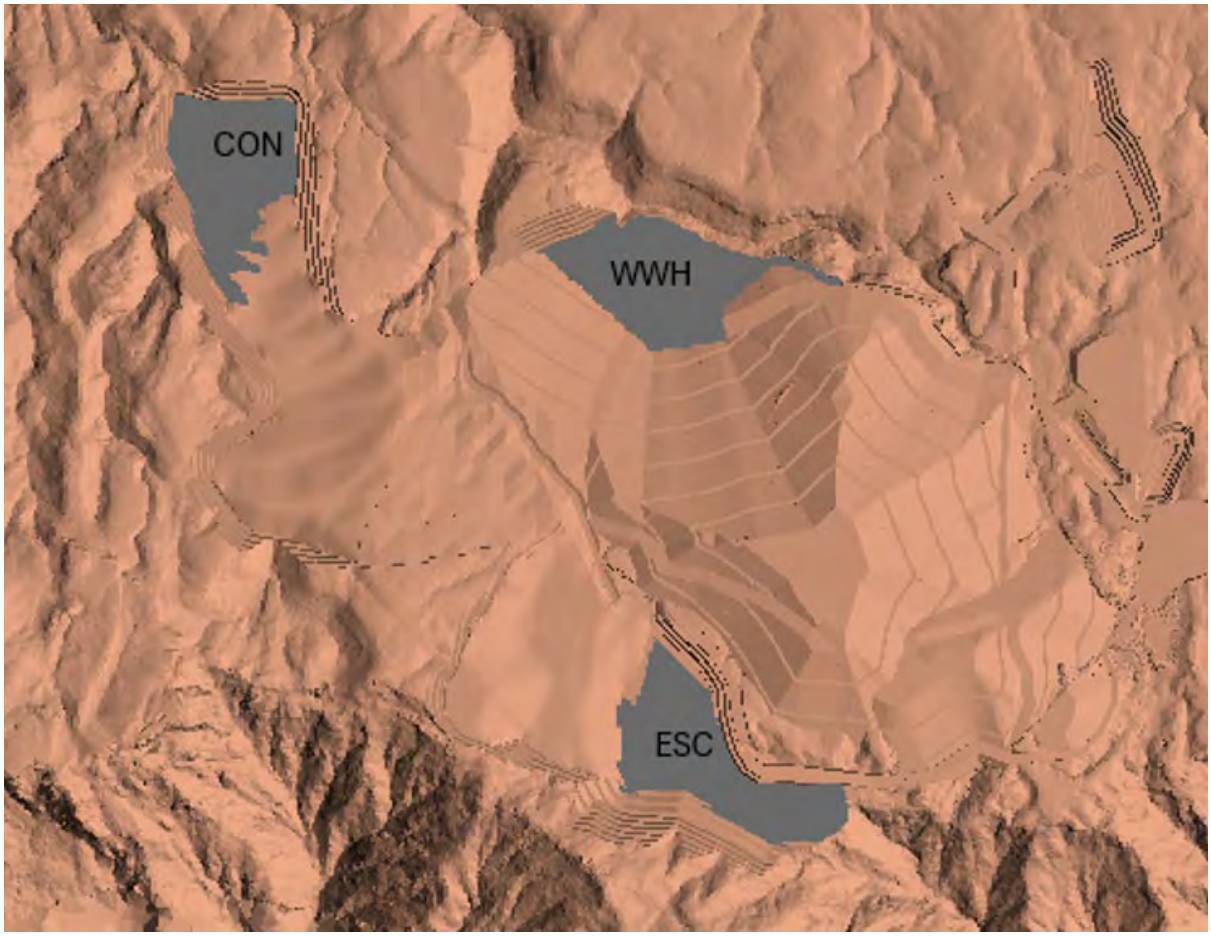


Figure 20: ESE closure coal floor.

[redacted]

The sulfur content was used to develop the source term for each coal floor using the same approach that was utilised for the highwalls (Section 7.1.3). However, given the ABA nature of these surfaces, the ESE coal floor required an adjustment for the non-acid forming nature of the material. This was done using the same process for NAF ELF seepage (Section 6.3).

Source terms are summarised in Table 18. Application of the CON coal floor runoff source term (kg/ha/day) to typical rainfall events is shown in Figure 21 as an example of water quality.

Table 18: Source term for ESE coal floor runoff.

PARAMETER	UWHR Site 3 [2,3] (mg/L)	CON (kg/ha/day)	ESC (kg/ha/day)	WWH (kg/ha/day)
pH [1]	3.8	-	-	-
Acidity to pH 8.3	15	1.35260	- [4]	1.52903
Chloride	3.57	0.32192	0.05599	0.36391
Sulfate	17.2	1.55098	0.26974	1.75328
Dissolved Aluminium	0.844	0.07611	- [4]	0.08603
Dissolved Antimony	<0.001	0.00005	0.00001	0.00005
Dissolved Boron	<0.03	0.00135	0.00024	0.00153
Dissolved Cadmium	<0.0002	0.00001	0.000002	0.00001
Dissolved Calcium	0.3	0.02705	0.00470	0.03058
Dissolved Chromium	<0.001	0.00005	0.00001	0.00005

PARAMETER	UWHR Site 3 [2,3] (mg/L)	CON (kg/ha/day)	ESC (kg/ha/day)	WWH (kg/ha/day)
Dissolved Cobalt	0.0012	0.00011	0.00002	0.00012
Dissolved Copper	0.0030	0.00027	0.00005	0.00031
Dissolved Iron	1.06	0.09558	0.01662	0.10805
Dissolved Lead	0.0007	0.00006	0.00001	0.00007
Dissolved Magnesium	0.44	0.03968	0.00690	0.04485
Dissolved Manganese	0.0238	0.00215	0.00037	0.00243
Dissolved Mercury	<0.0005	0.00002	0.000004	0.00003
Dissolved Nickel	0.0058	0.00052	0.00009	0.00059
Dissolved Potassium	0.52	0.04689	0.00815	0.05301
Dissolved Selenium	<0.005	0.00023	0.00004	0.00025
Dissolved Sodium	3.05	0.27503	0.04783	0.31090
Dissolved Tin	<0.0005	0.00002	0.000004	0.00003
Dissolved Zinc	0.022	0.00198	0.00035	0.00224
Dissolved Silica	4.99	0.44996	0.07825	0.50866
Dissolved Arsenic	<0.001	0.00005	0.00001	0.00005
Dissolved Thallium	<0.0005	0.00002	0.000004	0.00003

1 – pH is not converted into a load due to the complexity of assignment to variable flow rates. A pH of 3.8 has been used for modelling of PAF surfaces (CON and WWH) and a pH of 5.81 is used for NAF surfaces (i.e., ESC).

2 - With the exception of pH (unitless), all concentrations are reported in mg/L

3. - Source: MWM, 2024c.

4. – Source term for NAF samples is adjusted separately.

Red data uses ½ LOR

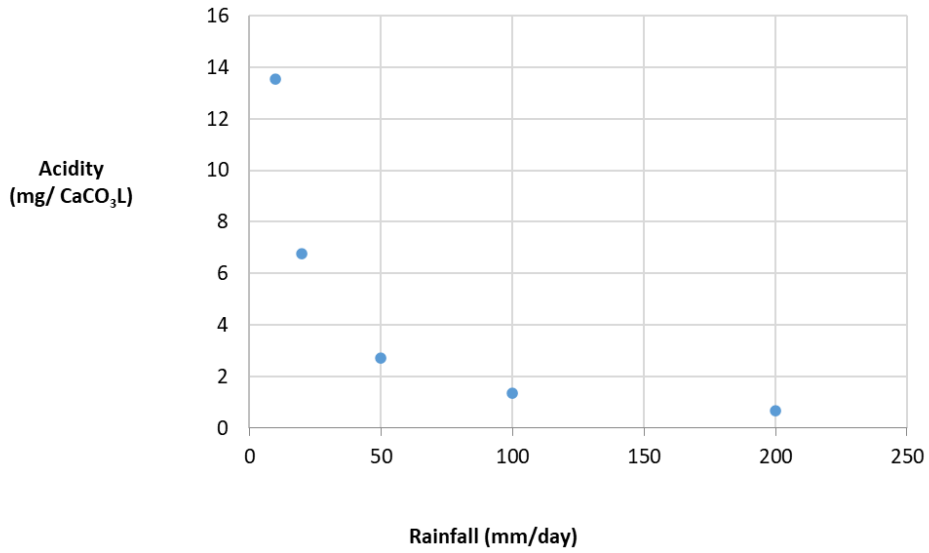


Figure 21: Daily rainfall events versus acidity (mg $CaCO_3$/L) for CON Coal Floor.

Based on a catchment sulfur content of 0.23 wt%.

7.3.2 Source Term: MFS Coal Floor - Closure

Five coal floor areas will be left at closure as part of the MFS sub-area (Figure 22 and Figure 23). ABA data are provided in Table 19 and indicates that in most cases the NAPP is low (e.g., low AMD risk) and that Coal Floor 1 and Coal Floor 3 will have a NAF coal floor. Coal Floor 2 (CF2) has a high sulfur content of 0.906 wt%. This is one of the higher values observed within the project area for AMD-

impacted surfaces. Run-off water quality (acidity) is presented in Figure 24 to understand the suitability of the approach. Data are reasonable and adequately reflect risk to run-off water quality from the CF2 surface.

The sulfur content was used to develop the source term for each coal floor using the same approach that was utilised for the ESE coal floor (Section 7.3.2) for PAF and NAF surfaces.

Table 19: ABA Data for MFS Coal Floors

COAL FLOOR	SURFACE AREA (m^2)	S (wt%)	ANC ($kg/H_2SO_4/t$)	NAPP ($kg/H_2SO_4/t$)
Coal Floor 1 (CF1)	223,932	0.113	3.69	-0.2
Coal Floor 2 (CF2)	18,101	0.906	0.814	26.9
Coal Floor 3 (CF3)	1,777	0.084	2.99	-0.4
Coal Floor 4 (CF4)	3,906	0.151	3.02	1.6
Coal Floor 5 (CF5)	1,291	0.157	2.96	1.8

[redacted]

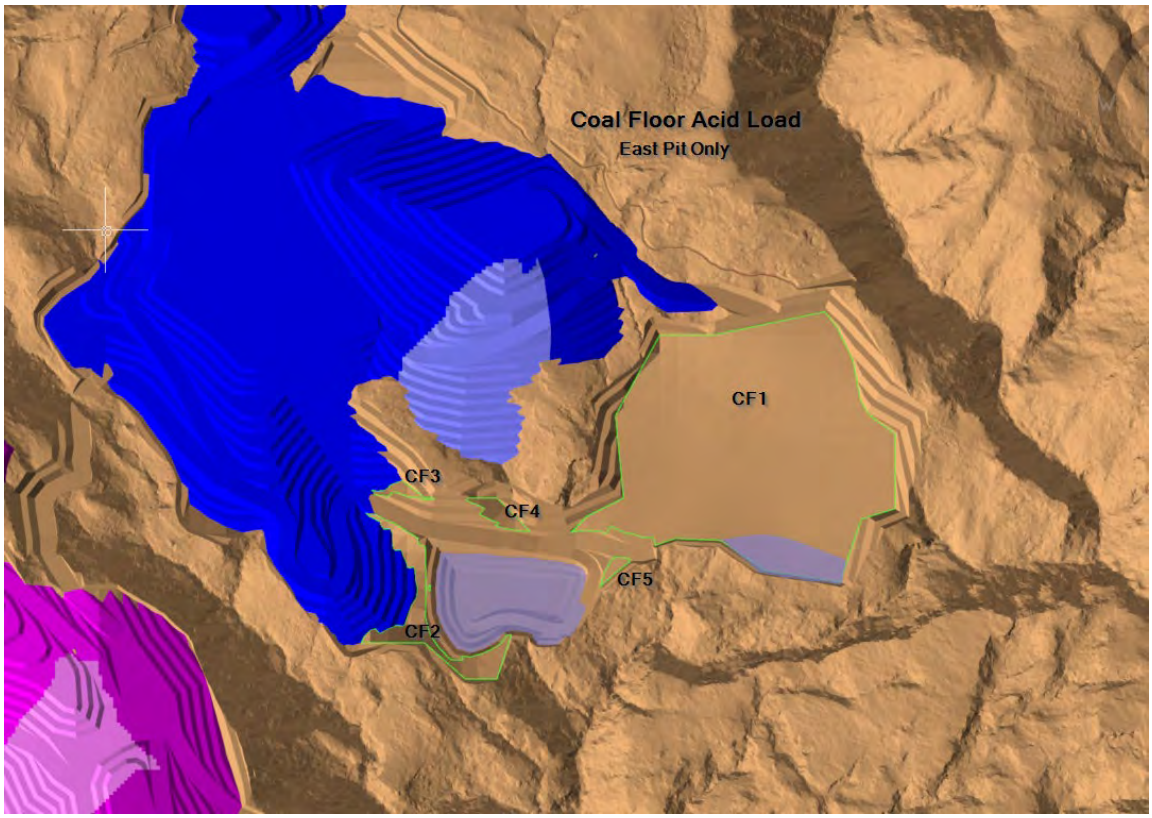


Figure 22: MFS Closure Coal Floor in relation to other project infrastructure.

Coloured areas represent engineered landforms

[redacted]

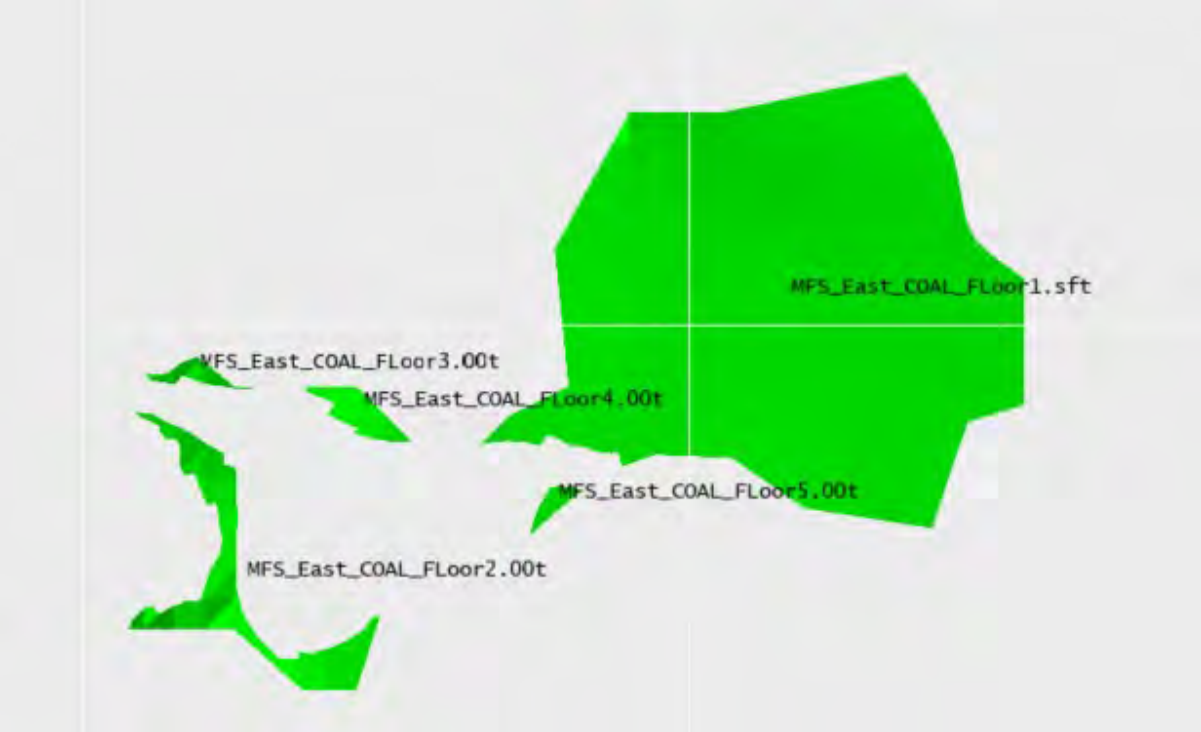


Figure 23: MFS Closure Coal Floors showing areal extent.

The location of the coal floor in relation to other project infrastructure is provided in Figure 22.

[redacted]

Table 20: Source term for MFS coal floor runoff.

PARAMETER	CF1 (kg/ha/day)	CF2 (kg/ha/day)	CF3 (kg/ha/day)	CF4 (kg/ha/day)	CF5 (kg/ha/day)
pH[2]	-	-	-	-	-
Acidity to pH 8.3	- [1]	5.32807	- [1]	0.88801	0.92330
Chloride	0.15816	1.26808	0.11757	0.21135	0.21974
Sulfate	0.76200	6.10952	0.56645	1.01825	1.05871
Dissolved Aluminium	- [1]	0.29979	- [1]	0.04997	0.05195
Dissolved Antimony	0.00002	0.00018	0.00002	0.00003	0.00003
Dissolved Boron	0.00066	0.00533	0.00049	0.00089	0.00092
Dissolved Cadmium	0.000004	0.00004	0.000003	0.00001	0.00001
Dissolved Calcium	0.01329	0.10656	0.00988	0.01776	0.01847
Dissolved Chromium	0.00002	0.00018	0.00002	0.00003	0.00003
Dissolved Cobalt	0.00005	0.00043	0.00004	0.00007	0.00007
Dissolved Copper	0.00013	0.00107	0.00010	0.00018	0.00018
Dissolved Iron	0.04696	0.37652	0.03491	0.06275	0.06525
Dissolved Lead	0.00003	0.00025	0.00002	0.00004	0.00004
Dissolved Magnesium	0.01949	0.15629	0.01449	0.02605	0.02708
Dissolved Manganese	0.00105	0.00845	0.00078	0.00141	0.00146
Dissolved Mercury	0.00001	0.00009	0.00001	0.00001	0.00002
Dissolved Nickel	0.00026	0.00206	0.00019	0.00034	0.00036
Dissolved Potassium	0.02304	0.18471	0.01713	0.03078	0.03201
Dissolved Selenium	0.00011	0.00089	0.00008	0.00015	0.00015
Dissolved Sodium	0.13512	1.08337	0.10045	0.18056	0.18774

PARAMETER	CF1 (kg/ha/day)	CF2 (kg/ha/day)	CF3 (kg/ha/day)	CF4 (kg/ha/day)	CF5 (kg/ha/day)
Dissolved Tin	0.00001	0.00009	0.00001	0.00001	0.00002
Dissolved Zinc	0.00097	0.00781	0.00072	0.00130	0.00135
Dissolved Silica	0.22107	1.77247	0.16433	0.29541	0.30715
Dissolved Arsenic	0.00002	0.00018	0.00002	0.00003	0.00003
Dissolved Thallium	0.00001	0.00009	0.00001	0.00001	0.00002

Red data uses ½ LOR

CF = Coal Floor

1. - Source term for NAF samples is adjusted separately as explained for NAF ELF Seepage – Section 6.3

2. - pH is not converted into a load due to the complexity of assignment to variable flow rates. A pH of 3.8 has been used for modelling of PAF surfaces (CON and WWH) and a pH of 5.81 is used for NAF surfaces (i.e., ESC).

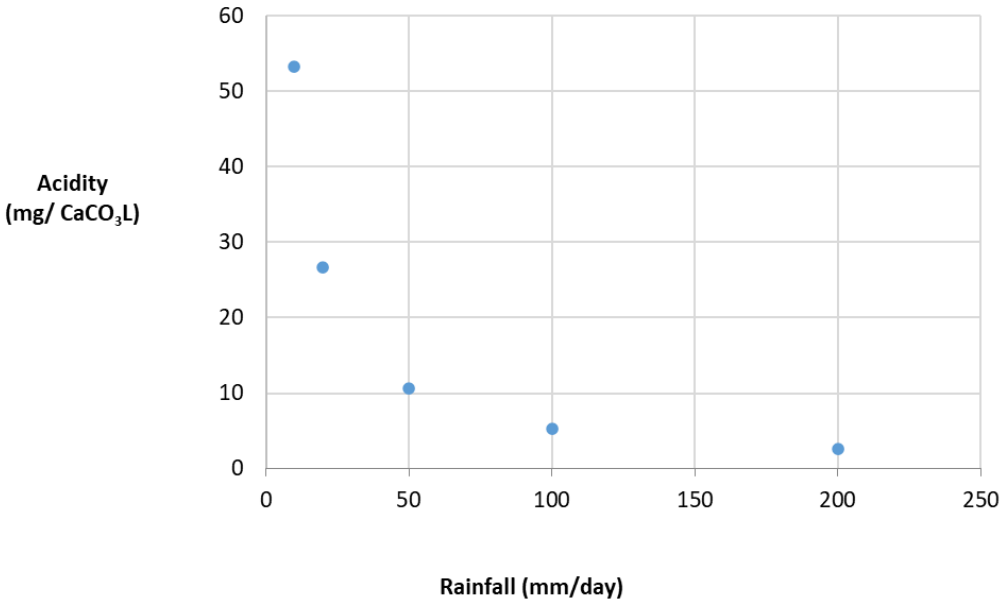


Figure 24: Daily rainfall events versus acidity (mg $CaCO_3$/L) for MFS Coal Floor 2.

Based on a catchment sulfur content of 0.906 wt%.

7.3.3 Decay of acidity and PCOC

To account for a long-term decrease in acidity loads, the relationship derived by Pope et al. (2018) (Section 7.1.5) has been utilised for coal floors. This is applied at the end of mine life to all coal floor surfaces and all acidity and PCOC.

7.3.4 Summary

Overall, the sulfur content of the proposed final closure coal floor is low for ESE and MFS (NAPP ranging from -2.2 to 4.4 kg H_2O_4/t), with several domains being non-acid forming and likely to generate neutral drainage. Neutral drainage may still contain some PCOC due to the oxidation of minor sulfides. The one exception is MFS Coal Floor 2, which is high sulfur (with a NAPP of 26.9 kg H_2SO_4/t) and the acidity in run-off could be significant (Figure 24).

7.3.5 Assumptions

The following assumptions are provided for the derivation of this source term:

- It is assumed that the Grand Canyon highwall PAF BCM data is suitable empirical data, coupled with BCM runoff PCOC data from the UWHR to derive the water quality estimates for exposed coal floor. Noting the dataset used includes the Grand Canyon load from both up-dip and down-dip surfaces to provide an average value and hence a more reliable number.
- The model is scaled from the Grand Canyon data using an acidity of 40 mg $CaCO_3$/L. Data from Pope et al. (2018a) suggests that acidity (average) from such surfaces (~ 10 years old) could be 76 mg $CaCO_3$/L (equivalent to a 2-3 mm rainfall event). However, the Mackenzie (2018) is based on a total catchment approach to generate a load, which is a more representative dataset. Other data from BRL (2018) as shown in Table 11suggest acidities are 9 mg/L $CaCO_3$/L (after 12 years). There remains uncertainty in the data and hence 40 $CaCO_3$/L is used as a reasonable estimate, mid-way between these datapoints. Noting that if 76 mg $CaCO_3$/L (after 10 years) is plotted on Figure 13, it is in reasonable agreement with the model (i.e., the model approach presented here agrees with empirical data / models derived on this empirical data provided by Pope et al. 2018).

7.3.6 Performance Monitoring

The following performance monitoring is recommended to validate the source term for coal floors:

- Further monitoring of drainage from coal floor surfaces (with no other water quality influence) is recommended to ensure the model is accurate
- Monitoring of such surfaces to improve confidence in the data for wetter periods and dryer periods.

7.4 ELF Surface Runoff: Uncovered and Revegetated

A source term is required for run-off from Engineered landforms including those that are uncovered and those that are rehabilitated. This section discusses the derivation of these source terms.

7.4.1 Source Term

Two source terms are required:

- NAF running surfaces and batter slopes, which uses NAF water quality data derived from the column leach testing. This source term is provided in Table 21. Further details on the derivation of this source term are provided in MWM (2026d). Noting that due to progressive rehabilitation activities, only 2-3 lifts containing PAF rock will be exposed before they are recontoured and capped with NAF rock (in this instance water quality will be directed away from rehabilitated slopes). A constant source term is applied.
- Rehabilitated surfaces, which uses background stream water quality for dissolved parameters (W-M2).

Table 21: ELF Runoff – Uncovered and Rehabilitated

PARAMETER	NAF RUNNING SURFACES AND NAF BATTER SLOPES	REHABILITATION SURFACES [1]
pH	5.6	4.9
Acidity (pH 7.0) – mg $CaCO_3$/L	1.3	4.2
Alkalinity (mg $CaCO_3$/L)	0.3	1.2
Chloride	1.0	4.2
Sulfate	4.3	1.8
Silicon	0.2	1.9
Aluminium	0.007	0.15
Arsenic	0.0005	0.001
Calcium	0.044	0.5
Cadmium	0.0001	0.0001
Chromium	0.0008	0.0001
Cobalt	0.00025	0.0062
Copper	0.00025	0.001
Iron	0.13	0.15
Lead	0.00025	0.0002
Magnesium	0.00025	0.5
Manganese	0.023	0.01
Nickel	0.0011	0.0006
Potassium	1.7	0.29
Selenium	0.0025	0.0025
Sodium	0.65	2.66
Thallium	0.00025	0.0004
Zinc	0.004	0.005
TOC		3.7
TSS	-	-

Red = ½ LOR

1. *Based on W-M2 data (MWM, 2024).*

7.4.2 Risk

The following risks are noted:

- A quality control / quality assurance (QA/QC) process is needed to ensure no PAF or HAF is placed near the ELF surface. As noted in Table 1 and Table 2, there is a NAF cover that will be placed prior to topsoil and/or final cover system placement. PAF or HAF near the surface compromise closure criteria. This is discussed in the ELF Management Plan.

7.4.3 Performance Monitoring

The following performance monitoring is recommended:

- Monitoring of rehabilitated surfaces to ensure surface water quality are suitable for discharge without treatment to achieve closure criteria.

7.5 Hardstand Runoff

Two water types are required for water run-off from hardstand areas including PAF and NAF surfaces. This section discusses the derivation of these source terms.

7.5.1 Source Term

A load model was developed to reflect decreasing concentrations with increasing rainfall. This is a similar approach to that used for highwalls (Section 7.1.3). Two source terms were selected (Table 22) including:

- WWH Coal floor runoff (ESE) as an example of water quality from PAF materials (0.26 wt% S), which has a NAPP of 4.4 kg H_2SO_4/t.
- Coal Floor 3 (CF3) runoff (MFS) as an example of water quality from NAF materials (0.084 wt% S) which has a NAPP of -0.4 kg H_2SO_4/t. Adjustments were made to the source term using the same process for NAF ELF seepage (Section 6.3).

Table 22: Waste rock runoff – NAF Hardstand

PARAMETER	PAF (WWH) (kg/ha/day)	NAF (CF3) (kg/ha/day)
pH[2]	-	-
Acidity to pH 8.3	1.52903	-[1]
Chloride	0.36391	0.11757
Sulfate	1.75328	0.56645
Dissolved Aluminium	0.08603	-[1]
Dissolved Antimony	0.00005	0.00002
Dissolved Boron	0.00153	0.00049
Dissolved Cadmium	0.00001	0.000003
Dissolved Calcium	0.03058	0.00988
Dissolved Chromium	0.00005	0.00002
Dissolved Cobalt	0.00012	0.00004
Dissolved Copper	0.00031	0.00010
Dissolved Iron	0.10805	0.03491
Dissolved Lead	0.00007	0.00002
Dissolved Magnesium	0.04485	0.01449
Dissolved Manganese	0.00243	0.00078
Dissolved Mercury	0.00003	0.00001
Dissolved Nickel	0.00059	0.00019
Dissolved Potassium	0.05301	0.01713
Dissolved Selenium	0.00025	0.00008
Dissolved Sodium	0.31090	0.10045
Dissolved Tin	0.00003	0.00001
Dissolved Zinc	0.00224	0.00072
Dissolved Silica	0.50866	0.16433

PARAMETER	PAF (WWH) (kg/ha/day)	NAF (CF3) (kg/ha/day)
Dissolved Arsenic	0.00005	0.00002
Dissolved Thallium	0.00003	0.00001

Red data uses ½ LOR

CF = Coal Floor

1. *- Source term for NAF samples is adjusted separately.*
2. *pH is not converted into a load due to the complexity of assignment to variable flow rates. A pH of 3.8 has been used for modelling of PAF surfaces and a pH of 5.81 is used for NAF surfaces.*

7.5.2 Summary

- It is assumed that the load derivation for surfaces is also applicable to hardstand areas.
- Assumptions and risks are comparable to other source terms that use the Grand Canyon load model.
- Performance monitoring is recommended to validate the source term for hardstand runoff:
    - Further monitoring of drainage from hardstand areas is recommended to validate the model.
    - Monitoring of such surfaces to improve confidence in the data for wetter periods and dryer periods.

8 ADITS

Numerous adits are present within the BPCP area and many of these discharge AMD impacted waters from historic underground workings. This section provides data for two key adits within the BPCP. A source term is derived from the historic Escarpment Adit to represent the risks associated with AMD impacted underground drainage for the ESE sub-area. A source term is also derived for Sullivan Adit, which discharges to Rapid Stream.

8.1.1 Escarpment Adit

The Escarpment Adit currently discharges to the V37 Creek and subsequently into the Cascade Stream. The Escarpment Adit (or Blue Shed) generated the majority of the discharge from the Escarpment underground workings with peaks in flow associated with rainfall entering the underground workings. Data are presented in Table 23. Average data are used in the model.

Table 23: Escarpment Adit water quality data (2008 and 2022).

PARAMETER	COUNT	MIN	MAX	AVE	MED
pH (pH units)	16	2.50	3.90	3.07	3.09
EC (µS/cm)	16	120	850	448	385
Flow rate (L/s)	10	1.6	16.4	7.8	6.9
Acidity (calculated) (mg $CaCO_3$/L)**	16	13.0	344.3	117.6	97.2
Average acidity load (kg/day)	1	-	-	79.3	-
Average acidity load (t/yr)	1	-	-	28.9	-
Al	16	0.62	17.0	5.83	3.95
As*	10	0.0005	0.037	0.0087	0.0016
B	10	0.0025	0.0064	0.0039	0.0025
Ba	10	0.0069	0.0160	0.0118	0.0115
Bi*	10	0.0001	0.0001	0.0001	0.0001
Ca	16	1.8	16.0	6.9	6.1
Cd*	16	0.00003	0.00015	0.00007	0.00005
Co	10	0.003	0.036	0.016	0.015
Cr*	16	0.000	0.004	0.002	0.001
Cu	16	0.001	0.011	0.004	0.003
Fe	16	0.99	48.0	15.9	6.5
K	10	0.50	2.60	1.52	1.50
Mg	16	0.63	2.90	1.55	1.45
Mn	16	0.05	0.41	0.17	0.16
Na	10	2.2	3.6	2.6	2.5
Ni	16	0.005	0.083	0.032	0.022
Pb*	16	0.001	0.003	0.002	0.002
Sb*	10	0.0001	0.0001	0.0001	0.0001
SO_4	14	24	490	188	105
Zn	16	0.03	0.53	0.20	0.12

Source: BRL 51279_RPT_Water (water quality excel database).

All units are presented in mg/L unless otherwise specified.

A hyphen (-) indicates no value is given.

** Some samples were below the LOR; in which case half the LOR was used.*

*** Due to acidity being reported across multiple titration tests, the acidity presented was calculated from pH, Al and Fe.*

Average and median pH presented is based on H+ content to present equivalent geochemical data.

8.1.2 Sullivan Adit: Source Term

Data for the Sullivan Underground Mine (Lower Adit) have been presented in MWM (2024a) and are presented below in Table 24.

Table 24: Sullivan Mine Adit Water Quality.

PARAMETER	SULLIVAN ADIT (N=18)			
	MAX	MEDIAN	AVERAGE	MIN
pH	3.2	2.9	2.9	2.6
EC (mS/m)	100	91	84	38
Acidity (mg/L as $CaCO_3$)	214	171	167	75
Turbidity (NTU)	44	22	22	0
SO_4 (mg/L)	460	342	314	57
Al (mg/L)	14.8	13	12.1	2.8
As (mg/L)	0.026	0.004	0.008	0.001
Cd (mg/L)	0.0002	0.0002	0.0002	0.0002
Ca (mg/L)	11.3	11.2	8.2	2.1
Cr (mg/L)	0.002	0.002	0.002	0.001
Co (mg/L)	0.034	0.031	0.027	0.015
Cu (mg/L)	0.012	0.010	0.008	0.002
Fe (mg/L)	56	31	33	8.0
Pb (mg/L)	0.0007	0.0006	0.0006	0.0005
Mg (mg/L)	6.02	6.01	4.86	2.54
Ni (mg/L)	0.134	0.110	0.102	0.031
Zn (mg/L)	0.38	0.36	0.29	0.15

Data derived from the BRL database

8.1.3 Source Term

The source term for the Escarpment Adit has been obtained from the average data (Table 23) that is available being considered the most representative water quality for the sub-areas.

8.1.4 Assumptions

It is assumed that the Escarpment Adit provides a reasonable source term for the ESE sub-area.

- It is assumed the water quality will remain constant over the life of the BPCP, although flow may change.

8.1.5 Model Effects

Water quality may change during the project due to disturbance of materials within the underground catchment. Currently the adit discharges to V37 Creek. This water will be captured for treatment.

8.1.6 Performance Monitoring

- It is recommended that ongoing performance monitoring of the Escarpment Adit continue during the Operational Phase of the BPCP.

9 TSS SOURCE TERMS

Source terms have been developed for TSS using empirical data from Stockton and background water quality data where available. Where representative empirical data were not available, terms were derived based on previous studies on the Buller Plateaux (e.g., WM Group, 2014) This section summarises the derivation of these source terms.

Note that the TSS source terms for active treatment effluent is described in Section 10.1.1.

9.1 Background Water Quality

TSS has been defined using water quality data from the W-M2 site on the Whareatea River. MWM (2026l) report TSS for this site to range between 1 to 440 mg/L, with an average of 7 mg/L and median of 5 mg/L. However, the high value was a one-off extreme with the 95th percentile value of the data ~6 mg/L. A dynamic source term was adopted in a similar manner to WM Group (2014), where TSS increased with daily rainfall accumulation as follows:

- Rainfall <= median, TSS = 1 mg/L.
- Rainfall > median and < 95th percentile = linearly interpolated.
- Rainfall >= 95th percentile = 10 mg/L.

These TSS values are expected to align with the Lake Brazil rainfall record, which, the relative daily rainfall accumulation statistics are defined as:

- Median Rainfall: 1.6 mm
- 95th Percentile: 69.7 mm

9.2 Mine Impacted Water Quality

Active mining areas can be highly impacted by elevated TSS. Source terms have been developed for:

- TSS prior to management through a sedimentation process
- TSS after mine impacted water passes through a sedimentation sump.
- Development was reliant on previous studies completed (MWM (2026k,t).

Previous TSS source term literature was reviewed by MWM (2026m). While the literature provided useful context, it was deemed unsuitable as a source term for active mining areas for the following reasons:

- Sampling and rainfall periods associated with each dataset did not align between the different studies.
- The methods used to obtain TSS data were not consistent between studies, and, in some cases, it is unclear as to how reported figures had been established or derived.
- It was assumed the URS (2011) [12] data has been utilised in the Golder (2013)[11] and WMG (2014)[11] reports, therefore resulting in repetition of some data whilst being reported differently.

[12] *Report uncited – citing is within MWM, 2025t.*

- Some data have been taken without description of site conditions, as opposed to being drawn from ongoing field trials or long-term data collection programmes.
- Therefore, use of empirical data for use as a source term was actioned (MWM, 2026k).

Empirical TSS data relating to mine impacted areas was derived from water quality data from the Stockton Mine, with monitoring data from site MGIU (Mangatini (sump) Inlet Untreated) used. MGIU data from 2011-2012 was identified as being the most suitable analogue site amongst later years. Catchments reporting to MGIU from 2013 onward and to other monitoring points (e.g., NELF) were less representative due to:

- Having limited vegetation. The proportion of the reporting catchment that is rehabilitated increased over time within the MGIU catchment and was less than other datasets.
- Observing limited upstream sedimentation. Noting, after 2012, the Mangatini Quarry Sump was installed upstream of the monitoring site, making later data less representative.
- Observing an expected TSS and turbidity range, especially when compared to similar disturbed areas.

This dataset was used to derive a source term for large, disturbed active mining areas; a combination of upstream sources such as overburden, highwalls, coal and soil.

The dataset was characterised using a frequency distribution and converted from instantaneous data to a daily average TSS distribution (Table 25). The resulting daily average TSS data was aligned with a frequency distribution of Stockton met daily rainfall data. This simplified approach (in the absence of comparable daily TSS and rainfall data) assumes that high daily rainfall produces high TSS, while low daily rainfall produces low TSS, under all conditions.

Table 25: Mine impacted area TSS source term derivation.

PERCENTILE	INSTANTANEOUS TSS (mg/L)	CONVERSION FACTOR	**RESULTING DAILY AVERAGE TSS (mg/L)**	**DAILY RAINFALL (mm)**
100	14,996	3.32	**4,518**	**457.6**
99	6,218	1.65	**3,757**	**148.6**
95	1,880	1.11	**1,688**	**72.6**
90	947	0.92	**1,035**	**48.4**
85	606	0.82	**735**	**35.4**
80	428	0.80	**535**	**25.2**
75	324	0.80	**405**	**18.6**
70	242	0.80	**302**	**12.9**
65	178	0.80	**222**	**9.0**
60	123	0.80	**154**	**5.9**
55	94	0.80	**117**	**3.4**
50	79	0.80	**99**	**2.0**
45	59	0.80	**73**	**1.0**
40	44	0.80	**55**	**0.4**
35	34	0.80	**43**	**0.2**
30	27	0.80	**34**	**0.1**

PERCENTILE	INSTANTANEOUS TSS (mg/L)	CONVERSION FACTOR	**RESULTING DAILY AVERAGE TSS (mg/L)**	**DAILY RAINFALL (mm)**
25	21	0.80	**26**	**0.1**
20	16	0.80	**20**	**0.1**
15	12	0.80	**15**	**0.1**
10	9	0.80	**11**	**0.1**
5	5	0.80	**7**	**0.1**
0	3	0.80	**3**	**0**

Source: MWM (2026k)

Table 25 has been simplified for use in water and load balance models as per Figure 25.

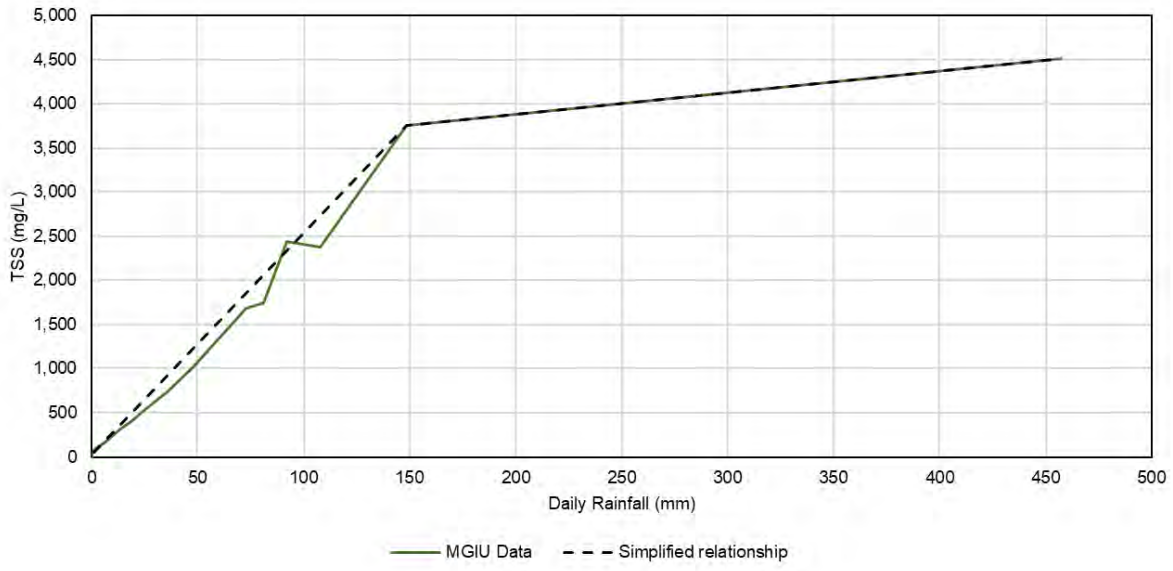


Figure 25: Mine impacted TSS relationship for use in WLBMs.

Source: Simplified from MWM (2026k)

It is important to note, MGIU is located downstream of sedimentation sumps with unquantified TSS capture rates; it therefore represents the result of partial sedimentation. Notwithstanding this limitation, it was considered the most reliable dataset available, therefore justifying its use.

To estimate pond sedimentation efficiency for use in WLBMs, the observed change in TSS before and after installation of the Mangatini Quarry Sump (a sedimentation structure directly upstream of MGIU, installed in 2013) was utilised. It was found that there was a potential reduction of up to 79% of TSS, as presented in Table 26. This reduction value then reduced to no observed sediment removal during what has been assumed as low flow periods (i.e., <10th percentile). This approach assumes that both TSS datasets observe an upward trend of TSS relative to flow, as described above where a high daily rainfall produces high TSS, while low daily rainfall produces low TSS, under all conditions.

Table 26: TSS load change before and after installation of the Mangatini Quarry Sump.

	2011 AND 2012	NOV 2014 TO OCT 15	
PERCENTILE	INSTANT. TSS (mg/L)	INSTANT. TSS (mg/L)	DIFFERENCE OF SEDIMENT LOAD
100	14,996	3,727	75%
99	6,218	1,310	79%
95	1,880	453	76%
90	947	314	67%
85	606	206	66%
80	428	151	65%
75	324	112	65%
70	242	73	70%
65	178	63	65%
60	123	46	62%
55	94	33	65%
50	79	29	63%
45	59	25	57%
40	44	21	53%
35	34	15	56%
30	27	13	53%
25	21	10	54%
20	16	9	45%
15	12	8	39%
10	9	6	28%
5	5	6	-7%
0	3	4	-72%

Source: MWM (2026k)

Table 26 has been simplified for use in WLBMs as the natural log relationship illustrated in Figure 26.

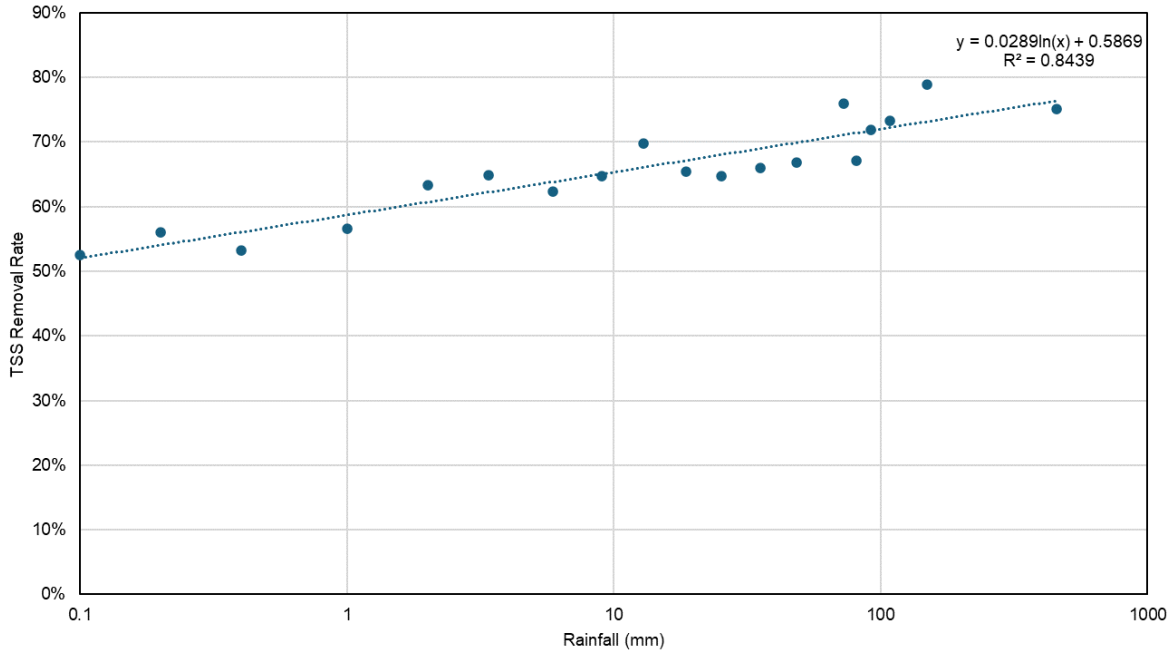


Figure 26: TSS reduction factor relationship applied to sumps

Source: Based on the empirical data from MWM (2026k)

9.3 Rehabilitated Surfaces

9.3.1 ELF Runoff

Rehabilitated engineered landform areas have been assumed to be stabilised after a period of two years following rehabilitation being undertaken [13]. This follows use of hydroseeding as the preferred method for early rehabilitation and erosion management, which allows for rapid stabilisation of surfaces [14].

Representative empirical data was not available to derive source terms for rehabilitated surfaces. As such, terms derived by WM Group (2014) were used. Following rehabilitation being established for two years, the TSS source term applied is that described in Table 27 following the approach provided by WM Group (2014).

Table 27: Rehabilitated ELF surface TSS source term.

RAINFALL (mm/day)	TSS CONCENTRATIONS (g/m^3)
0	3
21.6	3
95.1	12
800	12

Source: WM Group (2014): Table 16 (ELF rehabilitated forest runoff).

[13] *As per email correspondence with BRL, dated 29/08/2024*

[14] *As per email correspondence with BRL, dated 3/07/2025*

9.3.2 Coal Floor, Highwalls, and Hardstand

For other areas that are deemed to be in a rehabilitated state, including coal floor, highwalls and hardstands, runoff is assumed to be managed through sediment control structures, which will be designed to achieve the following level of performance:

- Rainfall <= median, TSS = 3 mg/L.
- Rainfall > median and < 95th percentile = linearly interpolated.
- Rainfall >= 95th percentile = 30 mg/L.

See Section 9.1 for median and 95th percentile rainfall values.

9.4 ELF Seepage

ELF seepage has assumed a constant source term of 20 mg/L for TSS following Table 16 (ELF-Uncovered seepage) of WM Group (2014).

9.5 Post Passive Treatment

Passive Treatment Polishing Pond discharge, which may include inflows from MSRs, coal floors and highwall runoff, is assumed to achieve the following level of performance:

- Rainfall ≤ median, TSS = 3 mg/L.
- Rainfall > median and < 95th percentile = linearly interpolated.
- Rainfall ≥ < 95th percentile = 30 mg/L.

See Section 9.1 for median and 95th percentile rainfall values.

10 SOURCE TERMS - TREATED WATER

This section discusses the source terms for the process of active water treatment through the proposed water treatment plant (WTP) and the passive treatment system (i.e., mussel shell bioreactor (MSR)).

10.1 Active Water Treatment

During operations, and into the closure phase an active WTP will be operating at MFS and at ESE sub-areas to treat mine impacted waters (TSS and AMD). Details relating to the proposed WTPs are provided by Process Flow (2026) who have completed an Order-of-Magnitude study for the WTP design.

10.1.1 Source Terms – Treated Water Quality

The source term for WTP effluent (treated water quality) is presented in Table 28:

- Some constituents use a fixed effluent limit, a function of the water treatment process.
- Other components are variable as presented in Table 28.
- The calcium (Ca) concentration is calculated and is a function of the influent acidity (as mg $CaCO_3$/L) and influent Ca concentration (mg/L). For instance, if the influent acidity is 440 mg $CaCO_3$/L, then this will be neutralised by CaO generating an equivalent amount of hardness (i.e., 440 mg $CaCO_3$/L) or a Ca concentration of (40/100) = 176 mg/L.

Table 28: Water Quality Source Term – WTP Effluent

PARAMETER	mg/L
H+	0.0003981
Acidity (as $CaCO_3$/L)	2.5
Alkalinity (as $CaCO_3$/L)	5.5
Ca	Calculated
Mg	= input water quality
Na	= input water quality
K	= input water quality
SO_4	= input water quality
Al	0.074
Fe	0.01
Ni	0.0027
Mn	0.18
Cr	0.0011
Cd	0.000025
Co	0.001
Cu	0.00025
Pb	0.00005
Tl	0.00117
Zn	0.0058
DOC	0.25
TSS	1.5
pH	6.4

10.2 MSR Treated Water

It is proposed that seepage from the various ELF basal sub-catchments is treated by MSR passive treatment systems. Treatment efficiencies vary for different PCOC. The treatment efficiencies are presented in Table 29. Further details are provided in MWM (2026e). The following notes are provided:

- MSR influent is multiplied by the treatment efficiency factor to derive the effluent water quality.
- Acidity in effluent is a fixed value of 1 mg $CaCO_3$/L based on other studies (MWM, 2026e).
- Alkalinity and pH are not a function of MSR influent concentrations. Generally, alkalinity and pH in effluent are reasonably stable. For this study the average alkalinity for the Barren Valley ELF MSR effluent was used (115.5 mg $CaCO_3$/L), which has been discussed previously (MWM, 2024i). Likewise, a pH of 7.9 was used from the same dataset.
- An adjustment was provided to Fe, where the MSR treatment efficiency was decreased from 99.8% to 80% to account for ELF design where sub-oxic conditions are expected (and Fe(II) may pass through a MSR untreated). This results in Fe entering the polishing pond of the MSR. In the MSR Polishing Pond this iron is removed (99%) efficient, which also facilitates the removal of additional Ni and Zn through adsorption as shown by Process Flow (2026) (Table 29).
- Data for the MSR (MWM, 2026f) shows that dissolved organic carbon (DOC) is exported from the MSR with an average for the Tara MSR of 7.59 mg/L; an average for the Barren Valley ELF MSR of 0.29 mg/L; and an average for the Whirlwind MSR of 0.86 mg/L. An average value of 2.9 mg/L has been used as a source term.
- Ca and Mg increase in concentration through the MSR. This is due to the dissolution of shells and is a function of the influent acidity. Given the relationship between acidity and sulfate in ELF seepage is strong, the relationship between Ca and SO_4 and Mg and SO_4 was used to calculate Ca (Figure 27) and Mg (Figure 28) concentration in the MSR effluent.

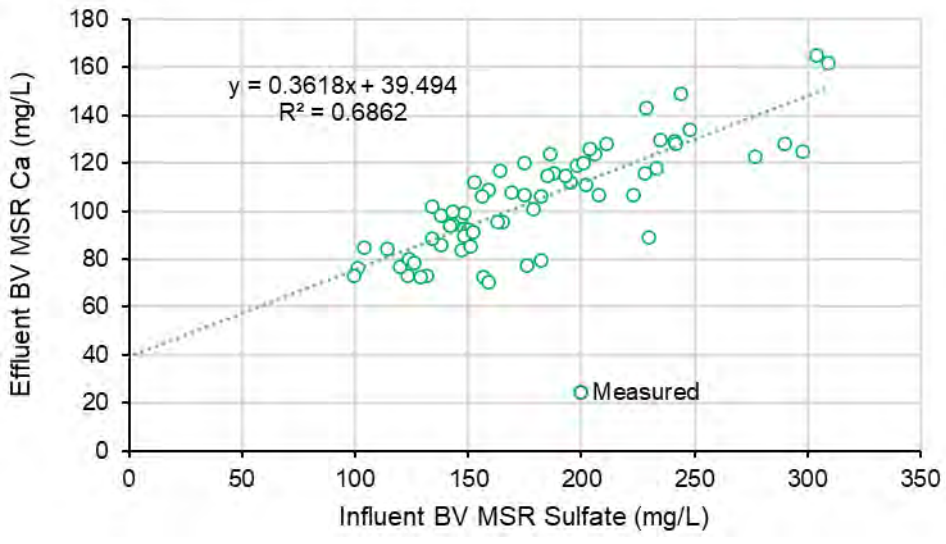


Figure 27: MSR influent sulfate versus MSR effluent Ca

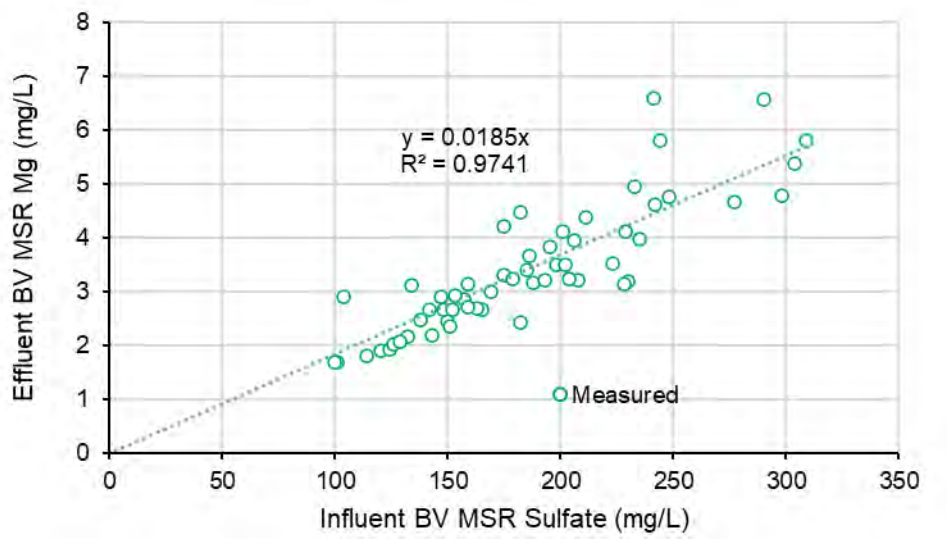


Figure 28: MSR influent sulfate versus MSR effluent Mg.

Table 29: MSR Treatment + Polishing Pond Efficiencies

PARAMETER	TREATMENT EFFICIENCIES FACTOR	REFERENCE MSR
Stage 1: MSR Reactor Treatment		
Acidity	-	BV MSR
Alkalinity	-	BV MSR
Ca	A [2]	BV MSR
Mg	A [2]	BV MSR
Na	-	-
K	-	-
SO_4	0.104	BV MSR
Al	0.997	BV MSR
Fe	0.8 [3]	BV MSR
Ni	0.402	BV MSR
Mn	0.586	BV MSR
Cr	-	BV MSR
Cd	0.0189	BV MSR
Co	0.828	BV MSR
Cu	0.966	BV MSR
Pb	0.858	BV MSR
Tl	-	-
Zn	0.637	BV MSR
Stage 2: MSR Polishing Pond Treatment of MSR Stage 1 Effluent		
Fe	0.99	Process Flow (2026)
Ni	0.125	Process Flow (2026)
Zn	0.590	Process Flow (2026)

1. *An efficiency of 80% is used rather than the measured 99.8% to account for the ELF being sub-oxic and some Fe(II) passing through the MSR untreated.*
2. *A - Determined by the relationships presented in Figure 27 and Figure 28.*

10.3 MSR and WTP Effluent Alkalinity

10.3.1 Introduction

The discharge of treated waters from the MSR and WTP can introduce waters that have elevated alkalinity compared to the receiving streams. The amount of alkalinity (measured as mg $CaCO_3$/L) is a function of whether the waters have been treated by $Ca(OH)_2$ or by passive treatment using $CaCO_3$ substrate. The use of $CaCO_3$-based media provides bicarbonate alkalinity (HCO_3^-) that can buffer acidity addition. The use of $Ca(OH)_2$ provides very little HCO_3^- such that there is little acid buffering capacity. This is explained in Figure 29, which shows significant alkalinity associated with the neutralisation of Mangatini Stream (at monitoring site MGIU) by limestone, yet no alkalinity when treated by $Ca(OH)_2$ or CaO as they contain no carbonate.

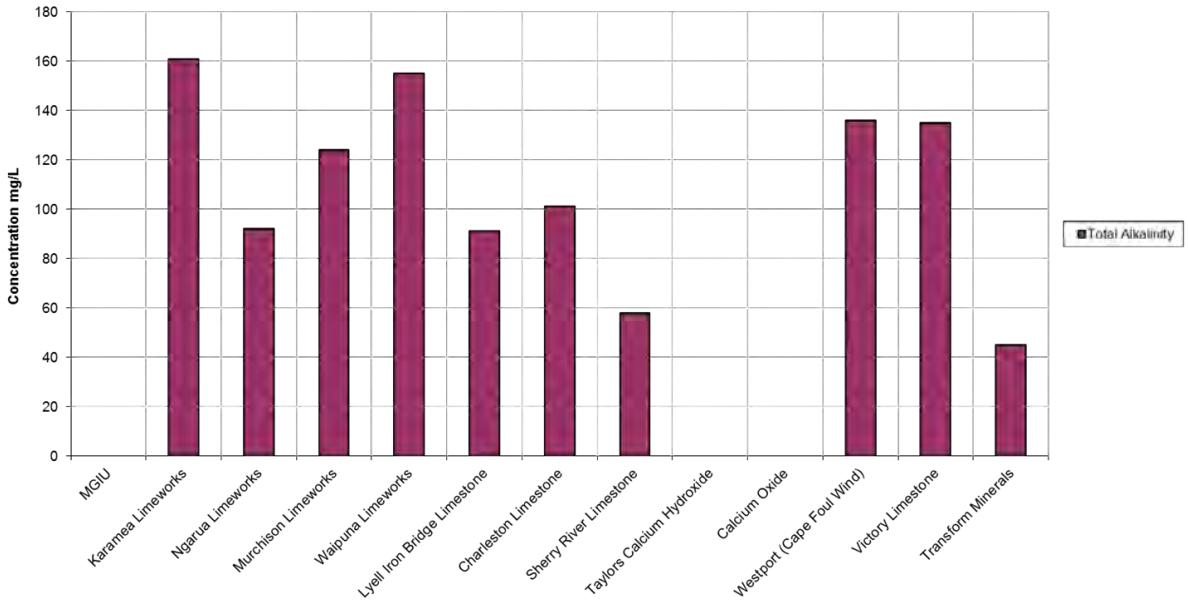


Figure 29: Alkalinity (mg $CaCO_3$/L) of Mangatini Stream after treatment

After limestone ($CaCO_3$) based products and $Ca(OH)_2$ and CaO based products. Site MGIU in the Mangatini stream (pH < 4) before treatment.

10.3.2 Alkalinity Modelling

No alkalinity adjustment is undertaken for the WTP due to the low alkalinity in the effluent (e.g., 5.5 mg $CaCO_3$/L) as shown in Table 28.

To account for the acid buffering capacity (e.g., the alkalinity) of the MSR effluent in the WLBM, trials were undertaken where MSR effluent was mixed with W-M2 background water (Process Flow, 2026). High alkalinity will buffer pH decrease hence the following approach was undertaken:

- Process Flow (2026) completed various mixing trial of MSR effluent with Whareatea River water (W-M2).
- The data for acidity and alkalinity for the various mixing trials were used to calculate the net alkalinity. It was assumed that at pH ~ 5 there would be no alkalinity.
- Net alkalinity was plotted against pH so that a natural log relationship could be derived for inclusion in the WLBM to estimate pH in the mixing of streams. This is shown in Figure 30.

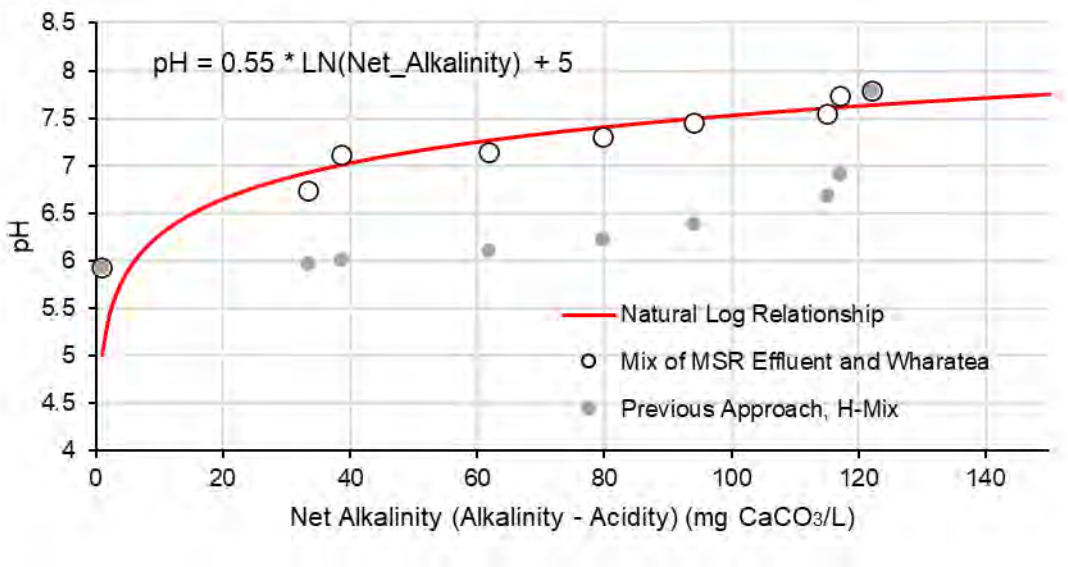


Figure 30: Net Alkalinity versus pH for laboratory test data:

Mixing of BV ELF MSR effluent with W-M2 water

As shown in Figure 30, the use of net alkalinity resulted in a higher pH compared to the preliminary model approach that only considered H^+ acidity. This relationship was used to model all mixing of MSR effluent with natural catchment waters.

11 CLOSING

This report provides source terms that are used in the WLBM to understand potential effects for the proposed BPCP.

11.1 Report Overview

The following comments are provided on this source term report. Each source term provides an explanation of how the source term was derived including:

- Background information to support the geochemical issues associated with the source term.
- Assumptions associated with the derivation of the source term.
- Risk for each source term and/or the mine domain it represents.
- Recommended performance monitoring to confirm the source term is suitable.

11.2 Adaptive Management

Once the BPCP is approved, ongoing monitoring of the individual components of the WLBM are recommended to validate their reliability as to quality and quantity.

If there is significant variance from the expected water quality for any sub-area domain then source terms and WLBM models should be updated in accordance with the principles of adaptive management.

12 REFERENCES

Australian and New Zealand Environment and Conservation Council (ANZG) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Canberra.

Chater, M. (2024). Rainfall-altitude gradient, SH67 to Mt Rochford, Denniston Plateau.

CRL, 2012. Geochemistry of rocks at the Escarpment mine site. CRL reference 12-41093. Dated 15 August 2012, 88 pp.

Elder, D.M., Pizey, M.H., Weber, P.A., Lindsay, P., Rossiter, P.J., Rutter, G.A., Thomas, D.G., Crombie, F.M., Cooper, T., Wildy, J.J., 2011. Addressing the environmental effects of mining on the Ngakawau River. New Zealand Water Conference, Rotorua 9-10th November 2011.

Hickey, C.W., 2026. Buller Coal Plateaux Continuation Project: Water quality protection guidelines. Report prepared by RMA Science Ltd for Bathurst Resources Ltd.

Macara, G. (2016). The Climate and Weather of West Coast (2nd ed.). NIWA Science and Technology Series No.72. National Institute of Water and Atmospheric Research. ISSN 1173-038.

Mackenzie, A., 2008. Quantification of Millerton Road Cut ARD Generation Rates. Unpublished report for Solid Energy New Zealand Limited. 9 pp and accompanying Microsoft Excel file.

MWM (Mine Waste Management), 2026a. Upper Waimangaroa Haul Road Site Visit. Mine Waste Management Report: J-NZ0453-001-M-FINAL.

MWM (Mine Waste Management), 2026b. Escarpment Extended Water and Load Balance Model. Mine Waste Management Report: J-NZ0433-003-FINAL.

MWM (Mine Waste Management), 2026c. Mount Frederick South Water and Load Balance Model. Mine Waste Management Report: J-NZ0377-003-FINAL.

MWM (Mine Waste Management), 2026d. Factual Report: Column Leach Testing - Mount Frederick South Sub-area. Mine Waste Management Report: J-NZ0377-005-R-FINAL.

MWM (Mine Waste Management), 2026e. Mussel Shell Reactor Design Toolkit - Buller Plateaux Continuation Project. Mine Waste Management Report: J-NZ0453-005-R-FINAL.

MWM (Mine Waste Management), 2026f. Escarpment Mine – Mussel Shell Reactor Performance Management. Mine Waste Management Report: J-NZ0349-010-M-FINAL

MWM (Mine Waste Management), 2026g – Construction Phase Report: Buller Plateaux Continuation Project. Mine Waste Management Report: J-NZ0453-007-R-FINAL

MWM (Mine Waste Management), 2026h. Factual Report: Geoenvironmental Hazards – Mount Frederick South Sub-area. Mine Waste Management Report: J-NZ0377-001-R-FINAL.

MWM (Mine Waste Management), 2026i. Escarpment Mine – Barren Valley ELF Water Quality Model. Mine Waste Management Report: J-NZ0349-008-R-FINAL.

MWM (Mine Waste Management), 2026j. ELF Water Quality and MSR Design Summary - Buller Plateaux Continuation Project. Mine Waste Management Report: J-NZ0453-006-R-FINAL.

MWM (Mine Waste Management), 2026k. MGIU TSS Review. Mine Waste Management Report: J-NZ0433-013-M-FINAL.

MWM (Mine Waste Management), 2026l. Background Surface Water Quality Review Report – Buller Plateaux Continuation Project. Mine Waste Management Report: J-NZ0472-001-R-FINAL.

MWM (Mine Waste Management), 2026m. Previous TSS Studies. Mine Waste Management Report: J-NZ0433-014-M-FINAL.

O'Kane Consultants, 2014. Escarpment Mine Project – Estimation of Draindown Seepage for Engineered Landform (ELF). Okane Consultants Memorandum dated 17 January 2014.

O'Kane Consultants Ltd., 2015. Acid Mine Drainage Liabilities – Stockton and Cypress Operations. Technical report prepared for Solid Energy New Zealand Ltd. Report No. 949/01-01. Dated July 2015.

Pope, J., Christenson, H., Gordon, K., Newman, N., Trumm, D., 2018a. Decrease in acid mine drainage release rate from mine pit walls in Brunner Coal Measures. New Zealand Journal of Geology and Geophysics, Vol. 61, No. 2, 195–206.

Pope, J., Christenson, H., Gordon, K., Newman, N., Trumm, D., 2018b. Erratum: Decrease in acid mine drainage release rate from mine pit walls in Brunner Coal Measures. New Zealand Journal of Geology and Geophysics, Vol 61, No. 4, page 578.

Pope. J., Rait. R., Newman. N., Hay. S., Rogers. M., McCraken. L. 2011. Geochemical studies of waste rock at proposed Escarpment open cast mine, Denniston Plateau West Coast. AusIMM New Zealand Branch Conference 2011, Queenstown, pp. 369-380.

Process Flow Limited, 2026. Active Water Treatment Testing Report – Summary of Tests. Document Number: PFL-2408-PRO-RPT-00001.

Weber, P.A., Olds, W.E., Bird, B., Pearce, J., 2015. Forecasting long term water quality at closure for current mining operations. New Zealand Annual AusIMM Branch Conference, Dunedin, 31 August – 2 September 2015, pp 495-505.

Weber, P., Reid, N., Robson, T., 2021. Nitrate and AMD: An opportunity to innovate. Virtual ICARD 2021, 21 – 23 September 2021. https://www.icard2021.com

WM Group, 2014. Escarpment Mine Project – Assessment of Revised Water Management Approach. Prepared for Buller Coal Limited, February 2014. Report 12001-036-R-002.

13 LIMITATIONS

Attention is drawn to the document “Limitations”, which is included in Appendix B of this report. The statements presented in this document are intended to provide advice on what the realistic expectations of this report should be, and to present recommendations on how to minimise the risks associated with this project. The document is not intended to reduce the level of responsibility accepted by Mine Waste Management, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in doing so.

APPENDIX A LIMITATIONS

This Document has been provided by Mine Waste Management Ltd (MWM) subject to the following limitations:

This Document has been prepared for the particular purpose outlined in MWM's proposal and no responsibility is accepted for the use of this Document, in whole or in part, in other contexts or for any other purpose.

The scope and the period of MWM's services are as described in MWM's proposal, and are subject to restrictions and limitations. MWM did not perform a complete assessment of all possible conditions or circumstances that may exist at the site referenced in this Document. If a service is not expressly indicated, do not assume it has been provided. If a matter is not addressed, do not assume that any determination has been made by MWM in regards to it.

Conditions may exist which were undetectable given the limited nature of the enquiry MWM was retained to undertake with respect to the site. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account in the Document. Accordingly, additional studies and actions may be required.

In addition, it is recognised that the passage of time affects the information and assessment provided in this Document. MWM's opinions are based upon information that existed at the time of the production of this Document. It is understood that the services provided allowed MWM to form no more than an opinion of the actual conditions of the site at the time the site was reviewed and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings, or any laws or regulations.

Any assessments made in this Document are based on the conditions indicated from published sources and the investigation described. No warranty is included, either express or implied, that the actual conditions will conform exactly to the assessments contained in this Document.

Where data supplied by the client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by MWM for incomplete or inaccurate data supplied by others.

MWM may have retained subconsultants affiliated with MWM to provide services for the benefit of MWM. To the maximum extent allowed by law, the Client acknowledges and agrees it will not have any direct legal recourse to, and waives any claim, demand, or cause of action against, MWM's affiliated companies, and their employees, officers and directors.

This Document is provided for sole use by Bathurst Resources Limited and is confidential to it and its professional advisers. No responsibility whatsoever for the contents of this Document will be accepted to any person other than the Client. Any use which a third party makes of this Document, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. MWM accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this Document.

MWM acknowledges that this report will be relied on by a Panel appointed under the Fast-track Approvals Act 2024 and these disclaimers do not prevent that reliance.

MINE WASTE MANAGEMENT

GREENROAD GROUP

APPENDIX K ENGINEERED LANDFORM DESIGN PHILOSOPHY

Engineered Landform Design Philosophy

Buller Plateaux Continuation Project

20 July 2026

J-NZ0453-004-R-FINAL

MINE WASTE MANAGEMENT
GREENROAD GROUP

BATHURST
RESOURCES LIMITED

Engineered Landform Design Philosophy

Buller Plateaux Continuation Project

Document Number: J-NZ0453-004-R-FINAL

Document Date: 20 July 2026

Prepared for:

Bathurst Resources Limited

Bathurst Resources Limited

[redacted]

Prepared by:

Mine Waste Management Limited

5 Sir William Pickering Drive, Burnside, Christchurch 8053, New Zealand

[redacted]

www.minewaste.com.au

REVISION	DATE	AUTHOR	RECORD OF REVIEW
J-NZ0453-004-R-FINAL	20/07/2026	PW	PW

EXECUTIVE SUMMARY

Mine Waste Management Limited (MWM) has provided this engineered landform (ELF) design philosophy report to Bathurst Resources Limited (BRL) for the management of waste rock associated with the proposed Buller Plateaux Continuation Project (BPCP).

Objectives of this Study

The objectives of this study are to:

- Summarise literature and provide industry proven design objectives for ELFs.
- Provide recommendations to prevent and minimise the potential risks associated with acid and metalliferous drainage (AMD) using source control technologies.
- Provide recommendations on how waste rock could be managed within an ELF at the proposed BPCP.

Findings

Previous studies (e.g., Elder et al., 2011) have indicated that waste rock associated with the BPCP will generate significant quantities of acidity and metals, which could have an effect on the downstream environment if the project materials are not managed in an appropriate manner. One aspect of AMD management is source control to prevent sulfide mineral oxidation and the mobilisation of these oxidation products and other potential constituents of concern (PCOC) from landforms.

BRL has committed to proactive source control for the ESE, MFS, and UWHR project areas, using engineered landforms, which provides a foundation for sustainable waste rock management, aligning with INAP[1] (2024) principles for long-term environmental stewardship.

Management

This report provides a design philosophy for ELFs to prevent the oxidation of sulfides and minimise the mobilisation of any oxidation products by water. The applicable design objectives are incorporated into the AMD ELF Management Plan (BRL, 2026).

ELF construction will use industry best practice techniques (e.g., INAP, 2020, 2024) to minimise oxygen and water ingress into sulfide-bearing materials and hence control the potential geochemical hazards at their source. The current proposed design opportunities are explained in Table E1 and focus on minimising oxidation of sulfide minerals and mobilisation of oxidation products (e.g., water management).

[1] *International Network for Acid Prevention: https://www.inap.com.au/acid-drainage*

Table E1: ELF Design objectives and materials management recommendations.

DESIGN FEATURE	DESIGN OPPORTUNITIES
Foundation Preparation and Earthworks	• Mapping of the ELF basal footprint to ensure there are no direct pathways to underground workings such that ELF seepage could drain to these workings and then discharge to the natural environment. Where these workings are identified and could be pathways for AMD, they should be sealed to prevent seepage loss to the receiving environment. An adaptive management approach within a conditions framework should be developed for this process. • Clean water diversion to minimise water/rock interaction during construction and minimise the volumes of water requiring treatment. • Any topographic surface level seeps emanating from within the footprint of the ELF should be directed into basal underdrainage network. • Non-Acid Forming (NAF) should be used as basal materials to minimise PCOC mobilisation due to seepage of water through these materials that could contribute to increased solute concentrations. • Construction of a basal underdrainage network to minimise water/rock interaction and reduce uncontrolled seepage pathways to ensure waters report to designated locations for management/treatment. • Construction of sediment ponds to flood the underdrain(s) and be available for passive treatment at closure (if required).
Clean Water Management	• Clean water diversion to minimise water/rock interaction and minimise the volumes of water requiring treatment. • ELF design to shed water as quickly as practical to reduce infiltration[1]. • Compaction of final Potentially Acid Forming (PAF) surfaces (batter slopes by dozer) to shed water. Noting that compaction of Non-Acid Forming (NAF) is to be avoided if lateral seepage will report to the batter slope. • Restrict/prevent ponding of water on the ELF footprint to reduce net percolation[1].
Materials Management	• Development of a material schedule and management process. • Where practicable, minimise time between blasting and placement of materials in the ELF. • Ensure blasting generates materials that will create matrix supported materials rather than generating coarse materials that will create clast supported materials that will enable advective oxygen flow. • The management process will ensure the correct materials are available and are placed in the correct location. This will be completed for all stages of mine planning, ideally avoiding a double handle of materials and limiting the amount of time that PAF materials are exposed before being covered. This will include topsoil and NAF scheduling for progressive rehabilitation.
Lift Height	• Commence construction of new ELFs using a 2-5 m lift height and validate that oxygen ingress is limited to diffusion. • Operate low tip heads (e.g., ~3 m in height) and confirm that advective airflow is eliminated.

DESIGN FEATURE	DESIGN OPPORTUNITIES
	• Undertake studies to confirm whether higher lifts (e.g., > 5m) can be used, yet advective oxygen ingress is prevented and diffusion of oxygen is limited to 10 m horizontal depth into the ELF. • Confirm grainsize segregation does not occur via test pitting or tip head inspections. • Ensure compaction of lift running surfaces to minimises advective airflow using traffic management procedures.
Encapsulation	• Placement of PAF and Highly acid forming (HAF) waste rock in the core of the ELF surrounded by low risk (lower sulfur materials) and then NAF materials. • Avoid PAF and HAF being placed on the outside edge of each lift during ELF construction. • Ensure a minimum of 1 m (thickness) of NAF is placed over PAF materials before soil placement. Based on mine scheduling a thicker NAF layer may be achievable.
Geochemical Controls	• Limestone dosing to the ELF materials will be undertaken. • Undertake trials to optimise limestone dosing (e.g., higher application rates in the oxidising outer sections of the ELF and lesser rates in the core of the ELF.
Geotechnical Stability	• Long term geotechnical stability is required to ensure ELFs are safe and stable. Stability is required to ensure that PAF materials will not be exposed in the long term, which could lead to AMD.
Cover System	• Develop and install a final rehabilitated cover system to limit net percolation and oxygen flux (further details in MWM, 2026b). • Measure cover system performance in regard to oxygen and water flux.
Progressive Rehabilitation	• During construction of the ELF, where practical, provide immediate surfaces for rehabilitation. • Placement of NAF, soils, and vegetation to reduce net percolation of rainfall. • Direct vegetation transfer should be considered where practicable and will reduce sediment loss from the ELF.
Performance Monitoring	• Geochemical characterisation and quality assurance / quality control (QA/QC) • Grainsize segregation and lift height • Compaction of running surfaces • Oxygen ingress depth • Net percolation rates (as measured by seepage flow rates) • Seepage water quality
Sign-off	• Confirmation that final landforms (ELFs and water management infrastructure) are acceptable for closure requires sign-off by the Engineer of Record (EoR). • Confirmation that final landforms are geochemically stable at closure and water treatment is appropriate requires sign-off by a suitably qualified and experienced person (SQEP).

1. Some areas of the ELFs will be rehabilitated as tarns. These areas will be constructed to retain water (i.e., a low permeability base). Further details are in the AMD ELF MP (BRL,2026d). Noting that a water cover is an effective mechanism to prevent oxygen ingress

TABLE OF CONTENTS

1 Introduction 1
1.1 Background 1
1.2 Objectives 1
2 AMD Management Approach 3
2.1 Background 3
2.2 AMD Management Approach 3
3 Source Control 5
3.1 Background 5
3.2 Prevention of Sulfide Mineral Oxidation 6
3.3 Water Management 9
4 ELF Engineering Controls 10
4.1 Foundation Earthworks 10
4.2 Clean Water Management 11
4.3 Groundwater 11
4.4 Materials Management 11
4.5 Lift Height 12
4.6 Encapsulation 12
4.7 Geochemical Controls 14
4.8 Cover System 14
4.9 Progressive Rehabilitation 15
4.10 Water Management 15
5 Performance Monitoring 16
5.1 Background 16
5.2 Recommendations 16
Quality Assurance / Quality Control 16
6 Health and Safety Considerations 17
6.1 Benefits of Lower Lift Heights 17
7 Summary 18
7.1 Overview 18
7.2 Further Work 18
8 References 19
9 Limitations 21
Appendix A Limitations 22

LIST OF TABLES

Table 1. AMD Management Steps. 3
Table 2. Clast vs matrix supported ELF. 12

LIST OF FIGURES

Figure 1. Oxygen content with horizontal depth into the Cypress North ELF. 6
Figure 2. Advective air flow driven by grainsize segregation. 7
Figure 3. Conceptual gas transport regime in a WRS with no engineering controls. 7
Figure 4. Conceptual gas transport regime into an ELF with trafficked air-entry disrupting running surfaces. 8
Figure 5. Grainsize segregation: high tipheads. 9
Figure 6. Acid generation rate (due to oxygen diffusion) as a function of cover thickness. 13
Figure 7. Advective toe barrier. 14

1 INTRODUCTION

Mine Waste Management Limited (MWM) has provided this engineered landform (ELF) design philosophy report to Bathurst Resources Limited (BRL) for the management of waste rock associated with the proposed Buller Plateaux Continuation Project (BPCP).

1.1 Background

BRL is seeking to obtain authorisation through the Fast-track Approvals Act (FTA) to progress development and mining of the coal resources across the wider Buller Plateaux.

The purpose of the BPCP is to secure the existing infrastructure and mining operations associated with the Stockton Mine and provide access to additional mining areas as the coal resources in the current operations are depleted. The project proposes to mine approximately 20 million tonnes of coking coal utilising existing infrastructure facilities over a 25-year timeframe to support and extend the mine life of the current Stockton Mine operations. There are four key project sub-areas:

1. Stockton.
2. Mount Frederick South (MFS).
3. Escarpment Extended (ESE).
4. Upper Waimangaroa Haul Road (UWHR).

MWM has developed this report to support BRL with the assessment of environmental effects (AEE) for its proposed mining activities for MFS and ESE.

Previous studies (e.g., MWM, 2026a) have indicated that waste rock could generate significant quantities of acidity and metals (i.e., acid and metalliferous drainage [AMD]) if the project materials are not managed in an appropriate manner, which could have an effect on the downstream environment. One aspect of AMD management is source control to prevent sulfide mineral oxidation and the mobilisation of these oxidation products and other potential constituents of concern (PCOC) from landforms to groundwater or surface waterways.

BRL has committed to proactive source control, using engineered landforms (ELFs), which provides a foundation for sustainable waste rock management, aligning with INAP[2] (2024) principles for long-term management of AMD that supports environmental stewardship.

This report provides the supporting information and technical data to demonstrate the benefits of an ELF to mitigate long term risks associated with AMD from waste rock associated with the Brunner Coal Measures.

1.2 Objectives

The objectives of this report are to:

- Summarise literature and provide industry proven design concepts for ELFs.

[2] *International Network for Acid Prevention: https://www.inap.com.au/acid-drainage*

- Provide recommendations to prevent and minimise the potential risks associated with AMD using source control technologies.
- Provide recommendations on how waste rock could be managed within an ELF at the proposed BPCP.

2 AMD MANAGEMENT APPROACH

This section describes the general approach to how AMD risks are managed.

2.1 Background

AMD needs to be managed to reduce health and safety risks for on-site staff and communities, reduce deleterious effects to the environment, and ensure that appropriate closure of the site can be achieved at the end of mining activities. This requires six AMD management steps to be undertaken as a holistic approach to AMD management, which is based on international industry proven guidance (e.g., International Network for Acid Prevention (INAP), 2014; DFAT, 2016). The six AMD management steps include:

1. Set Closure Goals
2. Predict
3. Prevent
4. Minimise
5. Control and Treat
6. Monitor Performance

These steps form the basis for any comprehensive AMD Management Plan, which is often supported by a risk assessment process and the development of site-specific operational controls to manage these risks and/or uncertainties. The AMD risk assessment process is based on data obtained from AMD prediction activities and determines the engineering controls requirements for the project (e.g., prevention, minimisation, control and treat).

2.2 AMD Management Approach

This section provides a high-level summary of the six steps of AMD management for context. This report focuses on prevention and minimisation of AMD, being key source control techniques

Table 1. AMD Management Steps.

AMD MANAGEMENT STEP	EXPLANATION	RELATED DOCUMENTS FOR THE BPCP
Set Closure Goals	• Closure goals are set in order to minimise legacy issues associated with potential AMD sources and any in-perpetuity uncontrolled AMD from mine domains containing AMD generating materials. • These goals are re-evaluated throughout the mine life and compared against performance monitoring results. • Closure goals should consider baseline conditions.	• Water quality objectives • Baseline water quality studies
Predict	• Prediction is critical to understanding the potential, severity, and longevity of AMD. • Prediction is facilitated by geochemical analysis, interpretations and a risk assessment. • A key prediction objective is to estimate water quality generated by various materials and mine domains that have the potential to generate AMD.	• AMD geochemistry reports • Water and load balance model reports • AMD ELF Management Plan that explains ongoing materials characterisation.

AMD MANAGEMENT STEP	EXPLANATION	RELATED DOCUMENTS FOR THE BPCP
Prevent	• Prevention of sulfide mineral oxidation, where practicable, is a key management step for AMD. • The prevention of AMD relates to reducing sulfide mineral oxidation as much as practicable by limiting the ingress of oxygen into a mine domain where it can oxidise sulfide minerals. • Prevention strategies are implemented during operations to manage a future risk.	• This memorandum. • AMD ELF Management Plan that explains the methods to be utilised to prevent pyrite oxidation.
Minimise	• Where prevention is not practicable, or has already occurred, the next management step involves minimising the contaminant load reporting to the receiving environment. • This often involves progressive rehabilitation strategies focused on minimising ongoing sulfide oxidation (potential oxidation products) and the mobilisation of oxidation products by minimising net percolation through the waste rock.	• This memorandum. • AMD ELF Management Plan that explains the methods to be utilised to prevent the mobilisation of PCOC.
Control and Treat	• Although the objective is to prevent and minimise AMD, control and treat measures are an important step in managing the effects of AMD to the receiving environment.	• Water and load balance model reports • Active Treatment • Passive Treatment • AMD Sludge Management. • AMD Water Management Plan on how AMD will be controlled and treated.
Monitor Performance	• Performance monitoring should be conducted to regularly evaluate how AMD management techniques are performing openly and objectively against closure goals and success criteria (ICMM, 2019).	• AMD ELF Management Plan. • AMD Water Management Plan

3 SOURCE CONTROL

Prevention and minimisation of AMD can be considered engineering controls to manage the AMD source hazard. This section discusses source control technologies for the proposed engineered landforms that would contain waste rock at the BPCP.

3.1 Background

Source control involves the prevention of sulfide mineral oxidation (where possible) and minimisation of contact water to reduce the mobilisation of oxidation products. Source control reduces the risks of long-term AMD management by tempering the maximum potential AMD risk at closure that requires mitigation / management.

Generally waste rock stacks (WRS) represent 60 - 80% of a site's AMD contaminant load (INAP, 2020) if the AMD source hazard is not managed appropriately. International case studies are available (e.g., Weber et al., 2017) to demonstrate the higher proportion of AMD associated with waste rock storage domains. Hence there is a strong driver to incorporate waste rock into engineered landforms that address the key principles of AMD source control: Prevention and Minimisation.

Many examples of successful source control for engineered landforms are from New Zealand. INAP (2020) notes the following sites as examples:

- Cypress Coal Mine, Stockton.
- Stockton Coal Mine.
- Reddale Coal Mine.
- Escarpment Coal Mine.
- Waihi Gold Mine (Martha Mine).

Other New Zealand sites that have utilised engineered landforms include:

- Macraes Gold Mine (Coronation North Landform).
- Canterbury Coal Mine.

Data presented for these sites (e.g., Pope et al., 2016; Weber et al., 2013) indicates that oxygen ingress into an ELF is not more than 5-10 m horizontally (e.g., as shown for the Cypress ELF, Stockton Coal Mine - Figure 1) if source control strategies are employed.

Such observed decreases in oxygen content with depth into a WRS indicate that oxygen ingress is by diffusion rather than advective ingress of oxygen (Ritchie, 1994). Advective ingress of oxygen is generally the dominant driver of oxygen flux into a WRS. Hence, a key design objective for ELF construction is a landform design that prevents significant advective oxygen flux. Advective oxygen flux will be managed by the ELF design.

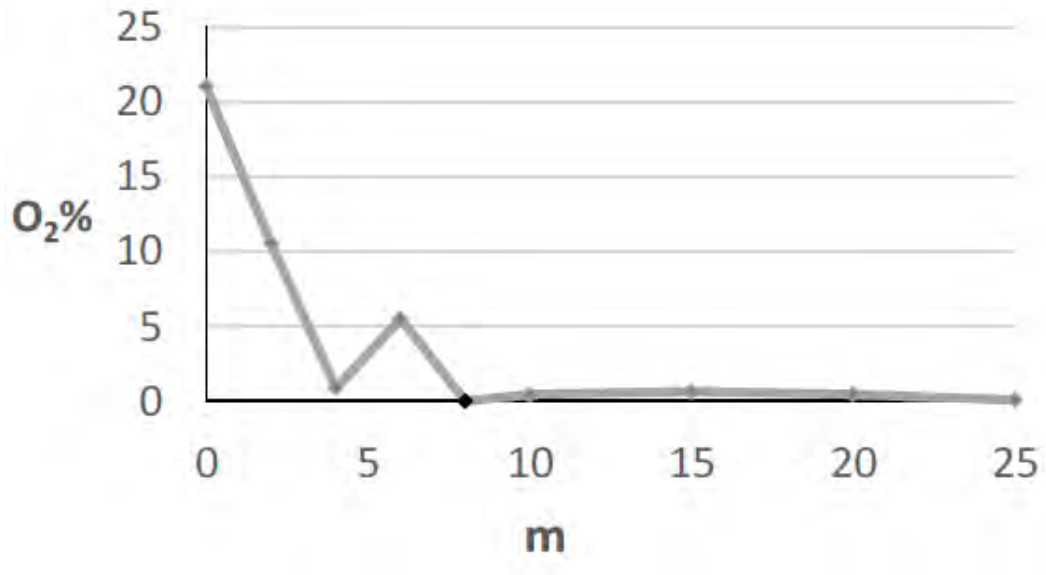


Figure 1. Oxygen content with horizontal depth into the Cypress North ELF.
Source: Pope et al., 2016.

3.2 Prevention of Sulfide Mineral Oxidation

Waste rock that is end dumped in high lifts (>4-6 m in height) and the associated kinetic energy can result in grainsize segregation and the development of alternating coarse-textured and fine-textured bedding planes of poorly graded and well sorted material with high vertical airflow capacity (e.g., Fala et al., 2003; Wilson, 2008). This also results in an overall downward coarser grading providing higher airflow capacity deeper into the facility. In addition, the fall of rocks / cobbles from the end-tipped / dozer pushed material results in the development of a coarse basal layer with high lateral airflow capacity that provides oxygen ingress pathways into the core of the WRS as shown in Figure 2.

Blasting can also influence the risks for grainsize segregation. Hence, there is benefit in ensuring blasting generates materials that will create matrix supported materials rather than generating coarser materials that will create clast supported materials that will enable advective oxygen flow.

The dominant process for oxygen flux is by the advective and convective flow of oxygen (temperature differences, barometric pressure differences) along coarser waste rock layers that form within poorly constructed WRS. Work completed by Brown et al. (2014) has demonstrated that in a poorly constructed WRS, advection accounts for ~90% of oxygen ingress, and that diffusion of oxygen accounts for 10%.

Hence, a key control to prevent sulfide mineral oxidation and minimise the effects on seepage waters from WRS is to prevent the advective ingress of oxygen.

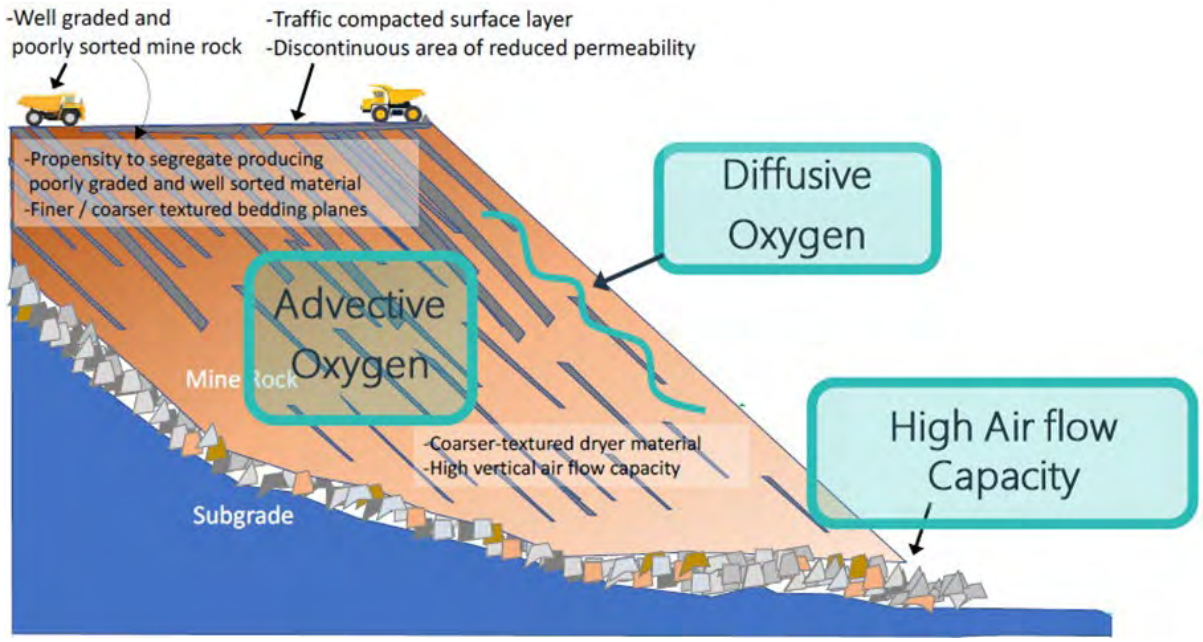


Figure 2. Advective air flow driven by grainsize segregation.

Source: Meiers (2020).

International research (INAP, 2020; 2024) has demonstrated that one of the most effective methods to minimise advective ingress of oxygen into WRSs is to minimise the height of the tiphead to <4 - 6 m and ensure that each lift has a compacted engineered surface, which reduces the size of the advective cell (both vertically and horizontally into the WRS; Figure 3 and Figure 4). Reducing oxygen ingress reduces sulfide mineral oxidation and hence the risks associated with AMD.

The establishment of multiple traffic compacted lifts also reduces the height of advective oxygen ingress to these cells.

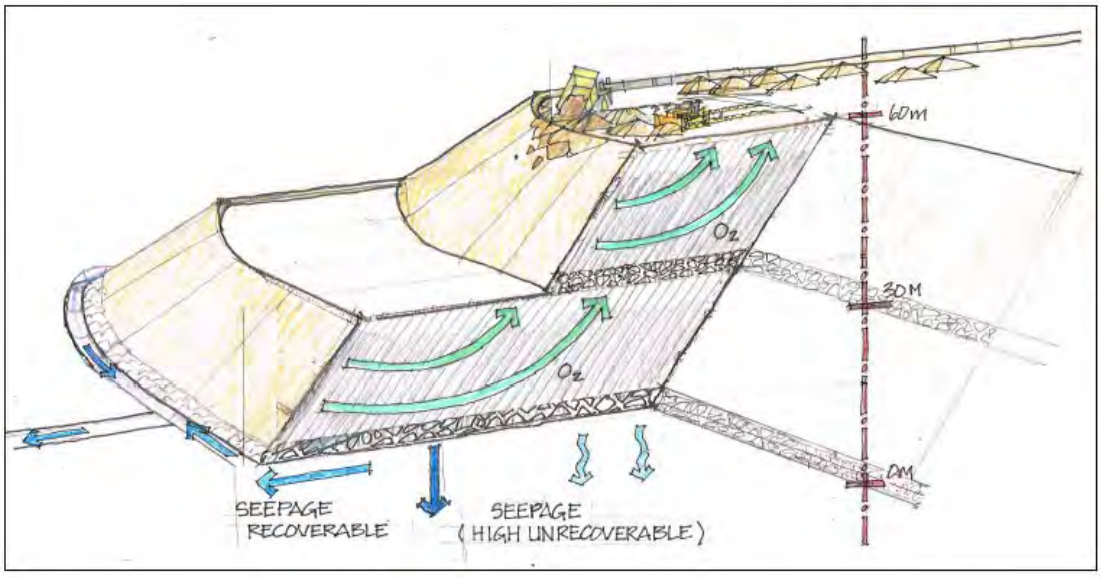


Figure 3. Conceptual gas transport regime in a WRS with no engineering controls.

Source: INAP (2024): Significant horizontal ingress along the basal chimney zone and significant vertical rise upwards along ch*imney zones.*

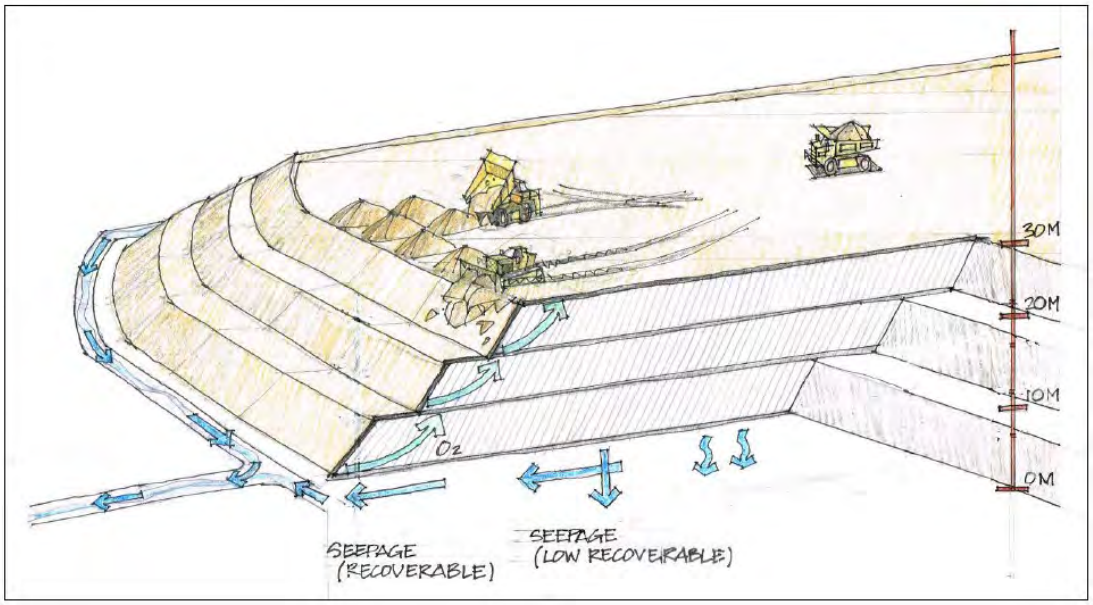


Figure 4. Conceptual gas transport regime into an ELF with trafficked air-entry disrupting running surfaces.

Source: INAP (2024): Limited oxygen ingress horizontally due to a lack of a basal rubble layer; limited vertical oxygen rise due to lower permeability running surfaces.

INAP (2024) note that an "Engineered Fill' approach "*allows for the ability to more accurately model and predict O_2 ingress and the volume and quality of recoverable seepage requiring treatment over time*" and that "this approach focuses on prevention, rather than a cure". This 'Engineered Fill' approach manages AMD "risks through implementation of source control, progressive reclamation, and cover systems, which allows for opportunities to move from active to passive water treatment over time thereby reducing asset liability, and likelihood of in-perpetuity management".

Figure 5 shows the impact of various grain-sized materials on the gas flux rate and acidity generation. Employing techniques like short lifts and paddock dumping effectively reduces oxygen ingress, leading to reduced sulfide mineral oxidation and, consequently, mitigating the potential risks associated with AMD.

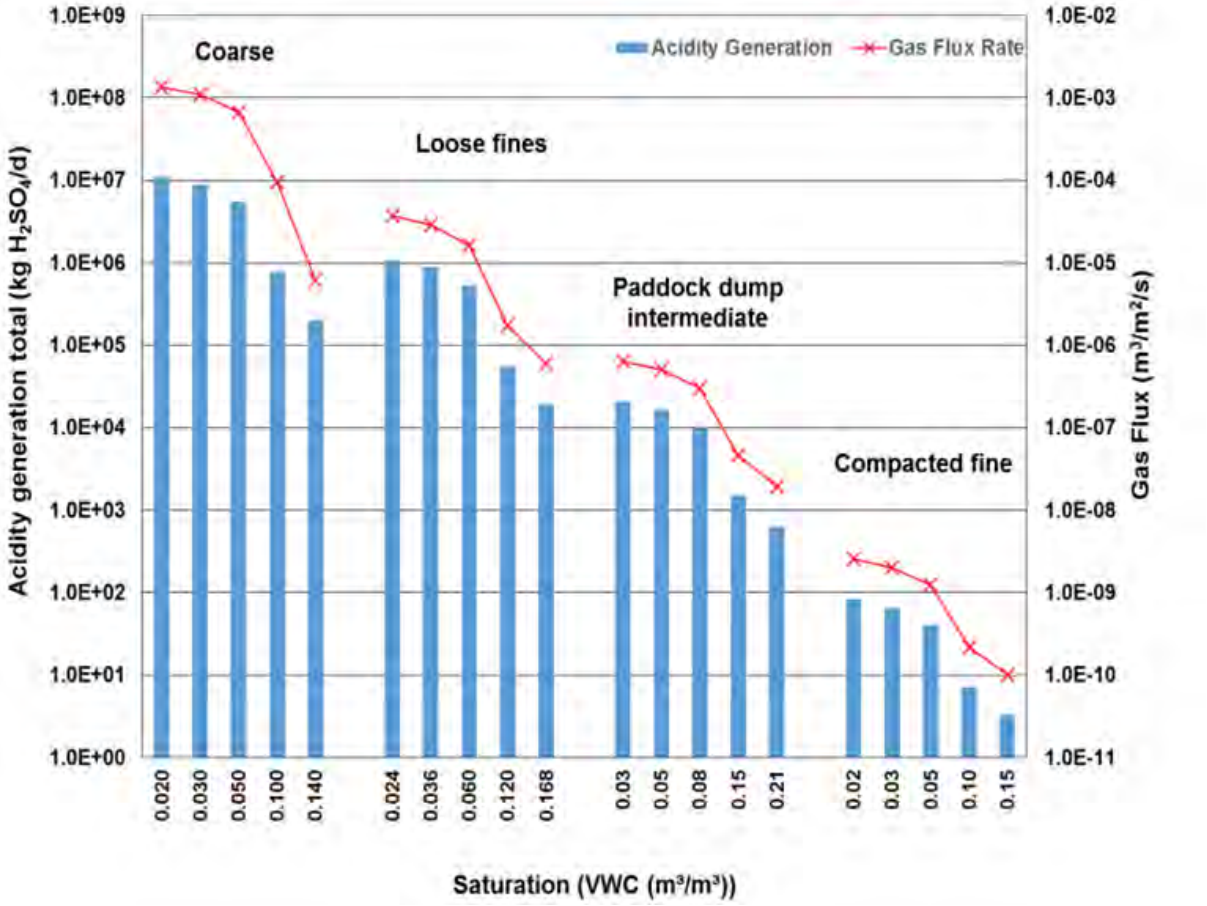


Figure 5. Grainsize segregation: high tipheads.

Source: Pearce et al (2016).

3.3 Water Management

Water flow through materials that contain sulfide oxidation products is the primary pathway for mobilisation of contaminants and the generation of AMD impacted waters. Diversion of run-on water and reducing infiltration of water into materials containing sulfide minerals, or sulfide mineral oxidation products, is a key management step for the minimisation of AMD. Often this is site specific and is dependent on climate, topography, location of mine domains, etc.

4 ELF ENGINEERING CONTROLS

The following section reviews source control opportunities for the BPCP. Appropriate design objectives can then be integrated into the mine schedule and the AMD ELF Management Plan (BRL, 2026). Note: The guidance provided needs to be considered by a competent geotechnical engineer as being appropriate for geotechnical risks.

4.1 Foundation Earthworks

The following is recommended for the starter lift:

- Mapping of the ELF footprint to ensure there are no direct pathways to underground workings such that ELF seepage could drain to these workings. For instance:
    - NSUL NAF ELF footprint has been mapped (Holmes, 2024), which confirmed no direct connection to the Sullivan underground workings
    - Any natural seeps should be identified during foundation mapping so that these waters can be managed / controlled as cleanwater.
- Where these workings are identified and could be pathways for AMD, they should be sealed to prevent seepage loss to underground workings A management process is required for the management of these underground workings.
- Clean water upstream of the ELF could be piped or drained around the facility as a management option during the operational phase of the mine to minimise water/rock interactions.
- Any topographic surface level seeps emanating from within the footprint of the ELF should be directed into basal underdrainage network.
- Basal lift materials should be NAF where they are likely to be in contact with seeps.
- Prior to construction of the first starter lift, ensure a drainage pathway (underdrain) is created so that any seepage from the ELF is directed to a few locations. The purpose is to avoid uncontrolled diffuse flow of AMD seepage. The outflow of the underdrain needs to be designed to prevent oxygen ingress into the ELF.
- Materials used for the underdrain should be inert, low sulfur materials and be sized to provide adequate permeability for the designed underdrainage flows. This will be designed by a suitably qualified and experienced engineer.
- Collection ponds should be constructed at the base of the underdrains once the ELF batter slopes achieve a certain height above the seepage point to ensure the underdrain remains flooded (to prevent the ingress of oxygen). If permanent saturation of the underdrain is not possible then a piped u-bend may be required through the toe bunds.
- Collection ponds can be repurposed as passive treatment systems for ELF seepage at mine closure if this is required. Collection ponds need to remain flooded to ensure the underdrains are not pathways for airflow.

4.2 Clean Water Management

Water flow through materials can mobilise stored acidic oxidation products and other PCOC. The following is recommended for ELF water management:

- Diversion of clean run-on water from upslope areas away from the ELF.
- Design of the ELF batter slopes and running surfaces to shed water as quickly as possible.
- Design running surfaces to grade gently back down towards the centre of the ELF (or away of ELF batter slopes) to connect with the haul road (drainage path off the ELF).
- Maintain a well graded drainage system along roadways used during ELF construction.
- Where practicable, avoid ponding of water on waste rock (e.g., avoid sediment sumps on ELF surfaces).
- Compaction of the ELF running surfaces during operations to shed water and minimise infiltration of rainwater thus reducing the volume of seepage water.
- Flattening out any paddock dumped materials and ideally wheel roll or compact to allow water to shed water before significant rainfall events.

4.3 Groundwater

ELFs will generate AMD, potentially influencing groundwater quality where seepage is not fully captured. The following comments are provided:

- At the base of in-pit ELFs, the lower conductivity rock mass will promote seepage to preferentially follow the coal floor/pit floor surface. Sub-ELF underdrains and perimeter drains will be cut into the bedrock above the phreatic surface to control seepage flow paths and direct seepage to water management structures.
- Seepage from in-pit ELFs to underground workings should be minimal due to sealing of highwalls with low permeability material. A management process is required for the management of these underground workings.

Post-closure, dewatering of mine pits will cease and groundwater levels will recover to some degree. This will result in reduced surface runoff and increased infiltration in areas where ELFs have been constructed, and potentially higher groundwater levels compared to baseline due to groundwater mounding within the ELF.

4.4 Materials Management

The following materials management processes need to be considered:

- Development of a materials schedule (and quantities) to ensure the correct materials are available and are placed in the correct location. This should be completed for all stages of mine planning, ideally avoiding a double handle of materials and limiting the amount of time that PAF materials are exposed before being covered. This will include topsoil scheduling.

- Minimise the time between blasting and placement of mineralised waste. This will reduce the oxidation of sulfide materials.
- Develop a traffic management plan to ensure the running surfaces are thoroughly compacted to minimise vertical rise of oxygen through the lift surfaces by advective processes.

4.5 Lift Height

It is recommended that the construction process and the height of end-tips is designed to prevent grainsize segregation and minimise advective flux of oxygen. Research has shown that tipheads <4 – 6 m do not generate grainsize segregation (Fala et al., 2003; Wilson, 2008), which reduces the risk of advective oxygen flux.

However, waste rock placement strategies and tiphead height will be specific to the project materials, the equipment used, and the climate. The following approach is proposed:

- Extensive paddock dumping will be avoided as this can lead to ponding of water, stability risks, and increased saturation of materials during wetter periods.
- Commence construction using a 2-5 m lift height.
- Operate low tip heads (e.g., ~3 m in height) and confirm that advective airflow is eliminated.
- Undertake studies to confirm whether higher lifts can be used (e.g., >5 m) yet advective oxygen ingress is prevented and diffusion of oxygen is limited to 10 m horizontal depth into the ELF.
- Undertake performance monitoring to confirm depth of oxygen ingress aligns with proposed design objectives of < 10 m horizontally.
- Confirm that segregation does not occur for different materials at different tiphead heights. Table 2 provides a high-level summary for the clast supported vs matrix supported ELF due to segregation processes.

Table 2. Clast vs matrix supported ELF.

ELF MATRIX	PROPERTIES	COMMENTS
Clast Supported	Greater porosity Greater air voids Lower density	End-tipping results in the separation of coarser and finer particles creating a material that tends to be clast supported with higher overall porosity
Matrix Supported	Lower porosity Less air voids High density	Paddock dumping and low-lift heights prevents material segregation such that the coarser materials are supported by a matrix of finer materials leading to lower porosity. Noting that co disposal of finer materials (e.g., sediment) has the ability to create materials that are clast supported.

4.6 Encapsulation

The encapsulation of reactive sulfide-rich materials with lower risk materials is a proven source control technology to reduce sulfide mineral oxidation. The greater the thickness of low sulfur bearing encapsulating material, the less oxygen diffusion from the atmosphere to the reactive materials (e.g., Figure 6), assuming that advective and convective airflow is minimised by material placement strategies.

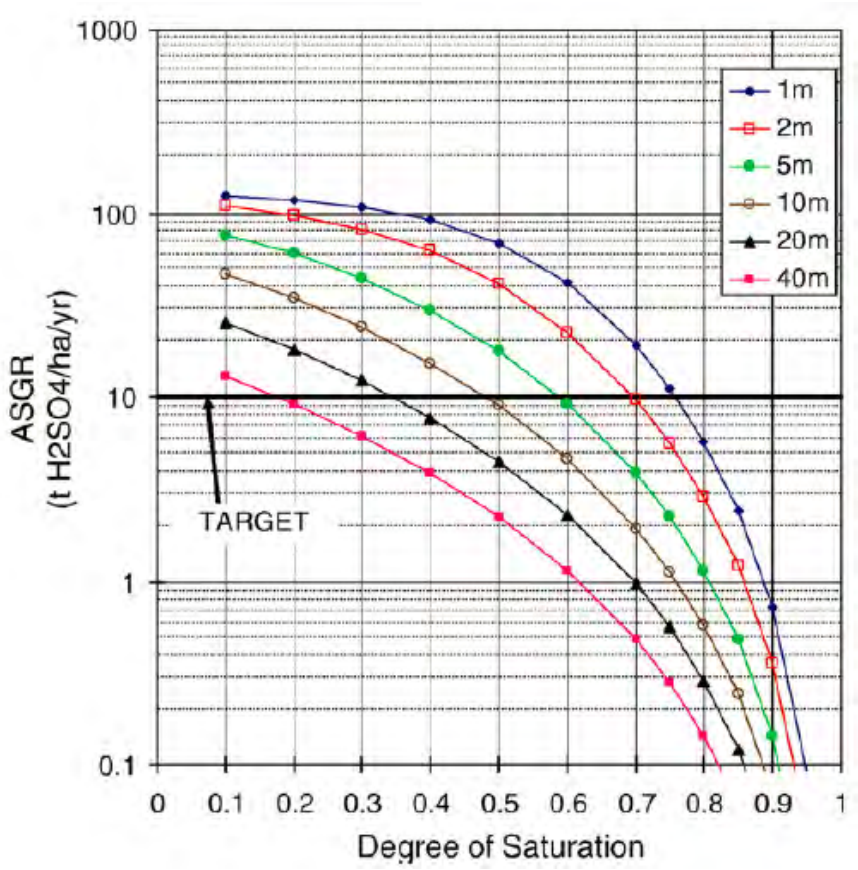


Figure 6. Acid generation rate (due to oxygen diffusion) as a function of cover thickness.

Source: Miller et al., 2010.

ASGR = Acid sulfate generation rate

Material thickness (1 m to 40 m) relates to the thickness of low sulfur non-acid forming materials

For the BPCP the following encapsulation options could be undertaken if required:

- Placement of higher sulfur materials towards the centre of each lift in a zone of limited airflow. As shown in Figure 4, this prevents higher-risk material from being within the zone of higher oxygen movement (e.g., the advective cell) near the front batter slopes of an ELF. The size of these zones and the number of individual zones will be a function of the materials schedule.
- Development of a perimeter bund of paddock dumped waste rock can be undertaken where grainsize segregation has occurred. This can then be compacted as a toe barrier. Toe barriers have been proposed for other projects to limit oxygen ingress where grainsize segregation has occurred (e.g., Figure 7). Further work is required to confirm the material properties required, height, and width of any advective toe barrier if this engineering control is required for the BPCP.

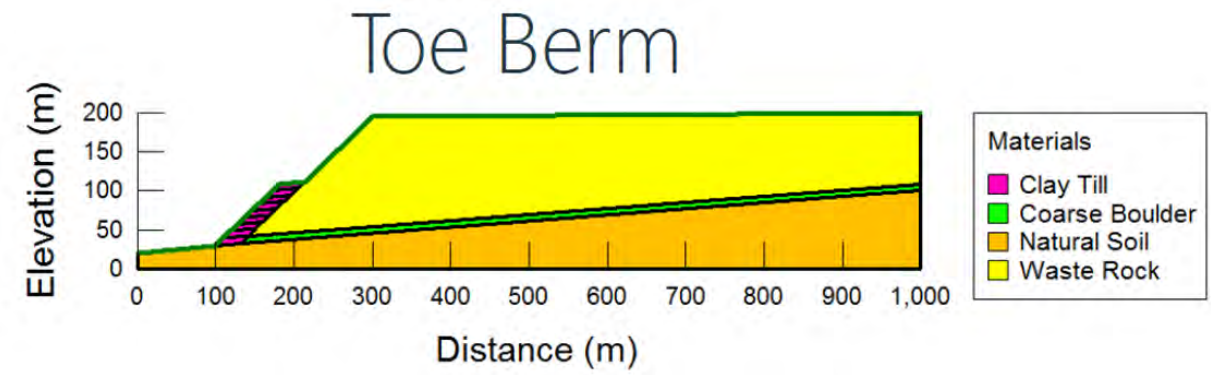


Figure 7. Advective toe barrier.

Source: Meiers (2020).

4.7 Geochemical Controls

The following geochemical controls are proposed:

Limestone will be applied to the running surfaces of each lift of the ELF or to each truckload of waste rock.

As shown by MWM (2026a), the application of limestone and the inherent acid neutralisation capacity of the Brunner Coal Measures can mitigate ~50% of the acidity generated by pyrite oxidation.

4.8 Cover System

A cover system can minimise the amount of oxygen flux and water percolation into an ELF as well as providing a stable revegetation medium. A variety of systems are available including soil/rock covers, low permeability compacted clays barrier layers, capillary breaks, geosynthetic clay layers, and membrane technology such as polythene that can minimise oxygen flux and net percolation. A cover system should be considered as one aspect of AMD management. INAP (2017) notes that cover systems for waste rock are designed to:

- Meet regulatory requirements.
- Divert clean water and reduce the volume of impacted surface water managed on site.
- Isolate chemically reactive waste material.
- Limit influx of oxygen and oxidation of certain minerals.
- Limit influx of meteoric water to limit oxidation of certain minerals and limit leaching and dilution of oxidation products.
- Control wind and water erosion of waste material as part of the overall landform stability.
- Provide a growth medium as the “building blocks” for establishing vegetation and ecosystems.

Types of cover systems include (INAP, 2017):

- Erosion-protection systems
- Store-and-release systems
- Enhanced store-and-release systems

- Barrier-type systems
- Cover systems with engineered layers
- Saturated soil or rock cover systems

MWM (2026b) has provided guidance on the expected net percolation rates (i.e., % of rainfall) for the engineered landforms at the proposed BPCP, which has been estimated at 40% (average value) based on the proposed cover system (topsoil with forest and shrubland vegetation). This flow will mobilise stored contaminants within the ELF mine domain.

MWM (2026b) has also assessed oxygen flux rates through the proposed cover system to understand long term acidity loads. Further details are available in that report.

4.9 Progressive Rehabilitation

Progressive rehabilitation will be a key component of the ELF construction process. This will include:

- Grading down materials from the dump crest to the toe of the batter slope and compaction with a dozer where required to reach the minimum NAF cover thickness.
- Placement of NAF materials.
- Topsoiling of the batter slope and the establishment of vegetation.
- Placement of VDT where practicable.

4.10 Water Management

Water management options need to be considered for the ELF and should be developed as part of a water load balance model (WLBM) process for the BPCP. This should include operational and post closure water management strategies (and any treatment requirements).

5 PERFORMANCE MONITORING

This section discusses performance monitoring for the proposed BPCP ELFs.

5.1 Background

Performance monitoring is an important aspect of AMD management and should include leading and lagging performance monitoring programs to confirm design objectives are being achieved. Performance monitoring provides the data to allow adaptive management in case there is a variance from the expected case and further actions are required to minimise potential effects. Performance monitoring should be designed around demonstrating success criteria (primarily based on design objectives) are being achieved and that performance can be demonstrated openly and objectively.

5.2 Recommendations

For the BPCP, performance monitoring could include, for instance:

- Monitoring of water quality and quantity at the discharge of the ELF underdrain to understand water quality effects and confirm net percolation rates.
- Monitoring of groundwater downgradient of the ELF to confirm that basal seepage into groundwater systems is not significant.
- Monitoring of oxygen flux into the ELF using nested oxygen probes and/or oxygen sensors to confirm the oxygen concentration.
- Installation of in-ELF lysimeters to validate net percolation rates are acceptable and meet design expectations.

Quality Assurance / Quality Control

Construction quality assurance / quality control (QA/QC) is also required during the construction of the ELF to ensure the facility has been constructed as per the basis of design. Construction QA/QC could include for instance:

- Geochemical characterisation of materials (pre-excavation and placement) for AMD risks.
- Auditing dig plans and GPS tracking to confirm disposal location as per design.
- Thickness of NAF cover systems
- Monitoring of tipheads to confirm that grainsize segregation is not occurring to ensure a clast supported matrix in the ELF is achieved.
- Survey of as built to confirm foundation preparation and underdrainage is completed as per design.

Performance monitoring is a key aspect of adaptive management.

6 HEALTH AND SAFETY CONSIDERATIONS

Construction methodologies involving small lift heights introduce several health and safety benefits during the construction/operational phases. This section reviews these benefits.

6.1 Benefits of Lower Lift Heights

The following health and safety benefits arise from lower lift heights

- Eliminating many risks related to working on and around tipheads with significant vertical drops.
- A reduction in the likelihood and consequence severity of geotechnical failures at tipheads due to restricted height.
- Lesser risk of differential settlement and areas requiring active control and management.
- Lesser reliance on catch-berms to control larger rocks at the toe of the tiphead.
- A reduction in point source dust emissions through smaller drop heights leading to improved air quality for operators within the immediate vicinity and a reduction to the cumulative particulate load released to receiving environments. Given the concerns by stakeholders and the local community around dust this may be important for the BPCP.
- A reduction in dozer / truck interaction when paddock stacking
- A general decrease in potential AMD effects and risks in the longer term.

7 SUMMARY

This section provides a summary of source control opportunities for the BPCP project.

7.1 Overview

INAP (2020) notes that “direct and indirect measurements of acidity load from various site domains at more than 40 sites over the past 25 years have revealed that mined sulfidic rock typically contributes to the majority of the total acidity load (60 to 80%) from most mine sites”. Hence the greatest long term source hazard for AMD is waste rock.

To address this risk, it is recommended that the BPCP implement proven industry best practice engineering controls for the engineered landforms that will contain the waste rock to ensure long term effects of mine impacted water are minimised.

7.2 Further Work

Further work is required to progress these conceptual opportunities. These opportunities are a function of the materials schedule, geochemical and geotechnical characteristics of the materials, regulatory requirements, community expectations, and cost.

Further details on the design objectives for the BPCP ELFs are provided in the AMD ELF Management Plan (BRL, 2026).

8 REFERENCES

BRL, 2026. AMD ELF Management Plan. Bathurst Resources Limited Document: BPCP-ENV-PLN-011.

Brown, P. L., Logsdon, M. J., Vinton, B., Schofield, I. & Payne, K. 2014. Detailed characterisation of the waste rock dumps at the Kennecott Utah Copper Bingham Canyon Mine – Optionality for Closure. In: Miller, H. & Preuss, L., eds. Eighth Australian Workshop on Acid and Metalliferous Drainage, May 2014. Adelaide, South Australia. 1-12.

DFAT, 2016. Leading Practice Sustainable Development Program for the Mining Industry - Preventing Acid and Metalliferous Drainage. Department of Foreign Affairs and Trade, Commonwealth of Australia. Canberra, Australia. https://www.industry.gov.au/publications/leading-practice-handbooks-sustainable-mining/preventing-acid-and-metalliferous-drainage.

Elder, D.M., Pizey, M.H., Weber, P.A., Lindsay, P., Rossiter, P.J., Rutter, G.A., Thomas, D.G., Crombie, F.M., Cooper, T., Wildy, J.J., 2011. Addressing the environmental effects of mining on the Ngakawau River. New Zealand Water Conference, Rotorua 9-10 November 2011.

Fala, O., Aubertin, M., Molson, J., Bussière, B., Wilson, G.W., Chapuis, R., Martin, V., 2003. Numerical Modelling of Unsaturated Flow in Uniform and Heterogeneous Waste Rock Piles. In “Proceedings of the Sixth International Conference on Acid Rock Drainage”, Cairns, Australia, 14-17 July (Eds. T Farrell and G Taylor), pp. 895 -902. Australian Institute of Mining and Metallurgy, Carlton, Victoria.

Holmes, M., 2024. Surface mapping of the Sullivan Ex-pit ELF footprint.

ICMM, 2019. Integrated Mine Closure, Good practice Guide, 2nd edition, February.

INAP, 2014. Global Acid Rock Drainage Guide (GARD Guide) – Rev1 International Network for Acid Prevention. http://www.gardguide.com/images/5/5f/TheGlobalAcidRockDrainageGuide.pdf.

INAP, 2017. Global Cover System Design – Technical Guidance Document. International Network for Acid Prevention, November 2017, 220 pp.

INAP, 2020. Rock Placement Strategies to Enhance Operational and Closure Performance of Mine Rock Stockpiles. Phase 1 Work Program – Review, Assessment & Summary of Improved Construction Methods. Report prepared for the International Network for Acid Prevention (INAP) by Okane and Earth Systems. 105 pp.

INAP, 2024. ARD/AMD Source Control for Mine Rock Stockpiles Phase 3. Report prepared for the International Network for Acid Prevention (INAP) by Okane. 53 pp.

Miller, S.D., Stewart, W.S., Rusdinar, Y., Schumann, R.E., Ciccarelli, J.M., Li, J., Smart, R. St.C., 2010. Methods for estimation of long-term non-carbonate neutralisation of acid rock drainage. Science of the Total Environment 408 (2010) 2129–2135

Meiers, G, 2020. A Case Study of the Influence of Shorter Tips in Mine Rock Storage on Internal Air Flow Capacity. BC-MEND Metal Leaching and Acid Rock Drainage Workshop. December 1 -3, 2020 Vancouver, British Columbia, Canada Zoom Conference.

MEND, 2009. Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials Report, MEND Report 1.20.1.

MWM, 2026a. Escarpment Mine - Barren Valley ELF Water Quality Model. Mine Waste Management Report: J-NZ0349-008-R-FINAL.

MWM, 2026b. Cover System Technical Report - Buller Coal Plateaux Continuation Project. Mine Waste Management Report J-NZ0349-013-R-FINAL.

Pearce, S., Baisley, A., O'Kane, M., 2016. Quantitatively Assessing the Benefits of Managing Gas Entry into Waste Rock Dumps During Placement to Reduce Long-Term ML-ARD Risk. BC MEND ML/ARD Workshop 2016, https://bc-mlard.ca/workshop-proceedings/2016-workshop, 28 pp.

Pope, J., Weber, P.A., Olds, W.E., 2016. Control of acid mine drainage by managing oxygen ingress into waste rock dumps at bituminous coal mines in New Zealand. Proceedings of IMWA 2016, Mining Meets Water Conflicts and Solutions. Carsten Drebenstedt, Michael Paul (Eds.) Leipzig, Germany, July 11-15, 2016, p 363-371.

Ritchie, A.I.M., 1994. The Waste Rock Environment, Chapter 5 in The Environmental Geochemistry of Sulfide Mine-Wastes, Short Course Handbook, Volume 22, May 1994, Waterloo, Ontario, Editors: D.W. Blowes and J.L. Jambor (Mineralogical Association of Canada) 133 – 161.

Weber, P.A., Olds, W.O., Crombie, F.H., Thomas, D.G., Pope, J., Pizey, M.H., 2013. Acid mine drainage investigations at the Reddale Coal mine, Reefton, New Zealand. New Zealand AusIMM Conference, Nelson 25 - 28 August 2013, 535 – 545.

Weber, P.A., McKeown, M., Christensen, D., Mueller, S., O'Kane, M., Bird, B., 2017. Forecasting long term water quality after closure: Boliden Aitik Cu mine. New Zealand Annual AusIMM Branch Conference, Christchurch, 10 - 13 September, p 353 – 361.

Wilson, G.W., 2008. Why are we still battling ARD. In "Proceedings of the Sixth Australian Workshop on Acid and Metalliferous Drainage", Burnie, Tasmania. 15-18 April 2008. (Eds LC Bell, BMD Barrie, B Baddock, and RW MacLean) pp. 101 - 112 (ACMER: Brisbane).

9 LIMITATIONS

Attention is drawn to the document “Limitations”, which is included in Appendix A of this report. The statements presented in this document are intended to provide advice on what the realistic expectations of this report should be, and to present recommendations on how to minimise the risks associated with this project. The document is not intended to reduce the level of responsibility accepted by Mine Waste Management, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in doing so.

APPENDIX A LIMITATIONS

This Document has been provided by Mine Waste Management Ltd (MWM) subject to the following limitations:

This Document has been prepared for the particular purpose outlined in MWM's proposal and no responsibility is accepted for the use of this Document, in whole or in part, in other contexts or for any other purpose.

The scope and the period of MWM's services are as described in MWM's proposal, and are subject to restrictions and limitations. MWM did not perform a complete assessment of all possible conditions or circumstances that may exist at the site referenced in this Document. If a service is not expressly indicated, do not assume it has been provided. If a matter is not addressed, do not assume that any determination has been made by MWM in regards to it.

Conditions may exist which were undetectable given the limited nature of the enquiry MWM was retained to undertake with respect to the site. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account in the Document. Accordingly, additional studies and actions may be required.

In addition, it is recognised that the passage of time affects the information and assessment provided in this Document. MWM's opinions are based upon information that existed at the time of the production of this Document. It is understood that the services provided allowed MWM to form no more than an opinion of the actual conditions of the site at the time the site was reviewed and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings, or any laws or regulations.

Any assessments made in this Document are based on the conditions indicated from published sources and the investigation described. No warranty is included, either express or implied, that the actual conditions will conform exactly to the assessments contained in this Document.

Where data supplied by the client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by MWM for incomplete or inaccurate data supplied by others.

MWM may have retained subconsultants affiliated with MWM to provide services for the benefit of MWM. To the maximum extent allowed by law, the Client acknowledges and agrees it will not have any direct legal recourse to, and waives any claim, demand, or cause of action against, MWM's affiliated companies, and their employees, officers and directors.

This Document is provided for sole use by Bathurst Resources Limited and is confidential to it and its professional advisers. No responsibility whatsoever for the contents of this Document will be accepted to any person other than the Client. Any use which a third party makes of this Document, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. MWM accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this Document.

MWM acknowledges that this report will be relied on by a Panel appointed under the Fast-track Approvals Act 2024 and these disclaimers do not prevent that reliance.

MINE WASTE MANAGEMENT

GREENROAD GROUP

APPENDIX L COVER SYSTEM FIELD INVESTIGATION

[redacted]

MEMORANDUM

Recipient:	[redacted] Bathurst Resources Limited
From:	[redacted], Mine Waste Management Limited
Date:	21 July 2026
Cc:	[redacted] – Hydro Geochem Group Limited [redacted] – Mine Closure Management Inc.
Document Number:	J-NZ0349-004-M-FINAL
Document Title:	Cover System Field Investigation

Bathurst Resource Limited (BRL) is seeking to obtain authorisation through the Fast Track Approvals Act 2024 (FTAA) to progress development and mining of the coal resources across the wider Buller Plateaux. This project is referred to as the Buller Plateaux Continuation Project (BPCP).

Mine Waste Management Limited (MWM) was retained by BRL to complete cover system design works for the Engineered Landforms (ELF) of the proposed BPC Project. The objective of the cover system is to limit the ingress of meteoric water and oxygen to the underlying potentially acid forming mine rock thereby minimising the effects of acid and metalliferous drainage (AMD) on the receiving environment in the short term and facilitate recovery of the environment disturbed by mining over the long term. The cover system and landform will also support the establishment of sustainable vegetation and a stable landform in terms of geomorphic stability to ensure the cover system maintains its functionality.

This factual memorandum documents the field characterisation program carried out to support the cover system design and landform for the BPC Project ELFs. Details of the completed field work and field and laboratory test results as provided.

OBJECTIVE AND SCOPE

The primary objective of the field characterisation program was to supplement existing physical and hydraulic datasets (much of which were from nearby sites) with data reflective of site materials and conditions. The data collected will aid in the development of conceptual models and establishing material properties for cover system assessment and design.

The existing Barren Valley ELF (BV-ELF) and soil stockpiles at Escarpment Mine provide representative analogues of the material that will be used to support cover system construction for the BPC Project. Hydro Geochem Group Ltd (HGG), who are subcontracted by MWM, visited the Escarpment Mine on 15 February 2024 to complete field investigations to support cover system assessment and design.

Field investigations involved:

- Excavation of four (4) test pits in mine rock at the BV-ELF and the soil stockpile.
- Collection of seven (7) total mine rock and soil samples.
- Completion of one (1) standpipe piezometer falling head test (FHT) on the BV-ELF.
- Completion of seven (7) permeameter tests in mine rock and soils.

SITE CONDITIONS

Weather and soil conditions on the day of the field work were relatively wet. Periods of heavy showers and wind gusts occurred throughout the day, with an average air temperature of 17 °C. A minor amount of BV-ELF surface runoff generation was noted following the showers but ceased within an hour or so. Runoff was primarily generated from compacted surfaces and flowed via localised erosion channels, with no observable runoff associated with less compacted coarser areas such as batter slopes (Figure 1). Total rainfall for the day, as measured at the Lake Brazil meteorological station, was 6.2 mm. Peak rainfall intensity was recorded as 1.8 mm in 10 mins (or $3x10^{-6}$ m/s). There had been no rain recorded over the four days prior. Over the preceding two weeks, a total of 160 mm of rainfall was recorded, most of which (122 mm, or 76 %) occurred in one day (04/02/2024).

Figure 1: Runoff example.

VEGETATION OBSERVATIONS

Examples of some vegetation types to be reestablished post-closure of the final BPC Project ELFs are shown in Figure 2.

Pakihi Vegetation

Manuka Shrub

Figure 2: Post-closure vegetation examples.

PHYSICAL PROPERTIES TESTING PROGRAM

Methodology

Two (2) test pits into the surface of the BV-ELF were excavated with a Hitachi four tonne excavator with a spade bucket (i.e., without teeth). Test pit locations were chosen to target one area that was thought to be subject to heavy equipment traffic (based on visual observation of tighter packed surface rock) and one area with notably less equipment compaction (ESC-TP-02 and ESC-TP-01, respectively). Photographs of test pits sites are shown in Figure 3 showing different levels of compaction. ESC-TP-02 also visually appeared to have less coarse material. For comparison, Figure 4 shows the batter slope of the ELF with little to no compaction.

ESC-TP-01

ESC-TP-02

Figure 3: Post-closure vegetation examples.

Figure 4: Batter slope surface example.

Each test pit was excavated to approximately 1.5 m depth. Excavated depth intervals were placed in separate piles to allow sampling from specific horizons of interest for cover design works. Depth intervals were approximately:

- 0 to 0.2 m
- 0.2 to 0.5 m
- 0.5 to 1.5 m

Material was placed in piles approximately 1 m high to avoid particle size segregation.

Two shallow hand dug test pits were created in the Escarpment Mine weed-free soil stockpile. BRL (Campbell Robertson, pers. comm.) noted that stockpile material was of a general mix of soil from pre-stripping areas. Soil strip depth was approximately 0.5 m.

In total, seven (7) samples were collected for analysis to define the physical characteristics of the topsoil and mine rock. Samples were collected in 20 L pails). The physical properties testing was conducted by Central Testing Services, which involved particle size distribution (PSD), water content, and solid density. Table 1 summarises the characterisation program for samples collected during the field investigation.

Table 1: Physical properties characterisation program.

SAMPLE ID	MATERIAL	LOCATION	EASTING*	NORTHING*	DEPTH (m)
ESC-Soil-01	Soil	Weed-free soil stockpile	1499635	5374829	0.05 to 0.2
ESC-Soil-02	Soil	Weed-free soil stockpile	1499634	5374817	0.05 to 0.2
ESC-TP-01a	Mine Rock	BV-ELF (moderately-trafficked)	1499071	5374379	0.0 to 0.15
ESC-TP-01b	Mine Rock	BV-ELF (moderately-trafficked)			0.15 to 0.8
ESC-TP-01c	Mine Rock	BV-ELF (moderately-trafficked)			0.8 to 1.5
ESC-TP-02a	Mine Rock	BV-ELF (trafficked)	1499080	5374446	0.0 to 0.2
ESC-TP-02b	Mine Rock	BV-ELF (trafficked)			0.2 to 0.7

**Note: coordinate reference system used was NZTM, collected with a handheld GPS unit.*

Laboratory Results

Full laboratory testing reports are provided in Attachment A as provided by Central Testing Services. Photos of excavated sample piles are provided in Attachment B.

Figure 6 shows the PSD curves for samples collected during test pit excavation. The PSD of a given material indicates the relative proportions of the different particle sizes that make up the material on a mass basis and provides an understanding of:

- Material grading (i.e., whether it's well graded, poorly graded, or gap-graded).
- Potential for segregation during handling and placement procedures.
- Material structure (i.e., grain or matrix-supported).
- Anticipated hydraulic characteristics.

Figure 5: Investigation locations.

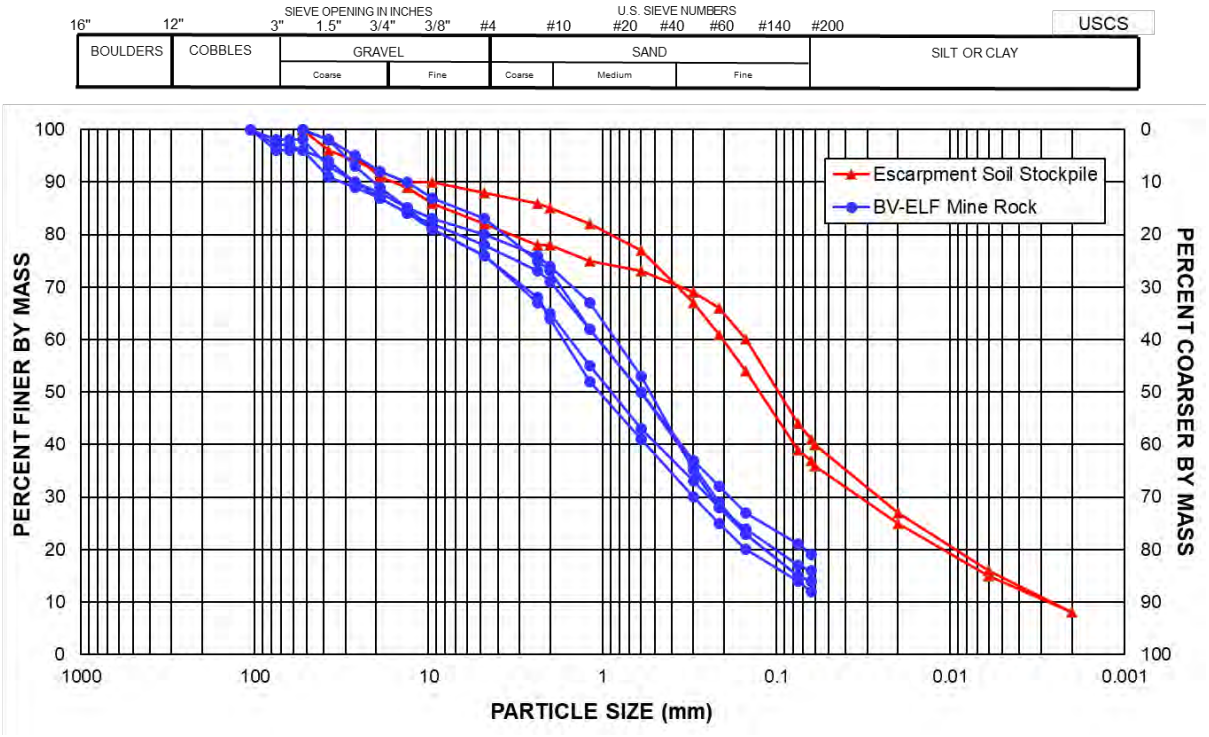


Figure 6: Particle size distribution curves for the mine rock and soil stockpile.

Textural triangles are utilised to augment the comparison of multiple PSD curves by simplifying the grain size distribution curve of a sample to a single data point. The sides of the textural triangle are scaled for the percentage of cobble and gravel, sand, and silt and clay-size particles. Figure 7 shows the PSDs of the materials encountered during the investigation. The soil was well-graded, consisting of approximately 18% cobbles and gravel, 40% sand, and 42% silt and clay size particles, based on the Unified Soil Classification System. The mine rock was also a well-graded material. On average the BV-ELF mine rock consists of approximately 28% cobbles and gravel, 56% sand, and 16% silt and clay-size particles. It is noted that the sampling cutoff for the laboratory PSD method was 106 mm.

Both the soil and BV-ELF mine rock plot within the domain classified as matrix-supported. Within a matrix-supported material the larger fragments, or clasts, are separated from each other within a finer-grained matrix, conversely, in a grain-supported material, the larger fragments, or clasts, provide the structural support and are in direct contact with each other. Visual estimates of the proportion of rock larger than this is approximately 5 to 10%, which is not anticipated to change the conclusion of matrix support vs grain supported.

The PSD data for mine rock samples are tabulated in Table 2. The trafficked surface (ESC-TP-02a) had a slightly higher fines content than the deeper sample at the same location (21 vs 17%, respectively), while there was little variation in fines content with depth at ESC-TP-01.

Table 2: Mine rock sample fines content.

SAMPLE ID	DEPTH (M)	COBBLE AND GRAVEL	SAND	CLAY AND SILT
ESC-TP-01a	0.0 to 0.15	32%	54%	14%
ESC-TP-01b	0.15 to 0.8	27%	58%	15%
ESC-TP-01c	0.8 to 1.5	24%	61%	15%
ESC-TP-02a	0.0 to 0.2	25%	54%	21%
ESC-TP-02b	0.2 to 0.7	33%	50%	17%

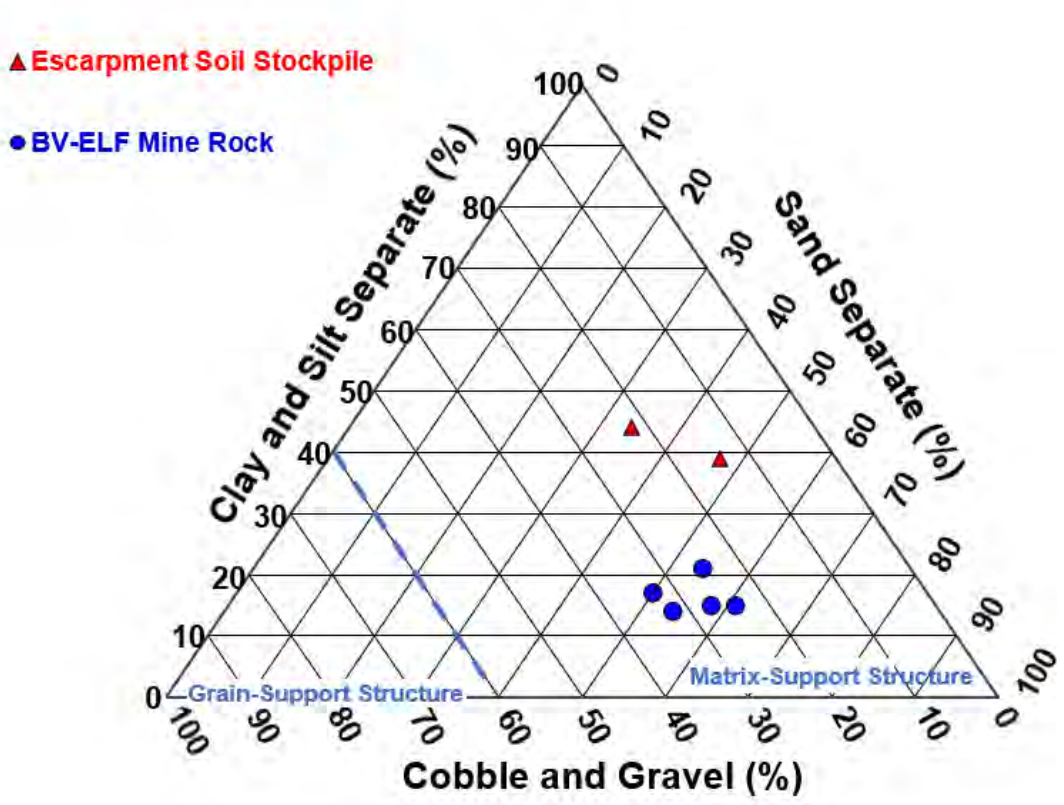


Figure 7: Textural triangle illustrating the texture of the mine rock and stockpile soil.

Note: Grain vs matrix supported structure based on Herasymuik (1996).

Water content and solid density of the samples are provided in Table 3. Average properties were as follows:

- Gravimetric water content (NZS 4402:1986, Test 2.1) for the soil was higher (~24%) than mine rock (~9%).
- Specific gravity or solid density (NZS 4402:1986, Test 2.7.1) was 2.54 t/m^3 on average for mine rock, and 2.46 t/m^3 for soil.
- Average estimated degree of saturation was 56% for mine rock and 80% for soil, assuming a bulk dry density of 1.8 t/m^3 and 1.4 t/m^3, respectively.

Table 3: Water content and solid density lab results.

SAMPLE ID	MATERIAL TYPE	WATER CONTENT (%)	SOLID DENSITY (t/m^3)	ESTIAMTED DEGREE OF SATURATION (%)
ESC-Soil-01	Soil	24.0	2.53	75
ESC-Soil-02	Soil	24.7	2.38	84
ESC-TP-01a	Mine Rock	9.0	2.46	60
ESC-TP-01b	Mine Rock	11.1	2.50	71
ESC-TP-01c	Mine Rock	9.5	2.64	54
ESC-TP-02a	Mine Rock	8.2	2.56	50
ESC-TP-02b	Mine Rock	7.2	2.55	44

FALLING HEAD TEST

Methodology

A single FHT was completed on a standpipe previously installed at the top of the BV-ELF (~7 years ago, C. Roberston, pers. comm.). The standpipes were understood to be pounded in with an excavator. Another standpipe was present too, but standing water was sitting in the base of the standpipe (while the BV-ELF surface and other standpipe were dry) suggesting some kind of blockage, with plastic bags found inside. As such, testing was not completed on this standpipe with a perceived blockage as testing results would be unlikely to be representative of mine rock properties.

Details of the standpipe tested were as follows:

- Material: steel pipe.
- Method of placement: advanced with excavator bucket (pers. comm. Cambell Roberton).
- Stick up of 1.02 m diameter of 0.2794 m (11 inch).
- Length below surface: ~0.78 assuming a 1.8 m total length of pipe (W. Olds, pers. Comm.).
- Mine rock depth (inside pipe): approximately BV-ELF surface, or 1.02 m from top of pipe.
- GPS coordinates: E: 1499084, N: 5374362 (NZTM).

A Solinist Levelogger 5 (M10) was suspended approximately 0.85 m from the top of the pipe with non-stretch cable and set to record every 5 seconds. The test was initiated with ~60 L of water at 12.43 pm. Manual measurements of water level decline were also recorded. The test ended at 3 pm.

The analysis method followed a modified ASTM D6391 Method B, Calculation Procedure 1 as follows:

$$K_{fs} = \frac{R_T G}{t_2 - t_1} \ln \frac{H_1}{H_2}$$

$$G = \frac{\pi}{11} \frac{D}{m} + L$$

$$R_T = 2.2902 \frac{0.9842^T}{T^{0.1702}}$$

Where:

- K_{fs} is field saturate hydraulic conductivity.
- G is a shape factor for the geometry of the test setup.
- R_T is the reservoir temperature.
- H_1 is the head displacement at t_1. Based on pressure transducer records.
- H_2 is the head displacement at t_2. Based on pressure transducer records.
- t_1 is the time at beginning of increments. Based on pressure transducer records.
- t_2 is the time at end of increments. Based on pressure transducer records.
- D is the diameter of the pipe. Measured as 0.2794 m.
- L is the length of the material within the pipe. Estimated as 0.78 m.
- m is the is anisotropy ratio. Assumed to be 1.0 (isotropic media).
- T is temperature in °C. Based on pressure transducer records.

Modification to the ASTM D6391 method was related to the shape factor (G) used. ASTM D6391 used a shape factor for a standpipe without material inside it. The shape factor used for this analysis used the Case E from Hvorslev (1951) to account for identified material inside the standpipe. Use of the shape factor as reported in ASTM D6391 resulted in K_{fs} estimates about an order of magnitude lower.

Analysis Results

Mine rock K_{fs} based on the FHT analysis was estimated to be 5×10^{-6} m/s, which is similar to those estimated from the permeameter tests (see next section). Estimates over time are shown in Figure 8, where a relatively stable period is reach after approximately 1,000 seconds.

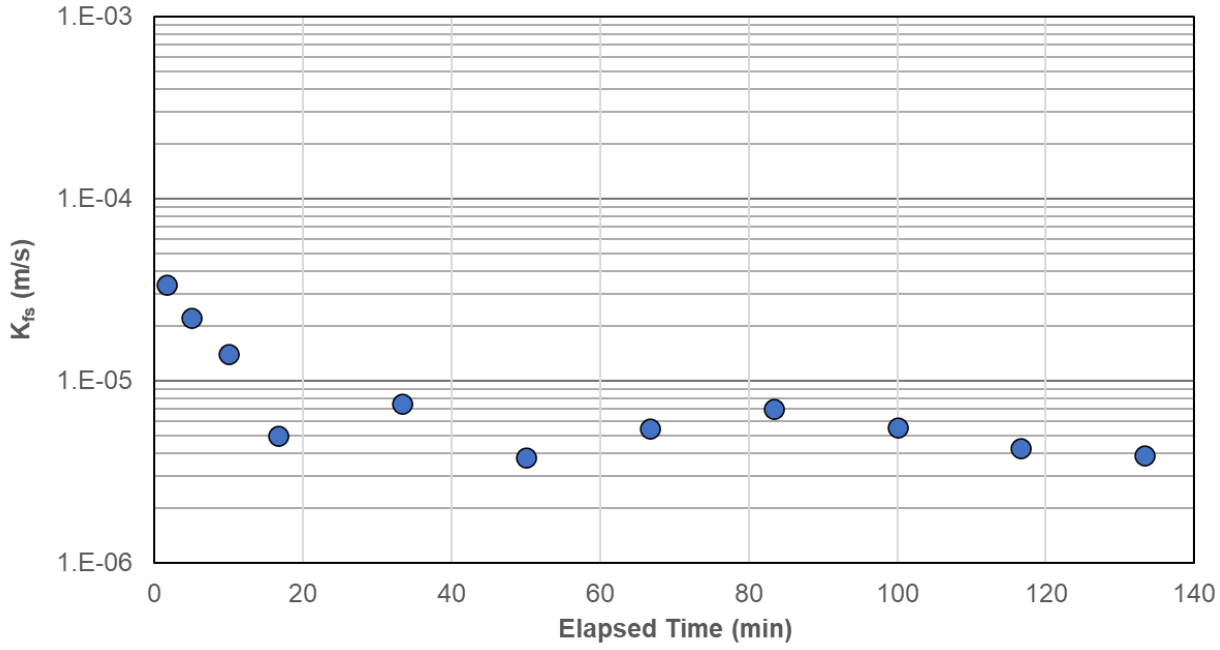


Figure 8: FHT analysis results for the mine rock.

PERMEAMETER TESTS

Methodology

Seven (7) permeameter tests were completed as part of the field investigation and are as follows:

- Two (2) tests in soil stockpile material.
- Six (6) tests in BV-ELF mine rock material.

The K_{fs} test locations, depth, and observations are summarised in Table 4. For each test, the borehole was excavated with a hand auger that produced a borehole 8.3 cm in diameter. The standard PASK Permeameter (ETC, 2022) was used to conduct the permeameter tests with the constant head method. The change in water level in the permeameter reservoir was recorded as time elapsed for each test until a relatively stable rate (i.e., steady state) of change was reached.

Table 4: Permeameter test details.

TEST ID	BOREHOLE DEPTH (m)	MATERIAL DESCRIPTION / OBSERVATIONS	ESTIAMTED K_{fs} (m/s)
ESC-Soil-01	0.25	Top of Escarpment soil stockpile; loamy material with some clay. Vegetation naturally re-established after less than 7 years of placement.	$4x10^{-7}$
ESC-Soil-02	0.24	Top of Escarpment soil stockpile; loamy material with some clay. Vegetation naturally re-established after less than 7 years of placement.	$2x10^{-7}$
ESC-TP-01_1	0.24	Mine Rock: Sandstone material, high sand content. Less surface compaction than ESC-TP-02_1a/b noted.	$9x10^{-7}$
ESC-TP-01_2	1.0	Mine Rock: Sandstone material, high sand content.	$4x10^{-6}$
ESC-TP-02_1a*	0.18	Mine Rock: Majority gravel, sand, cobbles; darker colour compared to ESC-TP-01. Relatively difficult to auger borehole as tightly packed cobbles impeded advancement. Higher compaction than ESC-TP-01_1 noted.	$<1x10^{-7}$
ESC-TP-02_1b*	0.18	As per ESC-TP-02_1a	$<1x10^{-7}$
ESC-TP-02_2	0.9	Mine rock, less pure sandstone, darker material, more angular.	$3x10^{-6}$

**Note: Due to time constraints, ESC-TP-02_1a could not be completed to reach steady rate of change; the rate of change was very slow, indicating a K_{sf} of $<10^{-7}$ m/s. ESC-TP-02_1b was completed adjacent to ESC-TP-02_1a to confirm the very low rate of change observed.*

K_{fs} was calculated based the following equation from Reynolds (1993):

$$K_{fs} = \frac{CQ}{2\pi H^2 + C\pi a^2 + \left(2\pi {}^{H}/_{\alpha^*}\right)}$$

Where:

- C is the shape factor for the borehole dimensions (dimensionless). A value of 1.3 was adopted[1];
- Q is the quasi-steady state water flow rate. It is a product of the stabilised rate of fall of water in permeameter reservoir (*R*) and cross-sectional area of permeameter reservoir, *X* (53.46 cm^2).
- H is the height of the pressure head above the borehole base. A depth of 15 cm is the recommended standard for the PASK Permeameter.
- a is the borehole radius (4.15 cm).
- $\alpha^*$is a visually estimated soil structure/texture parameter. A value of 0.12 cm^{-1} was adopted based on the material description[2].

Analysis results were not particularly sensitive to variation in assumed values of C and α^*.

Analysis Results

Analysis results are summarised in Table 4 and compared to sample fines content in Figure 9

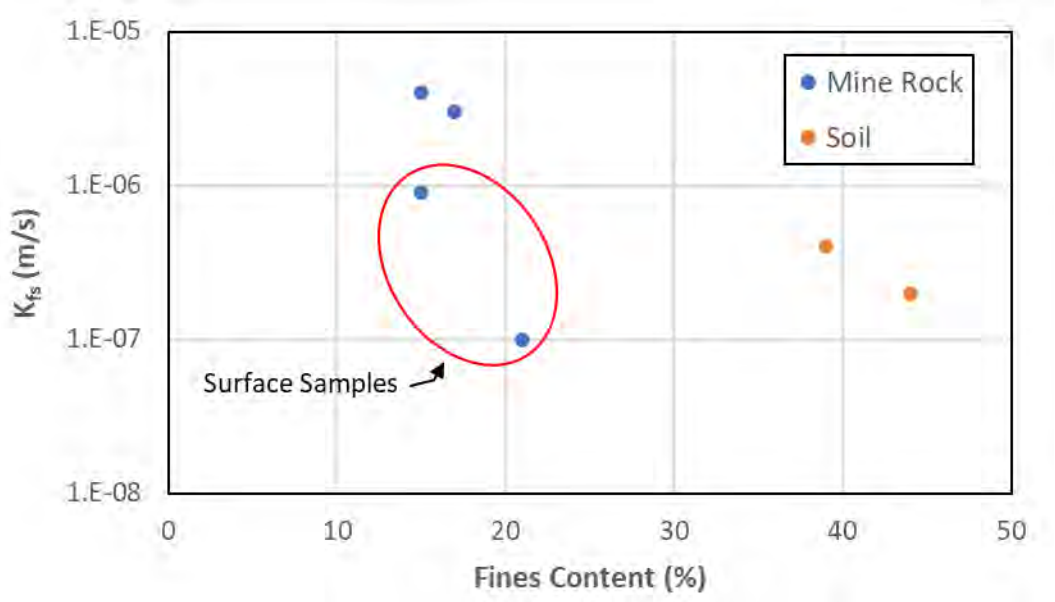


Figure 9: K_{fs} variation with fines content.

[1] *Based on Reynolds (2008), this values typically ranges between 1.2 and 1.4 for the borehole dimension created by the hand auger.*

[2] *Value typically ranges between 0.01 and 0.36 for a variety of material properties (Reynolds, 2008 and Reynolds et al., 2015).*

The following interpretations are made based on the permeameter testing results:

- The soil material has a relatively low K_{fs} values, approximately $3x10^{-7}$ m/s, which is consistent with the higher fines content for soil.
- Near surface mine rock K_{fs} was lower compared to values at greater depth (e.g., ESC-TP-01_1 vs ESC-TP-01_2a/b), varying between one half of an order of magnitude and a one order of magnitude.
- Mine rock at approximately one meter depth showed moderate K_{fs} values of $4x10^{-6}$ m/s on average. These values are consistent with the results from the FHT analysis.
- Variation in K_{fs} values is typically in line with what would be expect where values decease as fines content increases. Note, the two lower mine rock K_{fs} values are representative of surface samples which were subjected to traffic compaction, thus it is difficult to attribute lower K_{fs} values solely to fines content variation alone. Both aspects (i.e., compaction and fines content) likely contribute to the lowest K_{fs} value of $<1x10^{-7}$ m/s for ESC-TP-02_1a/b, while great compaction at surface can explain the lower ESC-TP-01_1 K_{fs} ($9x10^{-7}$ m/s) given similar fines content to deeper samples in this test pit.
- Observations of surface runoff from the rainfall event with a maximum intensity of $3x10^{-6}$ m/s are consistent with near surface permeameter results. Compacted surfaces with a K_{sf} lower than the maximum intensity (e.g., ESC-TP-01a and ESC-TP-02a) generated runoff via infiltration excess processes. Other surfaces with less compaction and/or coarser material (e.g., batter slopes) did not generate observable surface runoff, suggesting K_{sf} higher than $3x10^{-6}$ m/s, and potentially similar to deeper mine rock permeameter results.

FINDINGS SUMMARY

Findings from the field investigation are summarised as follows:

- Soil from the Escarpment soil stockpile was well-graded, consisting of approximately 18% cobbles and gravel, 40% sand, and 42% silt and clay size particles on average, based on the Unified Soil Classification System.
- The mine rock is also a well-graded material. On average (n=4) the BV-ELF mine rock consists of approximately 28% cobbles and gravel, 56% sand, and 16% silt and clay-size particles. Note that clasts >106 mm were not accounted for in these proportions due to lab testing limitations. Visual estimates place this unaccounted fraction to be in the range of 5 to 10%, which is unlikely to change findings of this investigation.
- Gravimetric water content for the soil was higher (~24%) than mine rock (~9%) reflecting greater capillarity forces of the finer textured soil.
- Solid density was 2.54 t/m^3 on average for mine rock, and 2.46 t/m^3 for soil.
- Average degree of saturation was estimated to be ~56% for mine rock and ~80% for soil.
- Soil material K_{fs} was estimated to be $3x10^{-7}$ m/s.
- Mine rock K_{fs} varied by depth/level of compaction, and fines content:

  - Shallow depth of mine rock was estimated to have an average K_{fs} of $4x10^{-6}$ m/s.
  - The near surface layer of mine rock, which appeared compacted, provided a K_{fs} that was approximately one half of an order of magnitude to one order of magnitude lower than material deeper in the test pit. The lower K_{fs} at surface were attributed to both compaction level and fines content variation.

- Observed runoff that occurred during the investigation was consistent with estimates of near surface K_{fs}. The lack of runoff observed on batter slopes suggest a K_{fs} for this portion of the BV-ELF to be greater than the maximum rainfall intensity (i.e., $>3x10^{-6}$ m/s).

The field test results will be interpreted to inform on the conceptual model of cover system and landform performance in further stages of the assessment and design program.

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 our memorandum in greater detail.

Attachments: Attachment A – Lab Testing Report
Attachment B – Excavated Sample Piles

REFERENCES

Engineering Technologies Canada (ETC), 2022. User Guide, ETC PASK (constant head well) permeameter for in-situ measurement of soil field saturated hydraulic conductivity. 33 pages. Dated April 2022.

Hvorslev, M.J., 1951. Time Lag and Soil Permeability in Ground-Water Observations, Bull. No. 36, Waterways Exper. Sta. Corps of Engrs, U.S. Army, Vicksburg, Mississippi, pp. 1-50.

Herasymuik, G M, 1996. Hydrogeology of a sulphidic waste rock dump, MSc thesis, University of Saskatchewan, Saskatchewan.

Reynolds, 1993. Saturated hydraulic conductivity: field measurement. In Carter, M.R. (ed.) Soil Sampling and Methods of Analysis. Canadian Society Soil Science. Lewis Publishers, Boca Raton, FL, USA. pp.599-613

Reynolds, 2008, Saturated Hydraulic Properties: Well Permeameter. In Carter, M.R. and Gregorich, E.G. (Eds.), Soil Sampling and Methods of Analysis (2nd ed.). Canadian Society of Soil Science. CRC Press, Boca Raton, FL., USA, pp. 1025-1042.

Reynolds. and Galloway. and Radcliffe, 2015. The relationship between perc time and field-saturated hydraulic conductivity for cylindrical test holes. Proceedings of the Annual Conference of the National Onsite Wastewater Recycling Association, West Virginia Beach, West Virginia. November 2015.

ATTACHMENT A – LAB TESTING REPORT

Central Testing Services [redacted]

Reference No: 24/838

Date: 15 April 2024

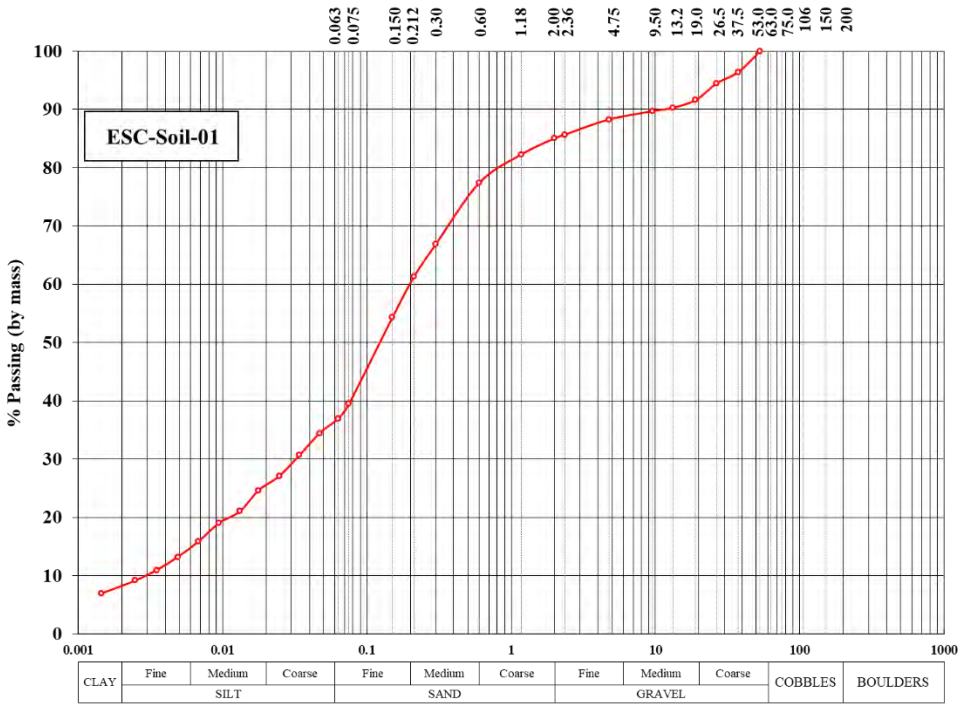
TEST REPORT – ESC COVER DESIGN FIELD INVESTIGATIONS

Client Details:	**Bathurst Resources Limited,** [redacted]	**Attention:**	[redacted]
Job Description:	**ESC Cover Design Field Investigation**		
Sample Description:	**SILT & SAND with some gravel & minor clay with trace of deleterious organics present (roots)**	**Client Order No:**	**539528**
Sample Source: (cs)	**ESC-Soil-01**	**Sample Depth: (cs)**	**0.05m - 0.20m**
Date & Time Sampled: (cs)	**15-Feb-24**	**Sampled By: (cs)**	[redacted]
Sample Method:	**Unknown**	**Date Received:**	**12-Mar-24**

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1 & 2.8.4)

Test Sieve (mm)	% Passing (by mass)
53.0	100
37.5	96
26.5	94
19.0	92
13.2	90
9.50	90
4.75	88
2.36	86
2.00	85
1.18	82
0.60	77
0.30	67
0.212	61
0.150	54
0.075	39
0.063	37

Fraction Size	Interpolated % Passing
60 µm	36
20 µm	25
6 µm	15
2 µm	8



The sample was received in a natural state. The percentage passing the 63µm test sieve was obtained by difference. The pH of the hydrometer suspension was 9.0. Sodium hexametaphosphate was used as a dispersant.

PARTICLE SIZE ANALYSIS & HYDROMETER ANALYSIS RESULTS - NZS 4402:1986, Test 2.8.1 & 2.8.4

Description	Fraction Range	% Within Range	Description	Fraction Range	% Within Range
Coarse Gravel	60.0 mm to 20.0 mm	8	Fine Sand	200 µm to 60 µm	24
Medium Gravel	20.0 mm to 6.0 mm	3	Coarse Silt	60 µm to 20 µm	11
Fine Gravel	6.0 mm to 2.00 mm	4	Medium Silt	20 µm to 6 µm	10
Coarse Sand	2.00 mm to 600 µm	8	Fine Silt	6 µm to 2 µm	7
Medium Sand	600 µm to 200 µm	17	Clay	< 2 µm	8

WATER CONTENT & SOLID DENSITY RESULTS - NZS 4402:1986, Test 2.1 & 2.7.1

Water Content: ("All In" As Received)	**24.0 %**
Solid Density: (-37.5mm Fraction)	**2.53 t/m^3**
Note: The sample was received in a natural state.	

Notes:

- ***Information contained in this report which is Not IANZ Accredited relates to the sample description based on NZ Geotechnical Society Guidelines 2005, the client supplied information (cs) and sampling.***
- ***This report may not be reproduced except in full.***

[redacted]

Date: 25-Mar-24 to 10-Apr-24

ACCREDITED IANZ TESTING LABORATORY №434

Test results indicated as not accredited are outside the scope of the laboratory's accreditation

Central Testing Services [redacted]

Reference No: 24/838

Date: 15 April 2024

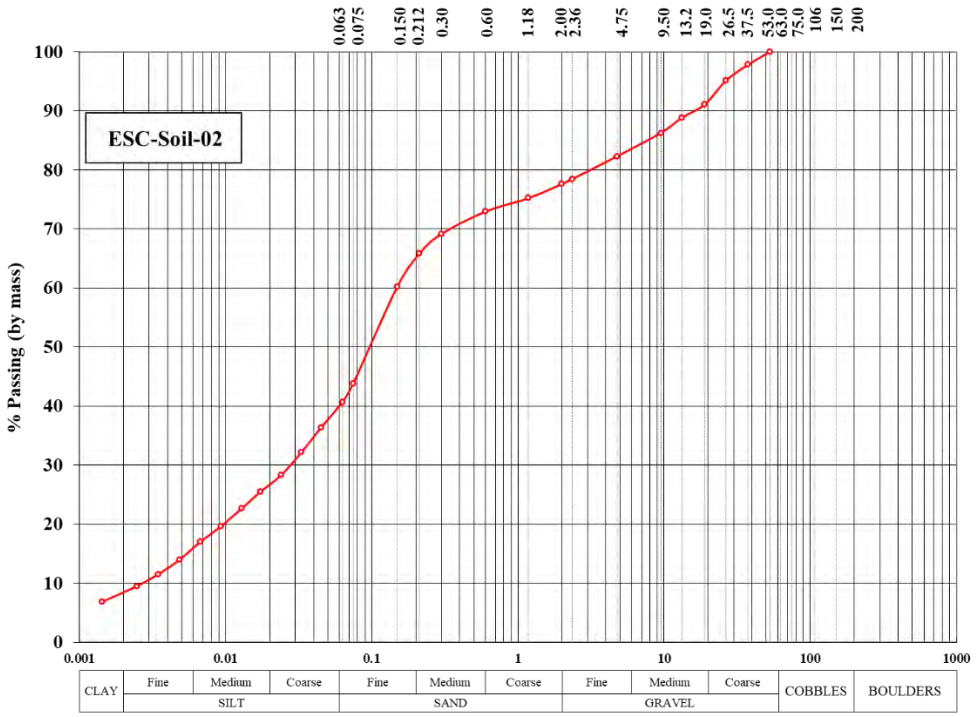
TEST REPORT – ESC COVER DESIGN FIELD INVESTIGATIONS

Client Details:	**Bathurst Resources Limited,** [redacted]	**Attention:**	[redacted]
Job Description:	**ESC Cover Design Field Investigation**		
Sample Description:	**Gravelly SILT & SAND with minor clay with trace of deleterious organics present (roots)**	**Client Order No:**	**539528**
Sample Source: (cs)	**ESC-Soil-02**	**Sample Depth: (cs)**	**0.05m - 0.20m**
Date & Time Sampled: (cs)	**15-Feb-24**	**Sampled By: (cs)**	[redacted]
Sample Method:	**Unknown**	**Date Received:**	**12-Mar-24**

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1 & 2.8.4)

Test Sieve (mm)	% Passing (by mass)
53.0	100
37.5	98
26.5	95
19.0	91
13.2	89
9.50	86
4.75	82
2.36	78
2.00	78
1.18	75
0.60	73
0.30	69
0.212	66
0.150	60
0.075	44
0.063	41

Fraction Size	Interpolated % Passing
60 µm	40
20 µm	27
6 µm	16
2 µm	8



The sample was received in a natural state. The percentage passing the 63µm test sieve was obtained by difference. The pH of the hydrometer suspension was 9.0. Sodium hexametaphosphate was used as a dispersant.

PARTICLE SIZE ANALYSIS & HYDROMETER ANALYSIS RESULTS - NZS 4402:1986, Test 2.8.1 & 2.8.4

Description	Fraction Range	% Within Range	Description	Fraction Range	% Within Range
Coarse Gravel	60.0 mm to 20.0 mm	8	Fine Sand	200 µm to 60 µm	25
Medium Gravel	20.0 mm to 6.0 mm	9	Coarse Silt	60 µm to 20 µm	13
Fine Gravel	6.0 mm to 2.00 mm	5	Medium Silt	20 µm to 6 µm	11
Coarse Sand	2.00 mm to 600 µm	5	Fine Silt	6 µm to 2 µm	8
Medium Sand	600 µm to 200 µm	8	Clay	< 2 µm	8

WATER CONTENT & SOLID DENSITY RESULTS - NZS 4402:1986, Test 2.1 & 2.7.1

Water Content: ("All In" As Received)	**26.7 %**
Solid Density: (-37.5mm Fraction)	**2.38 t/m^3**
Note: The sample was received in a natural state.	

Notes:

- ***Information contained in this report which is Not IANZ Accredited relates to the sample description based on NZ Geotechnical Society Guidelines 2005, the client supplied information (cs) and sampling.***
- ***This report may not be reproduced except in full.***

[redacted]

Date: 25-Mar-24 to 10-Apr-24

ACCREDITED IANZ TESTING LABORATORY №434

Test results indicated as not accredited are outside the scope of the laboratory's accreditation

Central Testing Services [redacted]

Reference No: 24/838

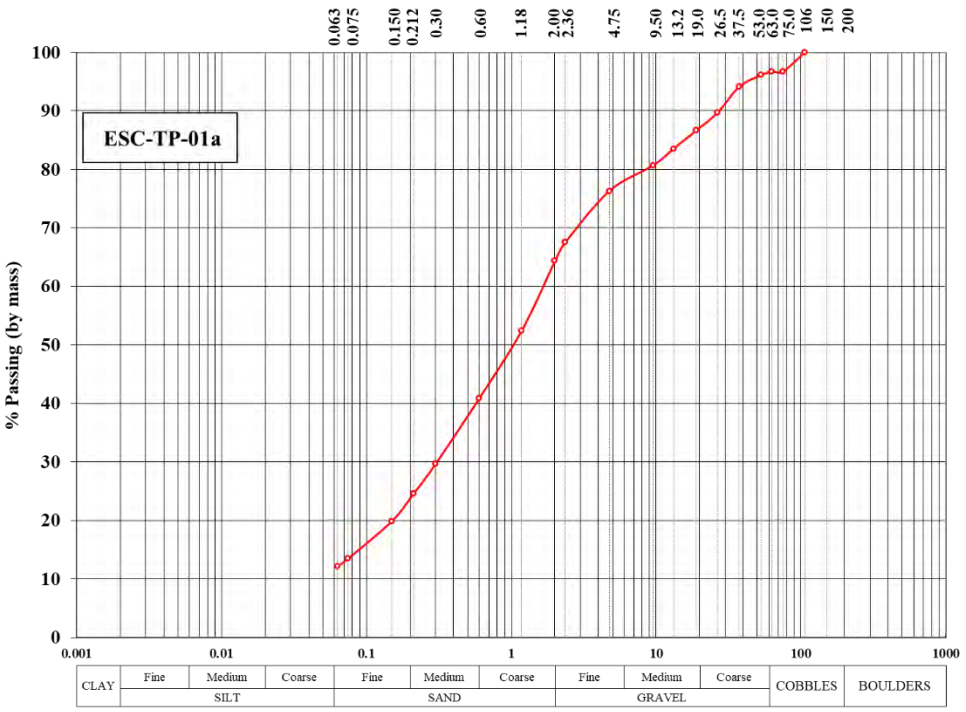
Date: 15 April 2024

TEST REPORT – ESC COVER DESIGN FIELD INVESTIGATIONS

Client Details:	**Bathurst Resources Limited,** [redacted]	**Attention:**	[redacted]
Job Description:	**ESC Cover Design Field Investigation**		
Sample Description:	**Gravelly SAND with some silt & trace of cobbles with trace of deleterious organics present (coal)**	**Client Order No:**	**539528**
Sample Source: (cs)	**ESC-TP-01a**	**Sample Depth: (cs)**	**0.00m - 0.15m**
Date & Time Sampled: (cs)	**15-Feb-24**	**Sampled By: (cs)**	[redacted]
Sample Method: (cs)	**Test Pit**	**Date Received:**	**12-Mar-24**

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1)

Test Sieve (mm)	% Passing (by mass)
106	100
75.0	97
63.0	97
53.0	96
37.5	94
26.5	90
19.0	87
13.2	84
9.50	81
4.75	76
2.36	68
2.00	64
1.18	52
0.60	41
0.30	30
0.212	25
0.150	20
0.075	14
0.063	12



The sample was received in a natural state. The percentage passing the 63µm test sieve was obtained by difference.

WATER CONTENT & SOLID DENSITY RESULTS - NZS 4402:1986, Test 2.1 & 2.7.1	
Water Content: ("All In" As Received)	**9.0 %**
Solid Density: (-37.5mm Fraction)	**2.46 t/m^3**
Note: The sample was received in a natural state.	

Notes:

- *Information contained in this report which is Not IANZ Accredited relates to the sample description based on NZ Geotechnical Society Guidelines 2005, the client supplied information (cs) and sampling.*
- *This report may not be reproduced except in full.*

[redacted]

Date: **25-Mar-24 to 10-Apr-24**

ACCREDITED IANZ TESTING LABORATORY №434

Test results indicated as not accredited are outside the scope of the laboratory's accreditation

Central Testing Services [redacted]

Reference No: 24/838

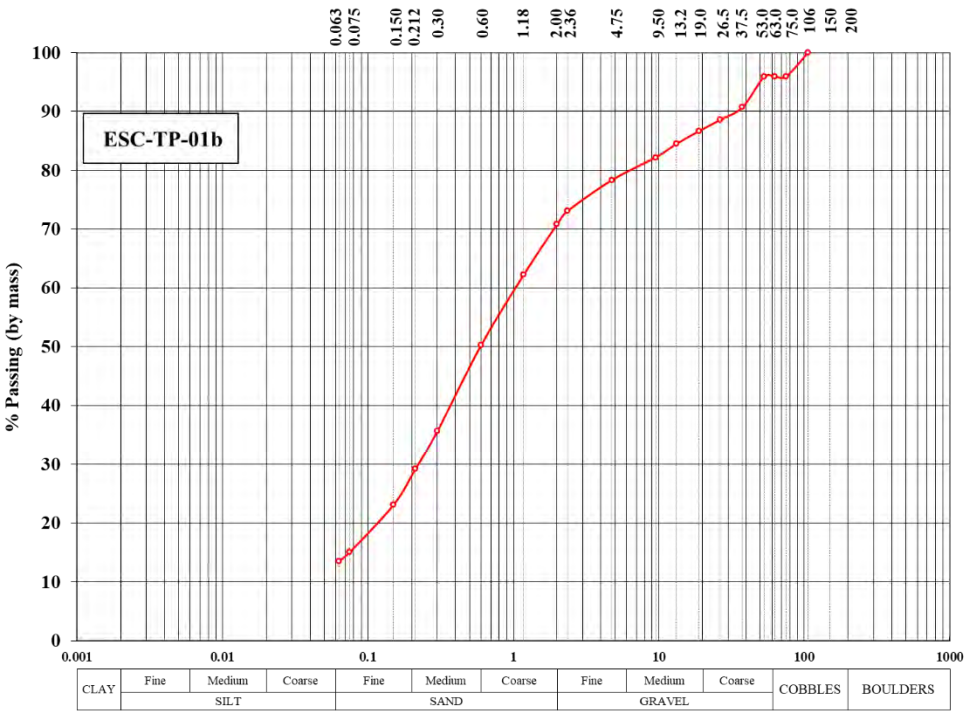
Date: 15 April 2024

TEST REPORT – ESC COVER DESIGN FIELD INVESTIGATIONS

Client Details:	**Bathurst Resources Limited,** [redacted]	**Attention:**	[redacted]
Job Description:	**ESC Cover Design Field Investigation**		
Sample Description:	**Gravelly SAND with some silt & trace of cobbles with trace of deleterious organic present (coal / roots)**	**Client Order No:**	**539528**
Sample Source: (cs)	**ESC-TP-01b**	**Sample Depth: (cs)**	**0.15m – 0.80m**
Date & Time Sampled: (cs)	**15-Feb-24**	**Sampled By: (cs)**	[redacted]
Sample Method: (cs)	**Test Pit**	**Date Received:**	**12-Mar-24**

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1)

Test Sieve (mm)	% Passing (by mass)
106	100
75.0	96
63.0	96
53.0	96
37.5	91
26.5	89
19.0	87
13.2	84
9.50	82
4.75	78
2.36	73
2.00	71
1.18	62
0.60	50
0.30	36
0.212	29
0.150	23
0.075	15
0.063	14



The sample was received in a natural state. The percentage passing the 63µm test sieve was obtained by difference.

WATER CONTENT & SOLID DENSITY RESULTS - NZS 4402:1986, Test 2.1 & 2.7.1	
Water Content: ("All In" As Received)	**11.1 %**
Solid Density: (-37.5mm Fraction)	**2.50 t/m^3**
Note: The sample was received in a natural state.	

Notes:

- *Information contained in this report which is Not IANZ Accredited relates to the sample description based on NZ Geotechnical Society Guidelines 2005, the client supplied information (cs) and sampling.*
- *This report may not be reproduced except in full.*

[redacted]

Date: 25-Mar-24 to 10-Apr-24

ACCREDITED IANZ TESTING LABORATORY №434

Test results indicated as not accredited are outside the scope of the laboratory's accreditation

Central Testing Services [redacted]

Reference No: 24/838

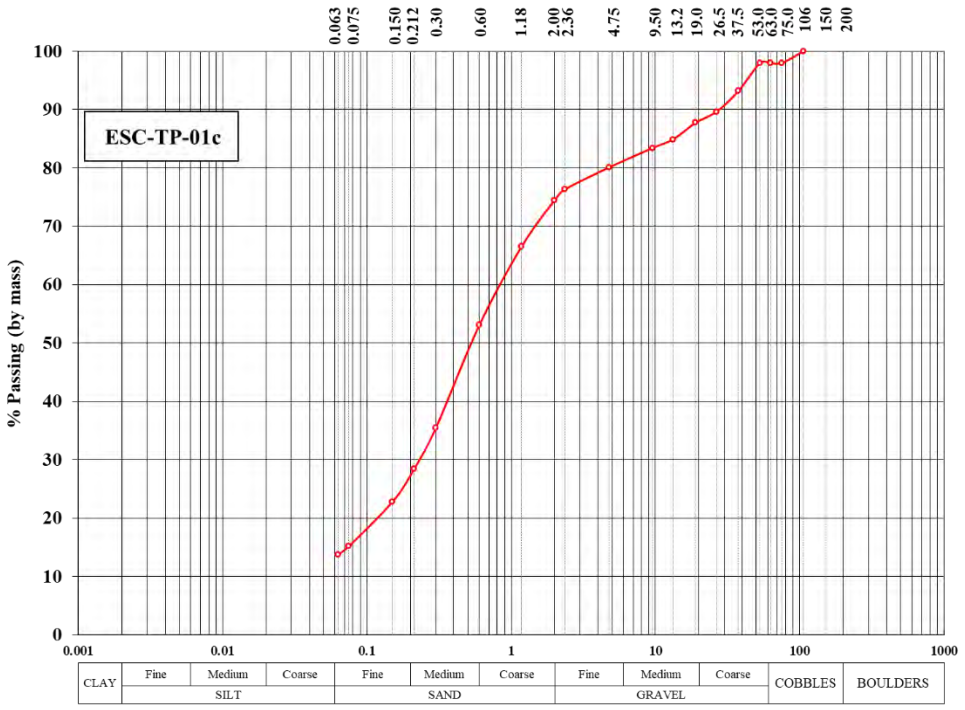
Date: 15 April 2024

TEST REPORT – ESC COVER DESIGN FIELD INVESTIGATIONS

Client Details:	**Bathurst Resources Limited,** [redacted]	**Attention:**	[redacted]
Job Description:	**ESC Cover Design Field Investigation**		
Sample Description:	**Gravelly SAND with some silt & trace of cobbles with trace of deleterious organics present (coal)**	**Client Order No:**	**539528**
Sample Source: (cs)	**ESC-TP-01c**	**Sample Depth: (cs)**	**0.80m - 1.50m**
Date & Time Sampled: (cs)	**15-Feb-24**	**Sampled By: (cs)**	[redacted]
Sample Method: (cs)	**Test Pit**	**Date Received:**	**12-Mar-24**

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1)

Test Sieve (mm)	% Passing (by mass)
106	100
75.0	98
63.0	98
53.0	98
37.5	93
26.5	90
19.0	88
13.2	85
9.50	83
4.75	80
2.36	76
2.00	74
1.18	67
0.60	53
0.30	35
0.212	28
0.150	23
0.075	15
0.063	14



The sample was received in a natural state. The percentage passing the 63µm test sieve was obtained by difference.

WATER CONTENT & SOLID DENSITY RESULTS - NZS 4402:1986, Test 2.1 & 2.7.1	
Water Content: ("All In" As Received)	**9.5 %**
Solid Density: (-37.5mm Fraction)	**2.64 t/m^3**
Note: The sample was received in a natural state.	

Notes:

- *Information contained in this report which is Not IANZ Accredited relates to the sample description based on NZ Geotechnical Society Guidelines 2005, the client supplied information (cs) and sampling.*
- *This report may not be reproduced except in full.*

[redacted]

Date: 25-Mar-24 to 10-Apr-24

ACCREDITED IANZ TESTING LABORATORY №434

Test results indicated as not accredited are outside the scope of the laboratory's accreditation

Central Testing Services [redacted]

Reference No: 24/838

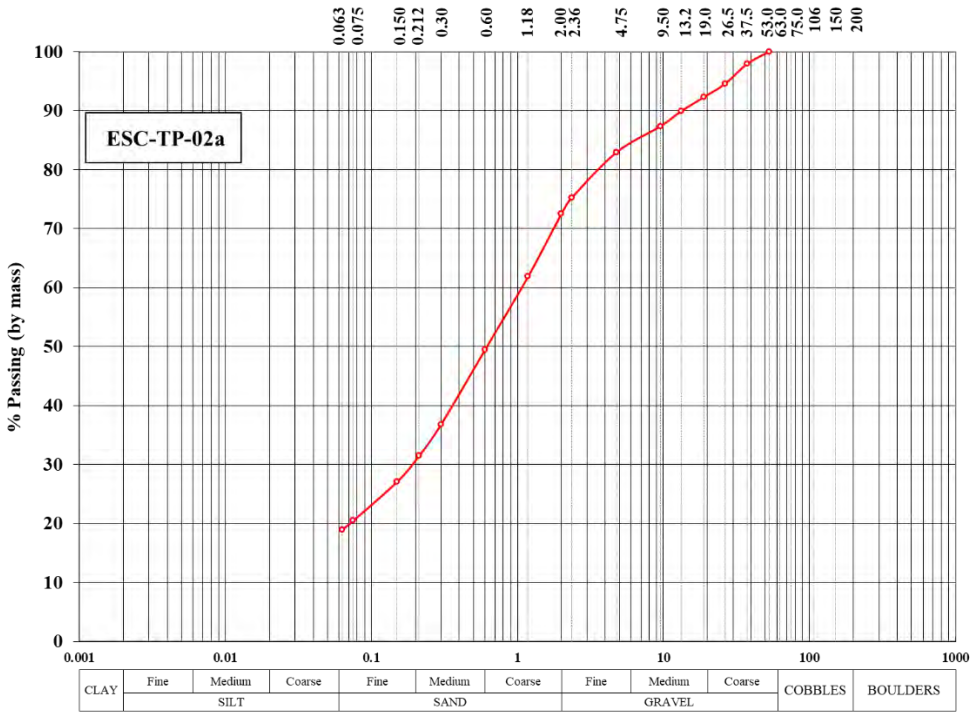
Date: 15 April 2024

TEST REPORT – ESC COVER DESIGN FIELD INVESTIGATIONS

Client Details:	**Bathurst Resources Limited,** [redacted]	**Attention:**	[redacted]
Job Description:	**ESC Cover Design Field Investigation**		
Sample Description:	**Gravelly SAND with some silt with trace of deleterious organics present (coal)**	**Client Order No:**	**539528**
Sample Source: (cs)	**ESC-TP02-a**	**Sample Depth: (cs)**	**0.00m - 0.20m**
Date & Time Sampled: (cs)	**15-Feb-24**	**Sampled By: (cs)**	[redacted]
Sample Method: (cs)	**Test Pit**	**Date Received:**	**12-Mar-24**

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1)

Test Sieve (mm)	% Passing (by mass)
53.0	100
37.5	98
26.5	95
19.0	92
13.2	90
9.50	87
4.75	83
2.36	75
2.00	73
1.18	62
0.60	50
0.30	37
0.212	32
0.150	27
0.075	21
0.063	19



The sample was received in a natural state. The percentage passing the 63µm test sieve was obtained by difference.

WATER CONTENT & SOLID DENSITY RESULTS - NZS 4402:1986, Test 2.1 & 2.7.1	
Water Content: ("All In" As Received)	**8.2 %**
Solid Density: (-37.5mm Fraction)	**2.56 t/m^3**
Note: The sample was received in a natural state.	

Notes:

- ***Information contained in this report which is Not IANZ Accredited relates to the sample description based on NZ Geotechnical Society Guidelines 2005, the client supplied information (cs) and sampling.***
- ***This report may not be reproduced except in full.***

[redacted]

Date: 25-Mar-24 to 10-Apr-24

ACCREDITED IANZ TESTING LABORATORY №434

Test results indicated as not accredited are outside the scope of the laboratory's accreditation

Central Testing Services [redacted]

Reference No: 24/838

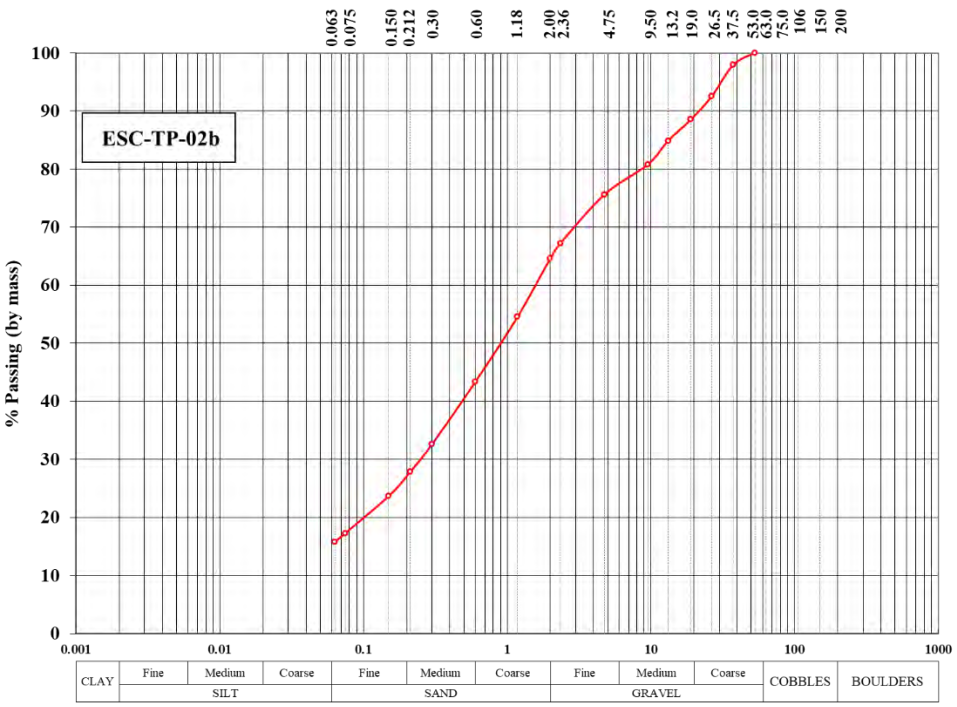
Date: 15 April 2024

TEST REPORT – ESC COVER DESIGN FIELD INVESTIGATIONS

Client Details:	**Bathurst Resources Limited,** [redacted]	**Attention:**	[redacted]
Job Description:	**ESC Cover Design Field Investigation**		
Sample Description:	**Gravelly SAND with some silt with race of deleterious organics presents (coal)**	**Client Order No:**	**539528**
Sample Source: (cs)	**ESC-TP-02b**	**Sample Depth: (cs)**	**0.20m - 0.70m**
Date & Time Sampled: (cs)	**15-Feb-24**	**Sampled By: (cs)**	[redacted]
Sample Method: (cs)	**Test Pit**	**Date Received:**	**12-Mar-24**

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1)

Test Sieve (mm)	% Passing (by mass)
53.0	100
37.5	98
26.5	93
19.0	89
13.2	85
9.50	81
4.75	76
2.36	67
2.00	65
1.18	55
0.60	43
0.30	33
0.212	28
0.150	24
0.075	17
0.063	16



The sample was received in a natural state. The percentage passing the 63µm test sieve was obtained by difference.

WATER CONTENT & SOLID DENSITY RESULTS - NZS 4402:1986, Test 2.1 & 2.7.1	
Water Content: ("All In" As Received)	**7.2 %**
Solid Density: (-37.5mm Fraction)	**2.55 t/m^3**
Note: The sample was received in a natural state.	

Notes:

- ***Information contained in this report which is Not IANZ Accredited relates to the sample description based on NZ Geotechnical Society Guidelines 2005, the client supplied information (cs) and sampling.***
- ***This report may not be reproduced except in full.***

[redacted]

Date: 25-Mar-24 to 10-Apr-24

ACCREDITED IANZ TESTING LABORATORY №434

Test results indicated as not accredited are outside the scope of the laboratory's accreditation

ATTACHMENT B – EXCAVATED SAMPLE PILES

ESC-TP-01: Surface

ESC-TP-01: 0 to 0.2 m

Note: card in image is approximately 90 mm in length.

ESC-TP-01: 0.2 to 0.7 m

Note: card in image is approximately 90 mm in length.

ESC-TP-01: Excavation profiled to 160 cm.

ESC-TP-02: Surface

ESC-TP-02: 0 to 0.2 m

Note: card in image is approximately 90 mm in length.

ESC-TP-02: 0.2 to 0.7 m

Note: card in image is approximately 90 mm in length.

ESC-TP-02: Excavation profile to 70 cm.

APPENDIX M COVER SYSTEM TECHNICAL REPORT

Cover System Technical Report

Buller Plateaux Continuation Project

21 July 2026

J-NZ0349-013-R-FINAL

MINE WASTE MANAGEMENT
GREENROAD GROUP

BATHURST RESOURCES LIMITED

Cover System Technical Report

Buller Plateaux Continuation Project

Document Number: J-NZ0349-013-R-FINAL

Document Date: 21 July 2026

Prepared for:

BATHURST RESOURCES LIMITED

[redacted]

Prepared by:

Mine Waste Management Limited

[redacted]

www.minewaste.com.au

REVISION	DATE	AUTHOR	RECORD OF REVIEW
J-NZ0349-013-R-FINAL	21/07/2026	RB	PW

EXECUTIVE SUMMARY

Bathurst Resources Limited (BRL) is seeking to obtain authorisation through the Fast -track Approvals Act (FTAA) to progress development and mining of the coal resources across the wider Buller Plateaux. This project is referred to as the Buller Plateaux Continuation Project (BPCP or Project).

The purpose of the BPCP is to reconsent the existing infrastructure and mining operations associated with the existing Stockton Mine and provide access to additional coal mining areas across the Buller Plateaux, as the coal resource in the current Stockton mine is close to depletion, and further coal resources for blending are required. There are five key Project sub-areas:

- Stockton mining area.
- Mt Frederick South (MFS)
- Escarpment Extended (ESE)
- Upper Waimangaroa Haul Road.
- Cypress mining area.

Potentially acid forming (PAF) mine rock will be stored in engineered landforms (ELFs). The ELFs will be constructed and rehabilitated with strategies that focus on reducing acid and melliferous drainage (AMD) risks associated with the PAF. The AMD risks associated with advective oxygen supply to PAF materials will be managed through the construction of design elements which reduce airflow. Long-term AMD emanating from the ELF (requiring active or passive treatment technologies) can be forecast from estimates of net percolation (NP) and oxygen ingress into the ELFs.

One-dimensional (1D) numerical simulations were completed to evaluate cover system net percolation and diffusive oxygen ingress for the MFS and ESE sub-areas. The net percolation and oxygen ingress numerical simulations were used within parallel studies to support the development of the water and load balance (WLB) models for MFS and ESE to estimate post closure AMD and collection and treatment requirements. The numerical simulations were completed with SEEP/W and CTRAN/W (GeoStudio 24.1.0.1406) software. The primary objective of the numerical simulation is to establish rates of net percolation and oxygen ingress, inform on the relative performance of alternate cover system scenarios, and develop an understanding of the influence of estimated / assumed boundary conditions and material properties.

Numerical simulation model input parameters were based on material index properties, a literature search, and professional experience with similar textured materials. Two cover system designs were considered in the analysis, based on revegetation objectives:

- Shrubland/wetland – 0.25 m soil-based growth medium layer (GML) overlying 2 m of non-acid forming (NAF) mine rock. This cover system is also considered to be representative of Pakihi wetland type rehabilitation.
- Forest – 0.5 m of a GML overlying 2 m of NAF mine rock.

The performance of the aforementioned cover system designs was simulated using 7 scenarios to assess the effect of alternate hydraulic properties, boundary conditions, and alternative cover designs.

The key advantage to the numerical modelling results summarised herein is the ability to enhance judgment. Hence, rather than a focus on the absolute results predicted, it is recommended that the modelling results be viewed as a tool to understand key processes and characteristics that will influence performance of the cover systems for the ESE and MFS sites, and to develop engineering decisions based on this understanding.

The shrubland/wetland and forest cover numerical simulations suggest:

- NP varied between approximately 15% and 60% of annual rainfall, with the lower percentages observed for the finer textured GML scenarios. Simulated runoff and NP were sensitive to the permeability of the surface GML, which was anticipated given high annual average rainfall at the site.
- The favourable water retention properties of the GML and high rainfall enable this layer to typically retain a high degree of saturation. As a result, mean annual oxygen ingress was simulated to fall within the low to medium category, ranging between approximately 100 and 230 g/m^2/yr, with exceedances of 320 g/m^2/yr (high category) occurring at a rate of 10% or less.
- Better performance (lower oxygen ingress) was achieved with finer textured mine rock and to a lesser extent, a finer textured and/or thicker GML. A higher degree of saturation with finer textured mine rock limited oxygen ingress when the GML desaturated during dry periods.

A sensitivity scenario that represented compacted running surfaces within the ELF showed promising results, with very low oxygen ingress. Further work is required to confirm this level of performance is achievable in the field.

Pakihi wetland type rehabilitation is expected to perform similarly or have lower oxygen ingress due to the wetland type setting.

It is recommended that within the first two years of mine life, once suitable material is available, cover system trials are initiated to confirm modelling results presented herein are representative of as built conditions in the field. Such a study would provide confidence that water quality closure objectives can be achieved and support closure planning.

In addition to field trials, it is recommended the full-scale constructed cover system be instrumented to allow for direct performance monitoring and confirmation the system is performing to expectations on built. If it is found through monitoring that the system is not performing such that closure objectives cannot be met, contingency measures can be considered, such as a longer active treatment period or increased semi-passive treatment capacity. Completion of adequately designed and constructed field trials and appropriate construction quality assurance and construction quality control will improve the likelihood of the full-scale constructed cover system performing to expectations and achieving closure objectives.

TABLE OF CONTENTS

1 Introduction 1
1.1 Model Objectives and Scope 1
2 Conceptual Model 2
2.1 ELF Rehabilitation Plan 2
2.2 Proposed Cover Systems 2
2.3 Climatic Setting 5
2.4 Material Texture 6
2.5 Engineered Landform 9
2.6 Post-closure Vegetation 9
2.7 Post-closure Phreatic Surface 11
2.8 Conceptual Model Summary 11
2.8.1 Engineered Landform 11
2.8.2 Cover Systems 12
3 Numerical Simulations 13
3.1 Model Geometry 13
3.2 Model Scenarios 14
3.3 Material Properties 15
3.3.1 Water Retention Curves 15
3.3.2 Hydraulic Conductivity Functions 16
3.3.3 Oxygen Diffusion 16
3.4 Boundary Conditions 17
3.4.1 Upper Boundary Conditions 17
3.4.1.1 Climate 17
3.4.1.2 Vegetation 17
3.4.1.3 Oxygen Boundary 19
3.4.2 Lower Boundary Conditions 20
3.4.3 Initial Conditions 20
4 Results of Numerical Simulations 21
4.1 Water Balance 21
4.2 Diffusive Oxygen Flux 23
4.3 Model Limitations 26
5 Conclusion and Recommendations 27
5.1 Conclusions 27
5.2 Recommendations 27
6 References 28
7 Limitations 30
Appendix A Covers Field Investigation Memo 31
Appendix B Limitations 32

LIST OF TABLES

Table 1: Scenarios for assessment. 15
Table 2: Material property summary. 15
Table 3: Qualitative performance ranges. 21
Table 4: Shrubland/wetland and forest simulated water balance. 22
Table 5: Simulated average oxygen flux. 23

LIST OF FIGURES

Figure 1: ESE Final landform features 3
Figure 2: MFS Final landform features 4
Figure 3: Cover system profiles. 5
Figure 4: Lake Brazil monthly rainfall and PE. 6
Figure 5: Particle size distribution curves of the mine rock and soil stockpile. 8
Figure 6: Textural diagram of the mine rock and soil stockpile materials. 8
Figure 7: Constructed Tarn. 10
Figure 8: Pākihi vegetation example (natural site). 10
Figure 9: Mānuka shrubland vegetation example (natural site). 11
Figure 10: Southern Rātā forest vegetation example (natural site). 11
Figure 11: Water retention curves for the mine rock and GML materials. 16
Figure 12: Hydraulic conductivity functions for the mine rock and GML materials. 16
Figure 13: Oxygen diffusion functions for the growth medium and mine rock. 17
Figure 14: Plant limiting function for the SPA model. 18
Figure 15: Root density function for the SPA model. 19
Figure 16: Soil cover fraction function for the SPA model. 19
Figure 17: Simulated diffusive oxygen flux. 23
Figure 18: Simulated oxygen profile for day 500 of numerical simulation. 25

1 INTRODUCTION

Bathurst Resource Limited (BRL) is seeking to obtain authorisation through the Fast-track Approvals Act 2024 (FTA) to progress development and mining of the coal resources across the wider Buller Plateaux. This project is referred to as the Buller Plateaux Continuation Project (BPCP or Project).

The purpose of the BPCP is to secure the existing infrastructure and mining operations associated with the Stockton Mine and provide access to additional mining areas as the coal resources in the current operations are depleted. The Project proposes to mine approximately 20 million tonnes of coking coal utilising existing infrastructure facilities over a 25-year timeframe to support and extend the mine life of the current Stockton Mine operations.

The BPCP is divided into five sub-areas ():

- Stockton mining area.
- Mt Frederick South (MFS)
- Escarpment Extended (ESE)
- Upper Waimangaroa Haul Road.
- Cypress mining area.

Potentially acid forming (PAF) mine rock will be stored in engineered landforms (ELFs) as part of the BPCP. Post closure, ELFs will be rehabilitated to manage acid and melliferous drainage (AMD) risks associated with these PAF materials and allow rehabilitation / revegetation to meet closure objectives. The AMD risks associated with advective oxygen supply to PAF materials will be managed through the construction with reduced airflow design elements (i.e., short lifts, trafficked surfaces, etc.). Long-term AMD emanating from the ELF (requiring passive treatment technologies) can be forecast from estimates of net percolation (NP) and oxygen ingress into the ELFs.

1.1 Model Objectives and Scope

This report documents soil-plant-atmosphere (SPA) modelling completed to estimate NP and diffusive oxygen ingress through cover systems planned by BRL at the MFS and ESE sub-areas. Other sub-areas were not within the scope of this assessment. Outputs from the SPA modelling will support the water and load balance (WLB) modelling for ESE and MFS, where water and oxygen ingress results will be translated into water volumes and acidity loads to understand post closure collection and treatment requirements.

This report is a supporting ‘factual modelling’ document and does not provide recommendations for a preferred cover system design. Rather, outputs from the WLB modelling will inform the overall likelihood that closure criteria can be achieved. The primary objective of the modelling documented herein was to bookend potential performance of planned cover systems to support WLB modelling. Extreme climate events were not included in the model scope outside of those that were included in the available historical dataset (spanning 2013 through 2023, see Section 2.3).

2 CONCEPTUAL MODEL

This section provides a description of the physical, chemical, and hydrological components considered in the conceptual model. The developed conceptual model provides MWM's understanding of the system (knowns and unknowns), which serves as the foundation for subsequent numerical simulations and interpretation of results. This allows the basis of the numerical simulations to be communicated and to inform management decisions.

2.1 ELF Rehabilitation Plan

ELF rehabilitation is described in the BPCP Rehabilitation Management Plan (BRL, 2026a). Figure 1 and Figure 2 present the layout of the final landform features for ESE and MFS, respectively. Two, feature types will be developed to rehabilitate the ELFs:

- Wetland/tarns, which will include a mixture of pākihi and tarn wetlands. This type will be established on gentle to flat slopes (<5°) with construction measures to maximise saturation (low permeability base and/or bunds).
- Native Ecosystem, which will include a mix of pākihi, shrubland and forest type vegetation. These will be established on steeper slopes that range between 5 to 35°.

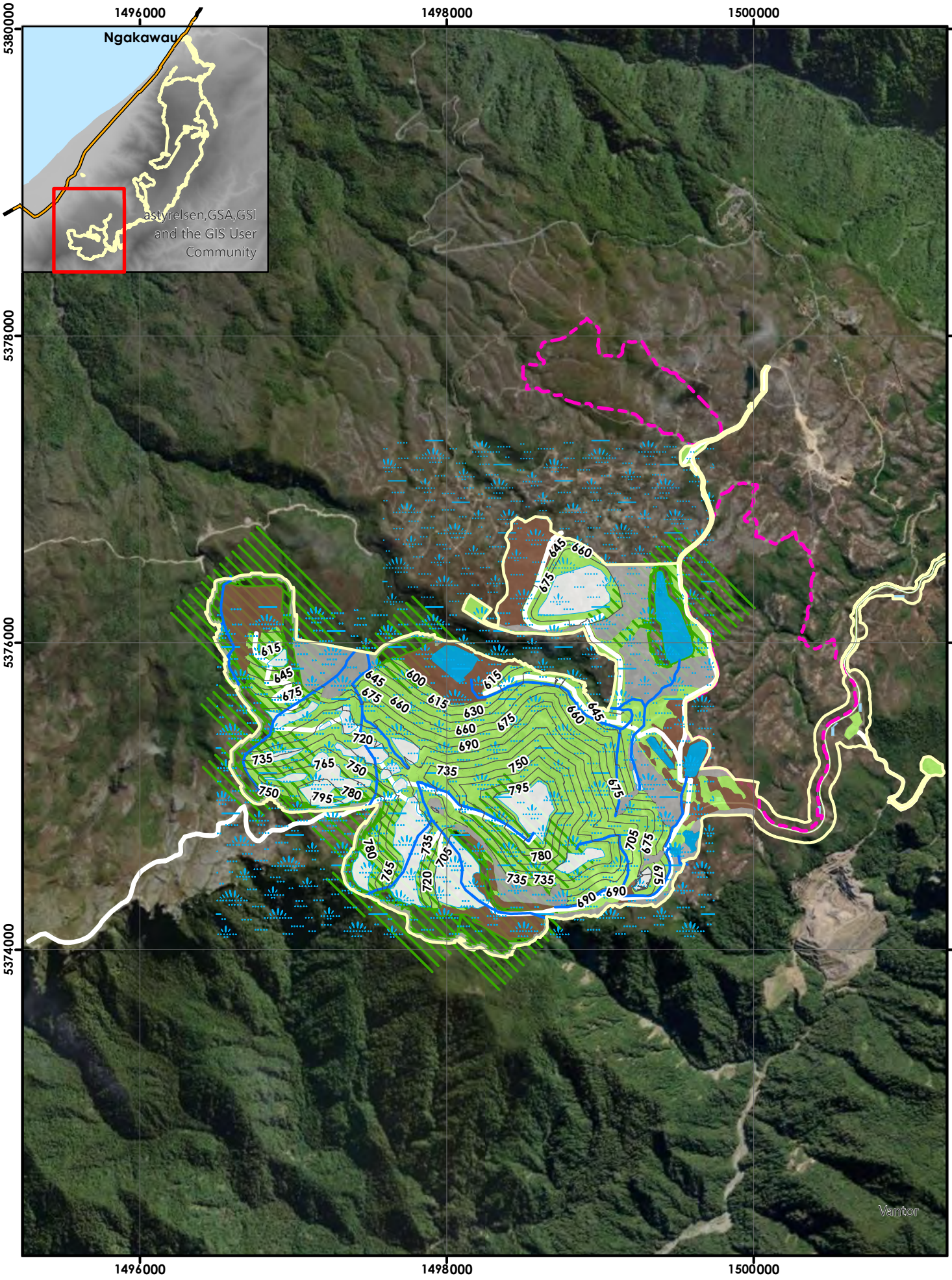
Coal floor rehabilitation is described in the BPCP Rehabilitation Management Plan (BRL, 2026a).

2.2 Proposed Cover Systems

The cover systems considered for assessment are as follows (see Figure 3):

- Shrubland/wetland[1]
  - 0.25 m thick growth medium layer (GML) soil cover.
  - 2 m thick non-acid forming (NAF) mine rock.
- Forest
  - 0.5 m thick GML soil cover.
  - 2 m thick NAF mine rock.

[1] Shrubland and wetland rehabilitation types are grouped together since they are expected to have similar vegetation; see Section 2.6.



NZGD 2000 Transverse Mercator

BATHURST RESOURCES LIMITED

COPYRIGHT. This Document is confidential and remains the property of Bathurst Resources Ltd. It must not be disclosed or copied by any member or used for any other project without the written approval of Bathurst Resources Ltd.

Figure 1

Legend

- Final Surface Contours
- Final Streams
- Proposed Predator Exclusion Fence
- Native Ecosystem
- Rehabilitated Highwall
- Rockfield Rehabilitation
- Undisturbed Area
- Closure Water Body
- Water Infrastructure
- White Infrastructure
- Wetland/Tarn
- Proposed Land Use Consent Boundary

Buller Plateaux Continuation Project

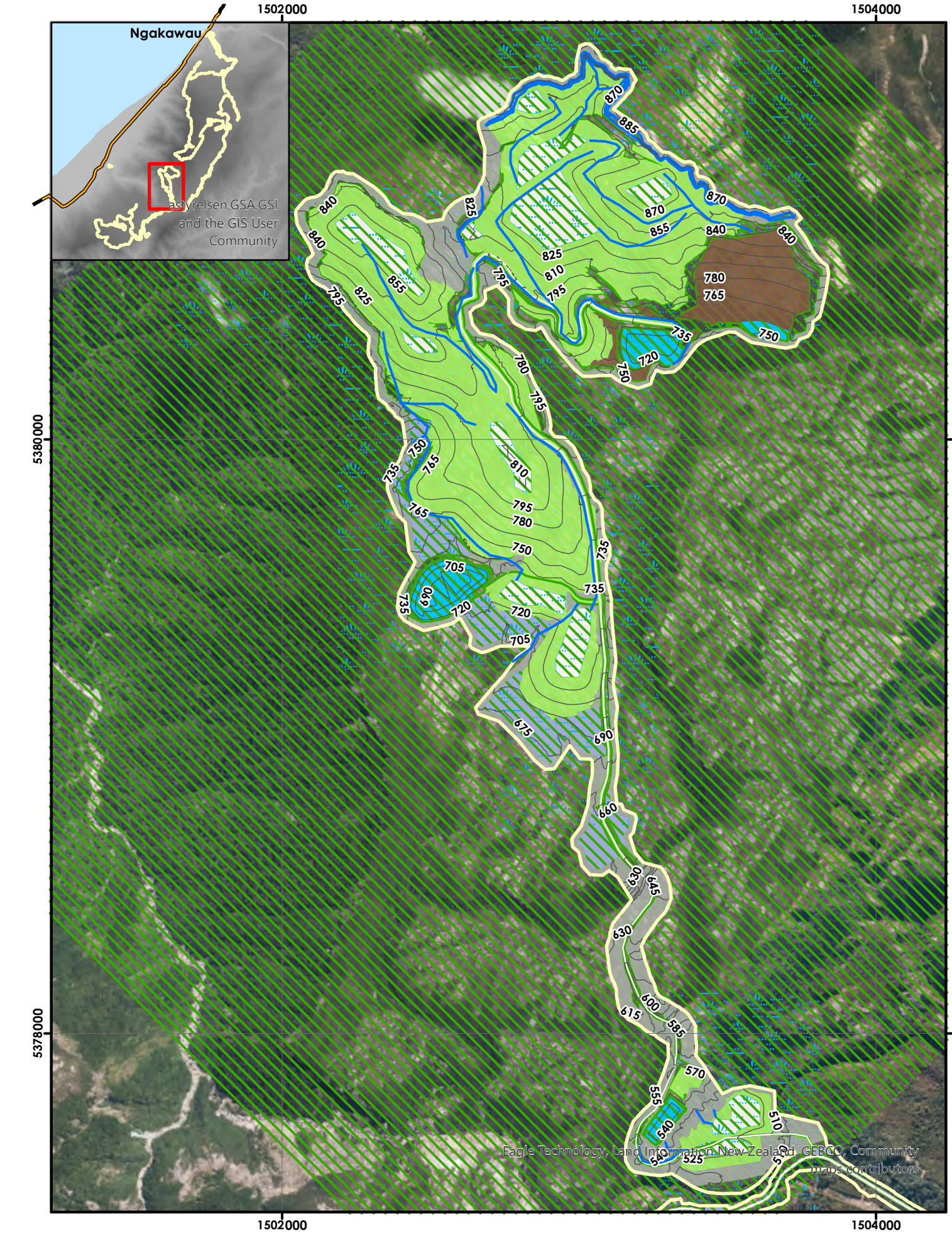
Indicative Final Landform Features and Final Surface Contours

SCALE: 1:32,000

DATE: 04 February 2026

DRAWING NUMBER: 100_5

N



NZGD 2000 Transverse Mercator

BATHURST RESOURCES LIMITED

COPYRIGHT. This Document is confidential and remains the property of Bathurst Resources Ltd. It must not be disclosed or copied by any member or used for any other project without the written approval of Bathurst Resources Ltd.

Figure 2

Legend

- Final Surface Contours
- Final Streams
- Native Ecosystem
- Rehabilitated Highwall
- Rockfield Rehabilitation
- Undisturbed Area
- Closure Water Body
- Water Infrastructure
- White Infrastructure
- Wetland/Tarn
- Proposed Land Use Consent Boundary

Buller Plateaux Continuation Project

Indicative Final Landform Features With Final Surface Contours

SCALE: 1:16,000

DATE: 13 February 2026

DRAWING NUMBER: 101_6_2

N

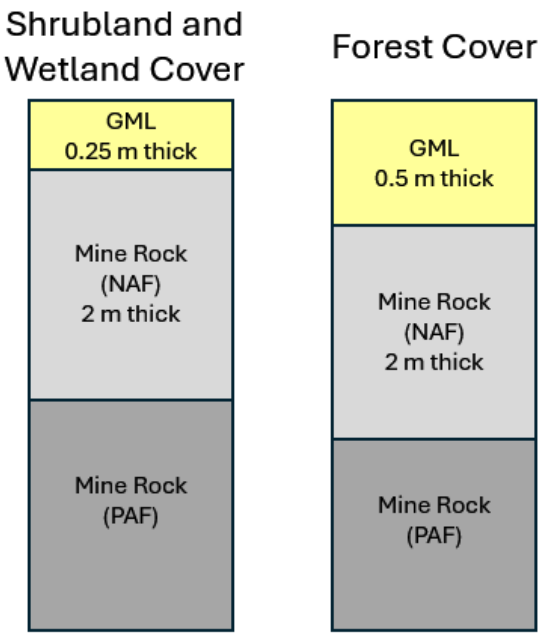


Figure 3: Cover system profiles.

Note: not to scale.

2.3 Climatic Setting

The Denniston Plateau, located on the West Coast of New Zealand's South Island, experiences a temperate maritime climate characterised by high annual average rainfall, cool temperatures, and frequent cloud cover. Annual precipitation often exceeding 5,000 mm, due to prevailing westerly winds that bring moisture-laden air from the Tasman Sea. Temperatures on the plateau are moderate, with colder and damp winters and mild summers. The combination of geology, high rainfall and moderated temperatures creates the unique ecological and hydrological characteristics of the Denniston Plateau.

Rainfall and potential evaporation (PE) representative of the Lake Brazil Meteorological Station are summarised on a monthly basis in Figure 4 from the period 25 January 2013 through 31 December 2023 (~11 years). PE was calculated based on the Penman method (Penman, 1948) using daily data from Lake Brazil Meteorological Station and estimates of solar radiation based on the position of the projects on the surface of the earth. An energy deficit[2] is apparent for all months, with PE calculated as approximately 15% of mean annual rainfall (5,414 mm/yr for the 11-year period). The median rainfall intensity was relatively high at ~1 mm/hr (~3 x 10^{-7} m/sec), with 90% of the rainfall amount occurring at intensities greater than 1 mm/hr. The numerical simulation models in this assessment used an hourly time step.

The lowest monthly rainfall over the 11 year dataset was ~100 mm (December 2021) while the highest was 1390 mm (January 2022). Monthly PE only exceeded monthly rainfall on two occasions out of 132 months on record, or ~1.5% (January 2013 and December 2021).

[2] The term energy deficit used here refers to the different between rainfall and potential evaporation. In other words rainfall is higher than evaporation on an annual and monthly basis.

Lake Brazil climate data is representative of the ESE. For MFS, PE will likely be similar, but rainfall is expected to be higher given the higher elevation (640 m above sea level [asl] vs ~750 m asl) of the Project compared to Lake Brazil and is estimated to be 10% to 15% higher on average based on a rainfall-elevation relationship developed by BRL (2024).

Climate change for the West Coast region is anticipated to increase annual rainfall by between 4% to 8% by 2101–10 for Representative Concentration Pathways (RCP) 2.6 and RCP 8.5, respectively (MfE, 2018). Mean annual daily temperature changes ranged between 0.7 °C and 3.7 °C, which translate to an increase in PE by 2% to 10% (similar magnitude to rainfall increases).

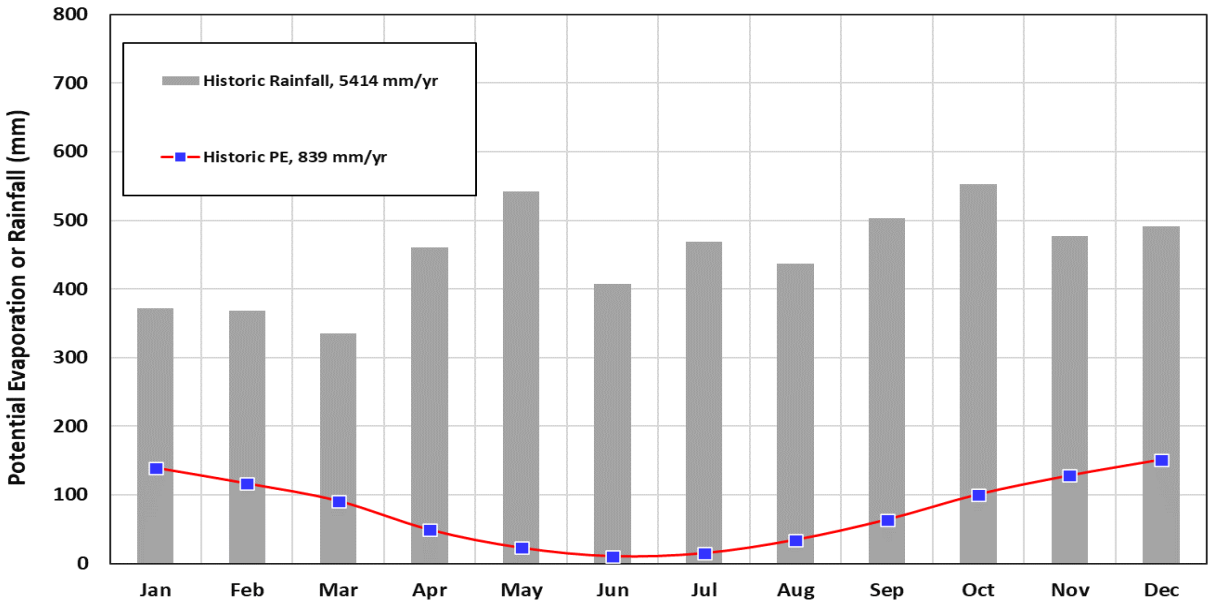


Figure 4: Lake Brazil monthly rainfall and PE.

Note: PE represents potential evaporation.

2.4 Material Texture

Particle size distribution (PSD) curves for mine rock and soil are shown in Figure 5, and plotted in a textural ternary diagram (see Figure 6). The PSD of a given material indicates the relative proportions of the different particle sizes that make up the material on a mass basis and provides an understanding of:

- Material grading (i.e., whether it's well graded, poorly graded, or gap-graded).
- Resistance or acceptance of compactive effort.
- Potential for segregation during handling and placement procedures.
- Material structure (i.e., grain- or matrix-supported).
- Anticipated hydraulic characteristics.

At MFS and ESE, mine rock placed within the ELFs will be from the Brunner Coal Measures (BCM). A summary memorandum on field investigations to characterise material textural properties is included in Appendix A (MWM, 2026).

The PSD curves for soil and mine rock are shown in Figure 5 and are described as follows:

- Escarpment Soil Stockpile: samples from the Escarpment Soil Stockpile, which has been sitting in place for approximately 7 years, including partial vegetation growth. It is deemed representative of a soil-based GML material in planned cover systems. Reported in MWM (2026).
- BV-ELF Mine Rock: grab samples from the surface of the Barren Valley ELF at the Escarpment Mine, which has been in place for approximately 7 years. Samples from up to one metre depth. Representative of BCM mine rock and potentially biased to a slightly finer texture. Reported in MWM (2026).
- SENZ (2007) Zone 3 Trial: Sample collected from 300 mm lifts of compaction trial at Stockton Mine. Compaction was achieved with a CP-663E Cat vibrating sheep's-foot roller. Representative of BCM mine rock. Reported in SENZ (2007).
- URS (2005) Overburden: Samples collected from 500 mm lifts from a compaction trial at Stockton Mine. Compaction was achieved with a loaded Cat777D haul truck. Representative of BCM mine rock. Reported in URS (2005).

Observations from the available texture data include:

- Soil textural data (from the Escarpment Soil Stockpile) indicate a relatively well-graded material with 20% cobbles and gravels, 40% sand, and a fines content of 40%, based on the Unified Soil Classification System (USCS). Clay was estimated at 8%. The soil will exhibit a matrix-supported structure.
- There are differences observed in the mine rock texture, with BV-ELF samples representing a finer texture, and the URS (2005) overburden a coarser texture. The URS (2005) samples exhibit greater heterogeneity. The BV-ELF material plots within the matrix-supported zone, while the URS data plots within the grain-supported zone. This would suggest that there is the potential for substantially different hydraulic and pneumatic properties between the URS (2005) and BV-ELF mine rock.
- It is noted that the PSD data collected by MWM (2026) did not include fractions larger than 106 mm (a function of the laboratory procedure) for mine rock. The proportion of particles larger than this was visually estimated to be between 5 to 10%, which is unlikely to materially change the observations made nor model inputs selected in Section 3.3 due to the degree of finer particles (e.g., sand and fines) present that would still form a consistent matrix around larger particles.

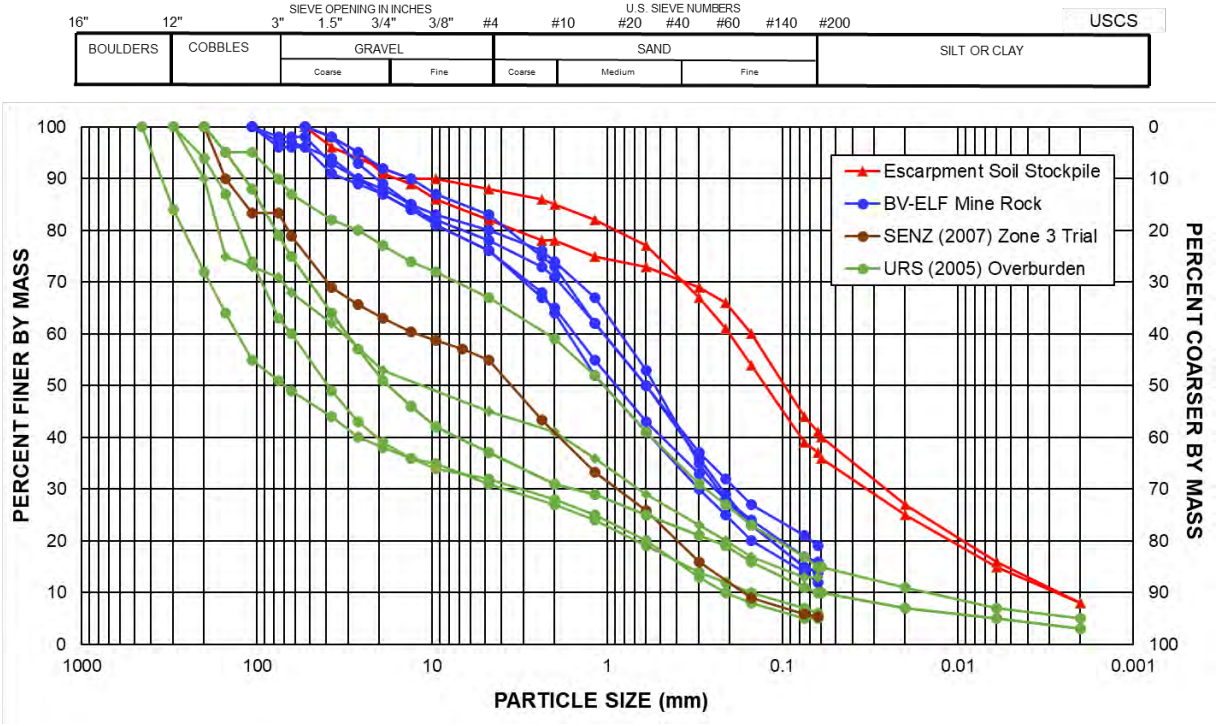


Figure 5: Particle size distribution curves of the mine rock and soil stockpile.

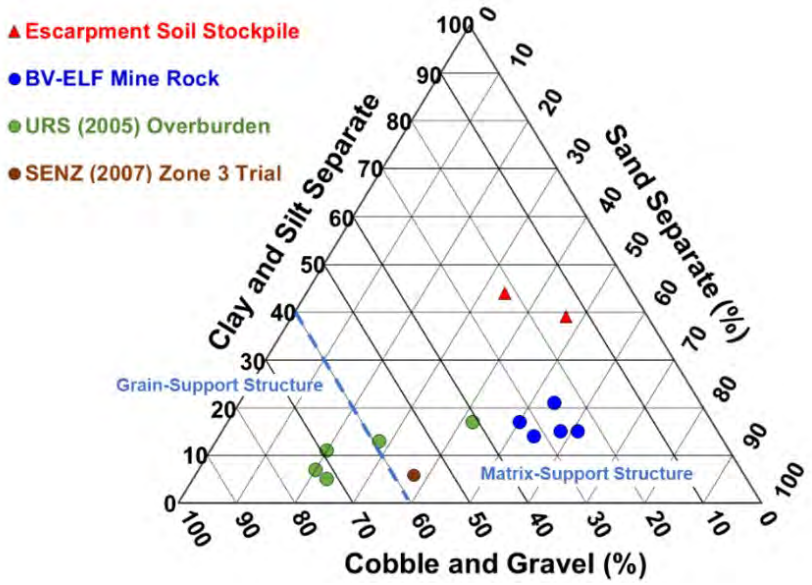


Figure 6: Textural diagram of the mine rock and soil stockpile materials.

Note: Grain vs matrix supported structure based on Herasymuik (1996).

MWM (2026) completed in-situ permeability testing, with an average saturated hydraulic conductivity of 3 x 10^{-7} m/s for soil stockpile, and 4 x 10^{-6} m/s for non-compacted finer textured mine rock. Near surface compacted layers of mine rock were an order of magnitude lower (1 x 10^{-7} m/s or less). For the coarser BCM mine rock, URS (2005) reported in-situ saturated hydraulic conductivity values of 1 x 10^{-5} m/s to 8 x 10^{-5} m/s for a compaction test pad constructed in 500 mm lifts and haul truck compacted.

Based on the measured field saturated permeability for the soil and mean rainfall intensity noted in Section 2.3, runoff is expected be a notable component of the water balance, in particular for the finer textured materials.

2.5 Engineered Landform

The ELFs will be constructed with the following aspects (BRL, 2026b):

- Bottom-up build with short lifts (2 m) to minimise segregation, with higher lifts possible if grainsize segregation does not occur and advective oxygen ingress is prevented.
- Traffic compaction on top of each lift.
- Progressively rehabilitated.
- At ESE, PAF material will be encapsulated with 1 to 3 m of NAF mine rock. At MFS, the outer NAF encapsulation layer will be 5 m thick or greater.
- The final landform surface will be constructed and profiled to a rehabilitation angle of 18 degrees.
- ELF heights will vary between 20 to 60 m.
- Where possible, ELFs will be developed in-pit to minimise lateral oxygen ingress where mine rock is placed against pit walls.
- Basal drainage systems (sub-ELF rock drains) will be established under the ELFs to collect and convey seepage for treatment.
- It is expected, based on previous studies that the ELF construction will result in a 10 m thick (horizontal) outer oxidising zone. Deeper than 10 m, the ELF will be under sub-oxic conditions.

2.6 Post-closure Vegetation

Three ELF rehabilitation vegetation types are planned for ESE and MFS post closure are described in the BPCP Rehabilitation Management Plan (BRL, 2026a) and are as follows:

- Tarns, present on low gradient sites with a low vegetation (pākihi, mānuka shrubland).
- Pākihi, a mix of mānuka and tussock/rush dominated vegetation in a wetland like setting.
- Shrubland, a mix of mānuka and flax dominated vegetation.
- Forest, a mix of vegetation dominated by beech and other taller shrubs and trees (podocarp/kamahi/rata).

Photographic examples of the natural vegetation are provided in Figure 7 through Figure 10.

Figure 7: Constructed Tarn.

Source: ESNZ (2026).

Figure 8: Pākihi vegetation example (natural site).

Source: ecoLogical Solutions (2024).

Figure 9: Mānuka shrubland vegetation example (natural site).

Source: ecoLogical Solutions (2024).

Figure 10: Southern Rātā forest vegetation example (natural site).

Source: ecoLogical Solution (2024).

2.7 Post-closure Phreatic Surface

The relatively coarse mine rock and planned underdrains beneath each ELF are likely to mean the phreatic surface within a given ELF will be relatively deep, such that it will be unlikely to have a high degree of influence on the cover system performance at the surface.

2.8 Conceptual Model Summary

2.8.1 Engineered Landform

It is likely that ELFs will wet-up shortly after construction given the likely initial wet placed condition, high rainfall, and water retention properties of the mine rock. Hence basal seepage is likely to initiate during construction providing mobilisation of oxidation products.

The ELFs will be constructed bottom-up using short lifts (less than 5 m) to minimize material segregation and incorporate numerous trafficked surfaces. As such, the airflow capacity of the facility will be reduced limiting advective transport of oxygen deeper in the facility. The ELF will be constructed with the objective to limit oxygen ingress to <10 m from the ELF surface (horizontally).

While the bottom-up construction will reduce advective airflow it is anticipated that there could be areas of the ELFs still influenced by minor advective airflow due to material heterogeneity and construction. Quality assurance and construction quality control (QA/QC) is required to ensure the areas influenced by advective airflow are minimised.

Sulfide minerals associated with the overburden will be exposed to oxidative conditions following blast, transport, and placement in an ELF before the next lift is placed. Diffusive oxygen is anticipated to penetrate an estimated 3 to 4 m of depth. As a result, the entire lift will likely be exposed to oxidative conditions until the following lift is placed. While the construction method will reduce long term sulfide oxidation due to restriction of advective airflow, sulfides will oxidise over the construction period providing a stored load of oxidation products that can be mobilised with infiltrating water.

Post-closure, stored oxidation products generated from the construction period will be flushed out until such time that equilibrium with diffusion influx is achieved.

2.8.2 Cover Systems

The strong climatic energy deficit (PE = 15% of average annual rainfall) means the primary strategy for reducing NP will be to divert rainfall into runoff. Runoff will likely be a significant proportion of the water balance given the following aspects:

- The relatively high rainfall intensity and low to moderate GML surface saturated hydraulic conductivity (K_{sat}) values.
- Frequent wet days driving moist antecedent conditions (low soil storage before saturation reached).
- The majority of the landforms will be sloped, likely enhancing runoff. However, based on the theoretical cosine factor (cosine[slope angle]) for steady state saturated conditions (e.g., Morbidelli et al., 2018), a slope of 18 degrees would reduce surface infiltration (and increase runoff) by approximately 5%.

The partitioning of rainfall between runoff and NP will likely be sensitive to the K_{sat} of the GML given their similar values.

The cover material is well graded with moderate water retention properties resulting in areas of the ELF with high volumetric water contents and low air permeability reducing oxygen transport to diffusion only. Hence the strategy for limiting sulfide oxidation is to encourage sufficient infiltration to suppress the oxygen diffusion coefficient and through a thick profile reduce the concentration gradient.

Given the substantial energy deficit it is likely that climate change would not pose a risk to performance unless the rainfall to PE ratio changed substantially. Available climate change projections do not suggest this will occur.

3 NUMERICAL SIMULATIONS

Numerical simulations were conducted to evaluate the performance of the cover system scenarios and identify potential risks related to the estimated/assumed material properties, where the term assumed is related to the parameter not being directly measured. GeoStudio version 24.1.0.1406 (SEEP/W and CTRAN/W) was used to simulate water and diffusive oxygen ingress through the cover system scenarios.

3.1 Model Geometry

A one-dimensional (1D) model geometry is a simplified representation used to simulate processes that vary primarily in one direction, typically depth. The model consists of a linear profile with nodes or elements arranged along a single axis, representing different depths or distances. The 1D approach reduces computational complexity while providing detailed insight into vertical gradients of pressure, temperature, or concentration, making it ideal for assessing a range of input parameters and 1D processes such as diffusive oxygen. While the numerical simulation models are 1D, runoff is enabled at the surface. Runoff is generated when the applied infiltration flux (after accounting for evaporative losses) is greater than the infiltration capacity of the material during the timestep, resulting in ponding. The ponded water is removed from the model domain and recorded as runoff. In the field at the landform scale, the slope angle will influence potential for runoff generation, which is not captured by the model.

2D numerical simulation are not required for assessing performance given that water flow through the ELF would be primarily 1D following surface infiltration. 2D simulation may be considered in future studies should a cover scenario with finer texture layers be placed below NAF on side slopes to better understand interflow.

Model temporal discretisation was set to one hour time steps in order to better account for runoff processes under high rainfall intensity events. Shorter time steps were also investigated but were found to unacceptably increase the model runtimes and numerical instability.

Two base case cover systems were developed, two for shrubland/wetland and forest type vegetation with a soil GML layer present. Each base case system is described in the following sub-sections, along with design alternatives. It is noted that the simulated results of the scenarios should be considered to reflect the potential range of base case performance, and any one scenario is not more representative than the others.

The model geometry was defined follows:

- Shrubland/wetland
  - 0.25 m thick GML soil cover
  - 2 m thick NAF mine rock.
  - PAF mine rock 12 m thick.
- Forrest
  - 0.5 m thick GML soil cover.
  - 2 m thick NAF mine rock.
  - PAF mine rock 12 m thick.

A 12 m thickness of PAF mine rock was included below all cover types. 12 m was selected as a balance between a thickness great enough to limit any influence on the model results of interest, but not so deep that computational effort and model run time increased unacceptably.

A Shrubland/wetland scenario that incorporated compacted running surfaces was also included, with the following geometry:

- 0.25 m thick GML soil cover
- 2.5 m thick NAF mine rock (uncompacted).
- 0.5 m thick PAF mine rock running surface (compacted).
- 2 m thick PAF mine rock (uncompacted).
- 0.5 m thick PAF mine rock running surface (compacted).
- 2 m thick PAF mine rock (uncompacted).
- 0.5 m thick PAF mine rock running surface (compacted).
- 2 m thick PAF mine rock (uncompacted).
- PAF mine rock 4 m thick.

These types of cover systems are anticipated to be representative of Pākihi rehabilitation area performance.

3.2 Model Scenarios

This section outlines the cover system scenarios simulated to assess the influence of variability in material properties and cover system configurations on simulated performance. Scenario cases included in the numerical simulations are summarised in Table 1. The scenarios explore how changes in hydraulic properties across different material layers affect water movement / retention and oxygen ingress. Coarser and finer textured hydraulic properties were developed to reflect alternative materials but also capture uncertainty in applying analytically derived properties. There was a greater range in material properties for the mine rock given the observed range in PSD and in-situ saturated hydraulic conductivity data for this material. In contrast, the difference in the GML properties were more constrained given the greater observed homogeneity. A shrubland/wetland scenario that included three 0.5 m thick trafficked running surfaces (i.e., more compacted) was also included.

The scenarios were selected to provide an understudying for how differences in material properties (e.g. K_{sat}) and cover system configurations (including a layer with enhanced water retention) can optimise the environmental performance of the engineered landforms.

Table 1: Scenarios for assessment.

SCENARIO ID	COVER TYPE	TEXTURAL PROPERTIES
S1	Shrubland/ wetland	GML: coarser Mine Rock: coarser
S2		GML: finer Mine Rock: coarser
S3		GML: coarser Mine Rock: finer
S4	Forest	GML: coarser Mine Rock: coarser
S5		GML: finer Mine Rock: coarser
S6		GML: coarser Mine Rock: finer
S1-SEN	Shrubland/wetland with compacted layers	GML: coarser Uncompacted mine rock: coarser Running surface mine rock: finer

3.3 Material Properties

This section describes the material properties used in the numerical model. The material properties considered in this analysis include media types, their permeability, porosity, and other relevant parameters that influence fluid flow through porous media. These parameters are used to develop the water retention curve (WRC) and hydraulic conductivity function (k-function). Material properties were based on available textural data (Section 2.4) and professional experience. Key properties are summarised in Table 2 and presented graphically in the following sub-sections. It was assumed that NAF and PAF mine rock had the same physical material properties.

Table 2: Material property summary.

MATERIAL TYPE	POROSITY	AEV	K_{SAT}
Coarse GML	0.4	2.5 kPa	$5x10^{-7}$ m/s
Fine GML		5 kPa	$1x10^{-7}$ m/s
Coarse NAF	0.3	0.3 kPa	$5x10^{-5}$ m/s
Fine NAF		5 kPa	$4x10^{-6}$ m/s

AEV = air entry value; K_{sat} = saturated hydraulic conductivity.

3.3.1 Water Retention Curves

WRCs describe the relationship between the water content and the matric suction (negative pore-water pressure) or energy state of a porous medium. The WRC is generally nonlinear and can be described using various models that allow the calculation of water content at different levels of matric suction. The WRCs used in the numerical modelling are presented in Figure 11 and are based on Fredlund and Xing (1994).

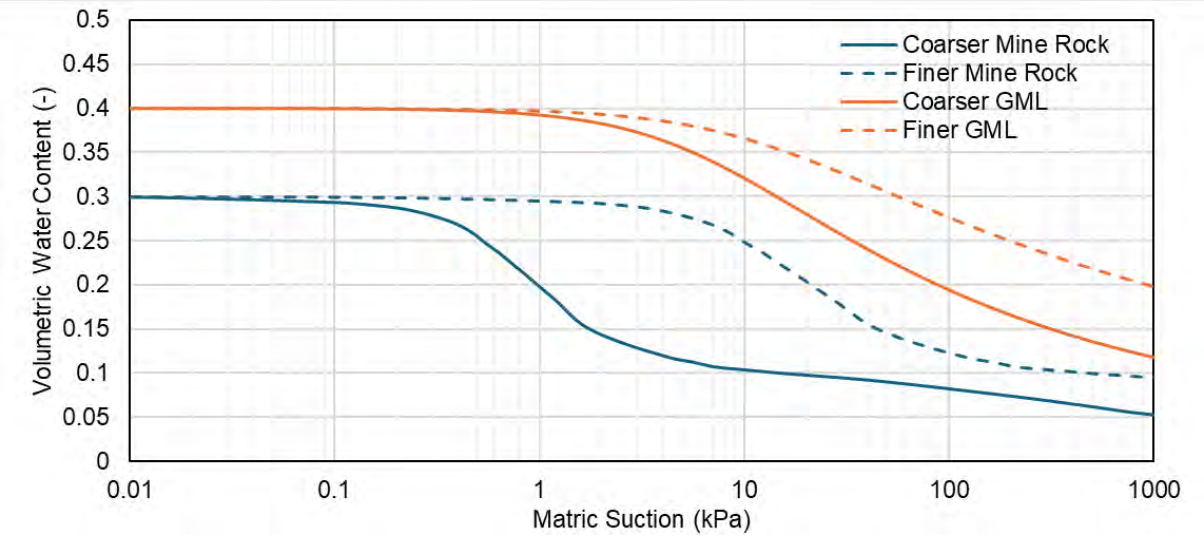


Figure 11: Water retention curves for the mine rock and GML materials.

3.3.2 Hydraulic Conductivity Functions

The k-function describe the effective hydraulic conductivity at the respective negative pore-water pressure. The k-functions used in this modelling effort are shown in Figure 12 which were based on the Fredlund et al. (1994) model. The median rainfall intensity is similar to or exceeds the K_{sat} of the GML, and as such runoff and NP will be sensitive to the surface material hydraulic properties.

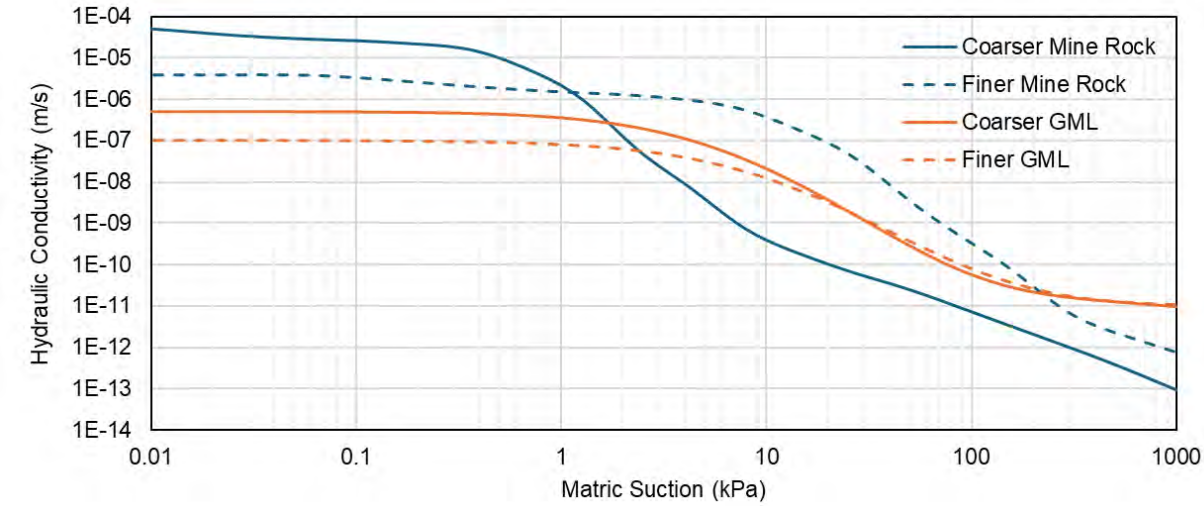


Figure 12: Hydraulic conductivity functions for the mine rock and GML materials.

3.3.3 Oxygen Diffusion

Diffusive oxygen ingress is controlled by the concentration gradient as defined by Ficks laws, where the diffusion coefficient (D) along with the concentration gradient influence the diffusive flux of oxygen. Diffusion through water filled pores (Dw) is orders of magnitude lower than diffusion through air filled pores (Da). Thus, as the degree of saturation increases, the effective diffusion coefficient (De) decreases. For this study, diffusion coefficients for each phase (Dw and Da) were calculated based on the Aachib et al. (2004) model. For input into CTRAN/W, these coefficients needed to be converted to their bulk form by accounting for the volumetric air content for each material. Values of 0.4 and 0.3 were used for the GML and mine rock units, respectively. A De function for each material type is presented in Figure 13.

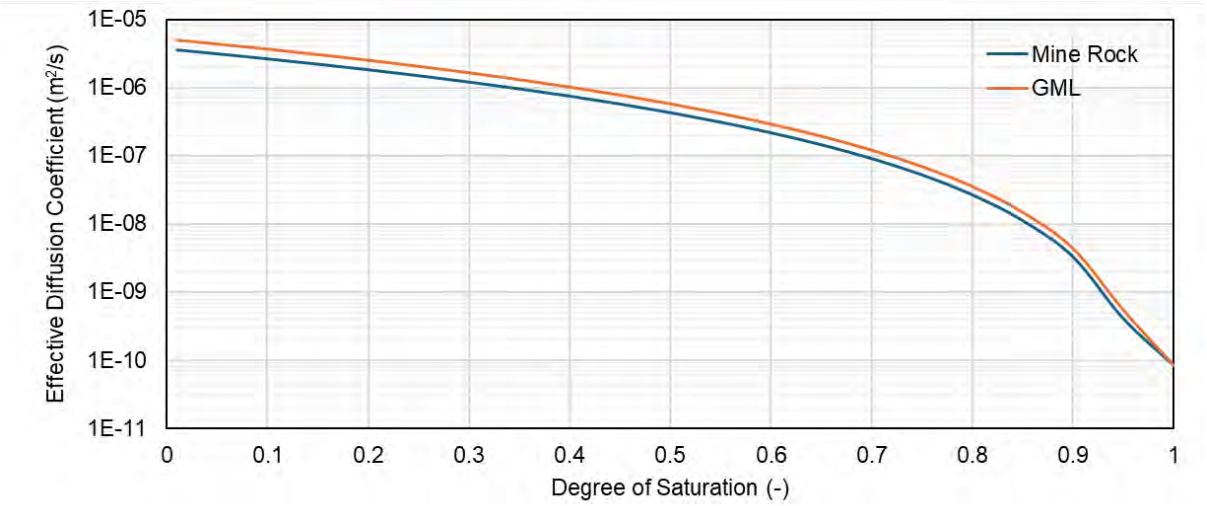


Figure 13: Oxygen diffusion functions for the growth medium and mine rock.

3.4 Boundary Conditions

This section describes boundary conditions used in the numerical model. Each boundary condition was developed to reasonably represent conditions expected for each scenario.

3.4.1 Upper Boundary Conditions

The three upper boundary conditions for this project are the climate, vegetation, and atmospheric oxygen concentration.

3.4.1.1 Climate

The climate boundary condition was defined using meteorological data from Lake Brazil. Key inputs included hourly rainfall, and daily average: temperature, relative humidity, and wind speed. Solar radiation was estimated from the project position on the surface of the earth; hence, the calculated PE could be biased slightly higher given the likely duration of cloud cover that would reduce solar radiation. The historic climate record that spans from 2013 to 2023 was utilised (see Section 2.3 for more details). This period was deemed adequate to capture a range of meteorological conditions to statistically provide a range of anticipated performance under historic climatic conditions.

The model converts PE to actual evapotranspiration based on a number of factors including: the ratio of actual vapour pressure deficit to the potential vapour pressure deficit and vegetation functions (see Section 3.4.1.2). The reader is referred to the Seequent (2022) for full theoretical details implemented in SEEP/W.

As noted in Section 2.8, climate change is not expected to noticeably influence model results so was not accounted for in the modelling completed.

3.4.1.2 Vegetation

For the purposes of assessing long-term NP and diffusive oxygen ingress, the vegetation boundary conditions were set to reflect mature vegetation / climax succession. The growth of vegetation over time following cover placement was not considered, yet alternate levels of vegetation succession would likely not have a marked influence on simulated performance given the observed monthly energy deficit.

The vegetation boundary condition consists of the following components:

- Leaf Area Index (LAI): LAI is a parameter that quantifies the total leaf area per unit ground area, influencing various hydrological and soil processes. LAI directly impacts evapotranspiration rates, with higher LAI values typically leading to increased transpiration and reduced soil moisture availability. LAI values adopted for numerical simulations varied by vegetation type, and were assumed constant in time given the predominant evergreen species and lack of defined growing season on the West Coast (MfE, 2021), and are as follows (based on Scurlock et al., 2001):
  - Shrubland/wetland LAI = 2.
  - Forest LAI = 6.
- Plant Limiting Factor (PLF): PLF is used to describe how plant water uptake is constrained by water availability. This function represents the relationship between cover water content and the ability of plants to extract water. The PLF used for this modelling effort is presented in Figure 14.
- Rooting depth: The rooting depth was specified based on vegetation type as follows[3]:
  - Shrubland/wetland = 0.25 m.
  - Forest = 0.5 m.
- Root Density Function: The root density function characterises how plant roots are distributed within the soil profile. The root density function used in this modelling effort is presented in Figure 15, based on Hoffman and van Genuchten (1983).
- Soil Cover Fraction: The soil cover fraction allows for the partitioning of potential evapotranspiration into evaporation and transpiration based on how the LAI varies. The soil cover fraction function is presented in Figure 16, and is based on Ritchie (1972).

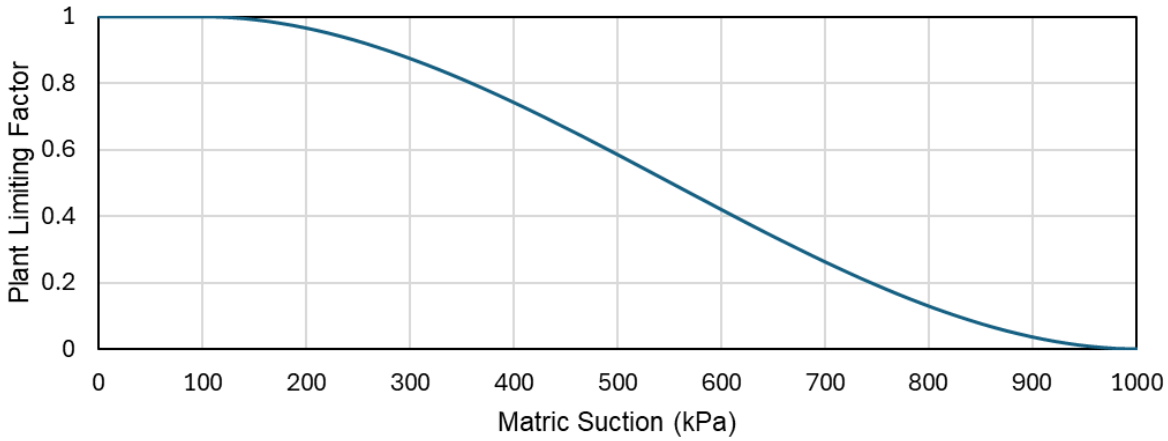


Figure 14: Plant limiting function for the SPA model.

[3] *Personal communication with G. Bramley of ecoLogical Solutions on 9 April 2024 for shrubland/wetland and forest.*

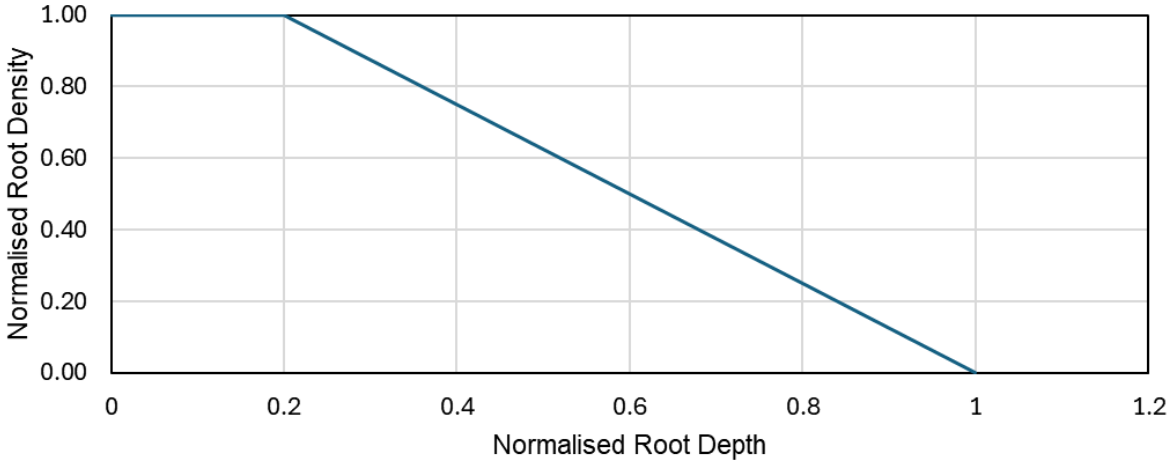


Figure 15: Root density function for the SPA model.

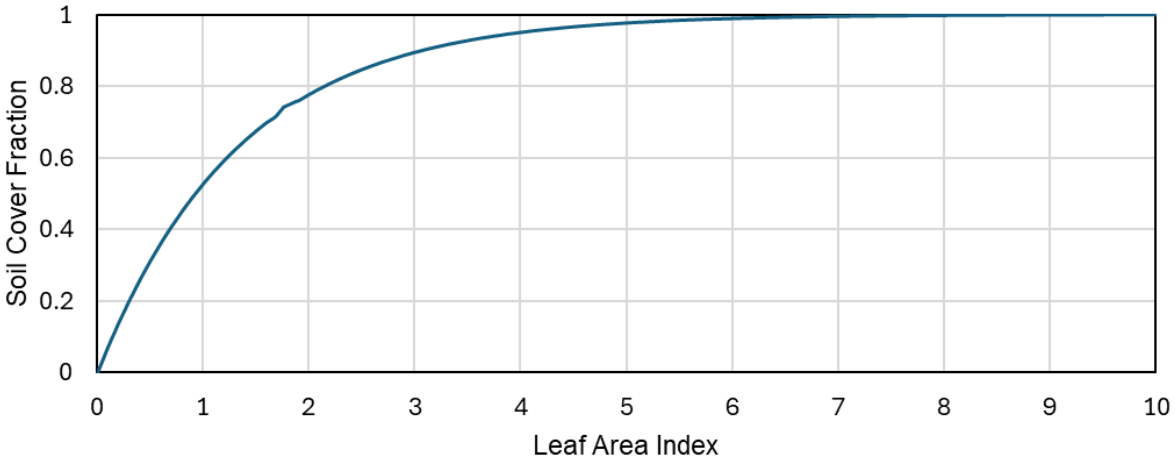


Figure 16: Soil cover fraction function for the SPA model.

3.4.1.3 Oxygen Boundary

A fixed oxygen concentration value of 258 g/m^3 was set at the surface of the model domain to represent the unlimited supply of oxygen available for diffusion into the cover systems. This value was corrected for site elevation, ~650 m above sea level (asl), from the sea level oxygen concentration of 280 g/m^3 based on the following relationship:

$$C_{corrected} = C_{sea\ level} \times 0.9877^{(Elv/100)}$$

Where C is the oxygen concentration (g/m^3) and Elv is the site elevation above sea level (m asl). Although MFS (~800 m asl) is higher than ESE (~650 m asl) the difference in atmospheric oxygen concentration is only about 5 g/m^3 lower at MFS (or 2% lower). Changes of this magnitude are not expected to materially affect the applicability of the model results between MFS and ESE.

3.4.2 Lower Boundary Conditions

Lower boundary conditions include both hydraulic and pore-gas concentration:

- Hydraulic Boundary: A unit gradient condition was set at the base of the model domain.
- Oxygen Boundary: An oxygen concentration of 0 vol.% (0 g/m^3) was set at 10 m depth within the mine rock layer to represent the outer 10 m oxidising zone developed due to the ELF construction methodology. This will develop a dynamic diffusion profile between the Upper and Lower boundary conditions.

3.4.3 Initial Conditions

Initial conditions were not specifically set. Rather, the start of the transient numerical simulation is considered the warmup period for pseudo stable conditions to develop. Early simulation tests suggested these conditions were established in less than 6 months of the 11 year simulation period. This approach is deemed reasonable given that the high annual precipitation promotes a cover system pressure profile that equilibrates relatively soon to the upper and lower boundary condition.

4 RESULTS OF NUMERICAL SIMULATIONS

This section presents the results of numerical simulations focused on the water balance and diffusive oxygen transport under different cover system configurations over the historic climate dataset (2013 to 2023).

NP is typically defined as the amount of water that passes below the cover system, below the limit of atmospheric demand and limited to gravitation drainage. The average amount of water exiting the model domain at the lower boundary condition over the simulation period was taken to represent this. For diffusive oxygen ingress, the modelling output used was the average flux of oxygen flux moving past the 2 m NAF mine rock layer to the PAF mine rock (i.e., base of NAF layer). For all model scenarios, results are presented for 2014 onwards to account for any model spin up period that could be influenced by the initial conditions[4].

Simulation results for oxygen and water ingress discussed in the following sub-sections are discussed in the context of expected cover system performance from industry guidance by INAP (2017) for a temperate climate setting, as shown in Table 3.

Table 3: Qualitative performance ranges.

DESCRIPTIVE TERM	NP RANGE	OXYGEN FLUX RANGE
Very Low	<5%	<30 g/m^2/yr
Low	5 to 10%	30 to 160 g/m^2/yr
Moderate	10 to 15%	160 to 320 g/m^2/yr
High	15 to 50%	320 to 1,600 g/m^2/yr
Very High	>50%	>3,200 g/m^2/yr

Note: NP is based on proportion of annual rainfall or precipitation. Source: INAP (2017).

4.1 Water Balance

Table 4 summarises the average annual water balance for the simulated shrubland/wetland and forest cover scenarios. Results are presented as a percentage of average annual rainfall (5,414 mm/yr) over the simulation period.

[4] *'Spin up' period refers to the initial phase of the simulation while the model reaches pseudo equilibrium. Initial conditions do not significantly influence the numerical solution past this point.*

Table 4: Shrubland/wetland and forest simulated water balance.

DESIGN	SCENARIO	AET	RUNOFF	NP	TOTAL
Shrubland/wetland	S1, Coarse GML, Coarse Mine Rock	15%	47%	40%	102%
	S2, Fine GML, Coarse Mine Rock	14%	75%	12%	101%
	S3, Coarse GML, Fine Mine Rock	15%	30%	55%	100%
	S1-SEN, Coarse GML, Uncompacted Coarse Mine Rock, Compacted Fine Mine Rock	15%	47%	40%	101%
Forest	S4, Coarse GML, Coarse Mine Rock	15%	41%	47%	102%
	S5, Fine GML, Coarse Mine Rock	15%	73%	13%	100%
	S6, Coarse GML, Fine Mine Rock	15%	36%	49%	100%

AET = actual evapotranspiration, NP = net percolation. Values reported as percentage of average annual rainfall.

Results presented are for 2014 onwards to account for any model spin up period[5]

Rounding errors in figures reported can make the total figure appear out of balance.

The simulated results are as follows:

- Modelling results are broadly similar between the shrubland/wetland and forest scenarios, with NP being slightly higher and actual evapotranspiration (AET) and runoff being conversely lower for the shrubland/wetland scenarios. Consistent with the conceptual model, runoff is a significant proportion of the water balance.
- In all scenarios AET is approximately equal to PE. This is due to the low negative pore-water pressure in the cover material due to ongoing precipitation.
- NP results are sensitive to the K_{sat} value of the soil material at surface. For example, a reduction in K_{sat} from 5 x 10^{-7} m/s (S1, S4) to 1 x 10^{-7} m/s (S2, S5) resulted in a NP reduction from ~45% to ~13% of annual rainfall (reduction factor of ~3), with the difference partitioned to runoff. This is due to rainfall intensity likely fluctuating around the input K_{sat} values.
- The finer mine rock scenarios (S3, S6) produced the highest NP results. Although these scenarios include lower K_{sat} values for mine rock, review of the pressure conditions indicate that the effective K value for mine rock is typically higher for these scenarios. This drains down the GML reducing the occurrence of saturated conditions and therefore runoff. For example, examination of Figure 12 shows that with a matric suction greater than about 1 kPa, the effective K value is greater for the finer mine rock material than the coarser material. Matric suction at the mid-point in the NAF layer was typically greater than 2 kPa (or effective K of less than 10^{-7} m/s) for the coarser scenarios, and typically less than 20 kPa (or effective K of more than 10-7 m/s) for the finer scenarios.
- The sensitivity scenario that incorporated compacted running surfaces (S1-SEN) has very similar water balance results to the same scenario without running surfaces (S1). These surfaces were too deep in the cover profile to influence model simulation results for NP.

[5]'Spin up' period refers to the initial phase of the simulation while the model reaches pseudo equilibrium. Initial conditions do not significantly influence the numerical solution past this point.

Overall, simulated NP ranges between 12% and 55% across all the scenarios. INAP (2017) guidance suggests that for a temperate climate, NP performance can be expected to range between 15% and 50% of annual rainfall, which is in line with simulated results. Simulated model results are a function of the climatic setting with climatic energy deficit and high rainfall intensity.

4.2 Diffusive Oxygen Flux

Simulated diffusive oxygen ingress for the shrubland/wetland and forest cover scenarios are presented as averages over the simulation period (Table 5) and as a probability of exceedance (Figure 17) to show variability in expected performance for a scenario. For added context, higher oxygen ingress will lead to a greater potential for sulfide oxidation (e.g., pyrite) and in turn a greater potential for AMD load generation.

Table 5: Simulated average oxygen flux.

DESIGN	SCENARIO	AVERAGE O_2 DIFFUSIVE FLUX ($g/m^2/yr$)
Shrubland/wetland	S1, Coarse GML, Coarse Mine Rock	230
	S2, Fine GML, Coarse Mine Rock	196
	S3, Coarse GML, Fine Mine Rock	98
	S1-SEN, Coarse GML, Uncompacted Coarse Mine Rock, Compacted Fine Mine Rock	13
Forest	S4, Coarse GML, Coarse Mine Rock	143
	S5, Fine GML, Coarse Mine Rock	112
	S6, Coarse GML, Fine Mine Rock	100

Results presented are for 2014 onwards to account for any model spin up period.

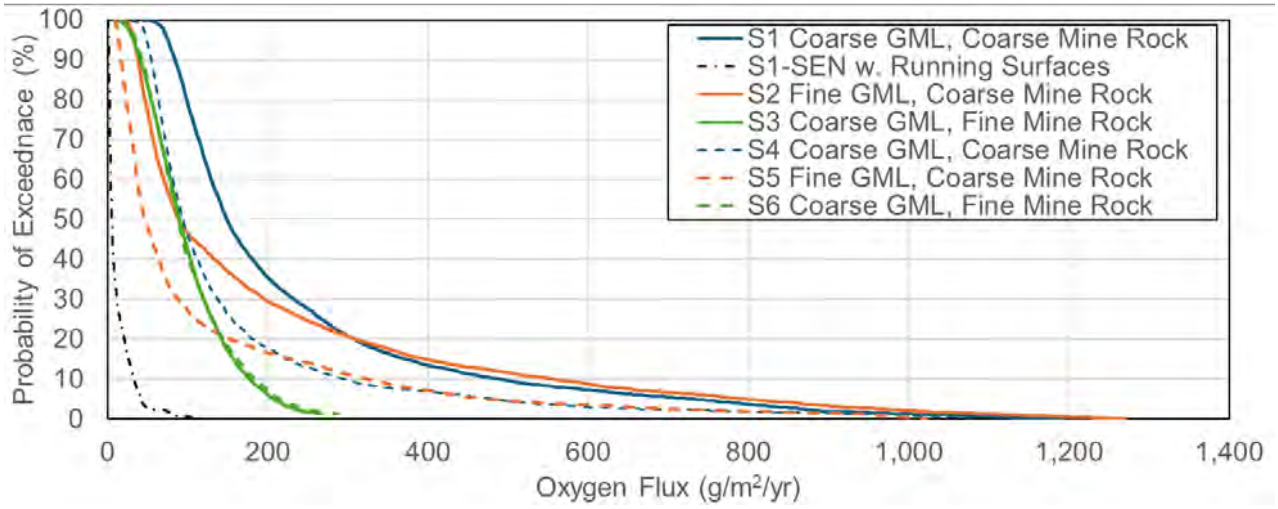


Figure 17: Simulated diffusive oxygen flux.

Note: solid lines represent shrubland/wetland scenarios and dashed line represent forest scenarios.

Results presented are for 2014 onwards to account for any model spin up period.

The simulated results are as follows:

- On average, the forest cover scenarios (S4 through S6) show lower diffusive oxygen ingress compared to the shrubland/wetland cover (S1 through S3) due to differences in the respective degree of saturation. The thinner GML layer of the shrubland/wetland cover provides less water storage to meet atmospheric demand than forest cover scenarios, so saturation levels are therefore lower on average (and oxygen flux rates higher) for shrubland/wetland scenarios.
- Scenarios with GML textural differences (i.e., S1 vs S2, and S4 vs S5) showed more difference above about 20% probability of exceedance, while they became more similar over lower frequency events, suggesting that AET is sufficient to desaturate either material texture, at which point the mine rock is the controlling factor of oxygen ingress (which is the same across these scenarios).
- Finer textured mine rock scenarios (S3 and S6) resulted in the lowest simulated oxygen ingress. This is attributed to the NAF mine rock layer having a higher degree of saturation than coarser textured mine rock scenarios, limiting oxygen ingress when the GML desaturates. As a result, the tails (i.e., probability of exceedance) are subdued compared to coarser mine rock scenarios.
- Overall model results suggest oxygen flux can range between approximately 100 to 230 g/m^2/yr. These results are classified as low to moderate in the context of INAP (2017) and are a result of the GML having favourable water retention properties and a strong climatic water surplus.
- The sensitivity scenario that incorporates compacted running surfaces shows the lowest oxygen flux, classified as very low in the context of INAP (2017). This is attributed to the running surfaces acting as water retention layers that maintain a high degree of saturation, even when the GML desaturates. Further work is required to confirm running surfaces can achieve this level of performance in the field.
- In general, there is approximately a:
    - 30 to 35% probability the oxygen ingress rate would exceed 200 g/m^2/yr for the shrubland/wetland cover scenarios with coarse mine rock (S1 and S2).
    - 15% probability for the forest cover scenarios with coarse mine rock (S4 and S5).
    - 5% probability or less for the cover scenarios with fine mine rock (S3 and S6) and sensitivity scenario that incorporates compacted running surfaces (S1-SEN).
- The shape of the probability exceedance curves with the extended tail displayed over the less than 10% probability may suggest that there could be some risk to performance under climate change for coarser mine rock scenarios. In general, where the probability of exceedance curve plots as a straight line, climate changes risks are noted to be subdued.

Figure 18 shows the oxygen concentration profile for an arbitrary day from the numerical simulation (day 500, representative of most conditions of the simulation period) for the shrubland/wetland and forest cover scenarios. Model results suggest:

- For coarse mine rock scenarios (i.e., S1, S2, S4, S5), the main component of the cover system limiting diffusion is the GML layer where oxygen pore concentration drops from >250 g/m^3 at the cover surface, to between 50 to 75 g/m^3 near the base of the NAF layer (8 m on y-axis of Figure 18, 2.25 m to 2.5 m from ground surface).
- For scenarios S3 and S6, however, the greater water retention properties of the finer mine rock cause both the GML and mine rock to limit diffusion, meaning thicker NAF mine rock layers would act to reduce diffusive oxygen ingress (if the mine rock was finer textured). Further investigations are required to confirm mine rock texture and if increased NAF layer thickness would improve oxygen ingress performance.
- The sensitivity scenario that incorporates compacted running surfaces shows step changes in oxygen concentration where the running surfaces act as water retaining layers that limit oxygen diffusion.

It should be noted that the simulated oxygen profile (Figure 18) does not account for consumption of oxygen within NAF and PAF mine rock layers, so may not be reflective of actual oxygen profiles.

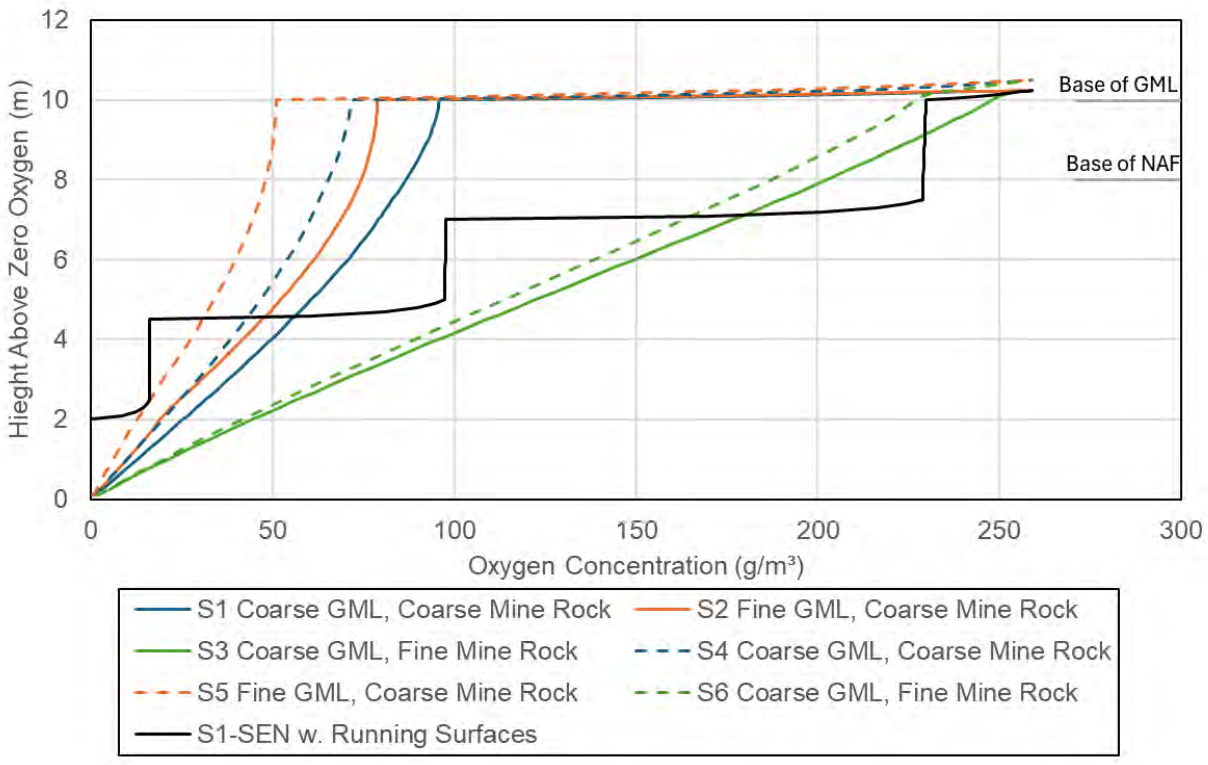


Figure 18: Simulated oxygen profile for day 500 of numerical simulation.

Note: simulated oxygen profile does not account of consumption of oxygen within the cover layers, so may not be reflective of actual oxygen profiles.

4.3 Model Limitations

The SPA models presented in this report are mathematical representations of water and gas transport within the ELF and cover system profiles examined for the site. The complex hydrogeology of the site had to be simplified into conceptual models that could be represented by mathematical models. The numerical models are thus limited by the accuracy and detail of the conceptual models.

The following limitations should be noted when interpreting model results:

- The conceptual model assumes that movement of water in the unsaturated zone can be represented as Darcian flow in a porous media. Darcian flow can be expected to dominate flow in uniform fine textured materials but may be less representative for soils at the atmospheric interface, NAF and PAF mine rock material. Non-Darcian flow in soil layers at the atmospheric interface can be attributed to structure due to wet and dry cycles and organics / root penetration over many years. Non-Darcian flow is also noted to occur in placed materials due to sorting and segregation.
- The conceptual model assumes that the ELF and cover system profiles can be represented by various material types with homogeneous and isotropic material properties. The potential influence of local heterogeneity (within a given material type) was not investigated. This may be more apparent for the soil GML, which may not capture soil structure / aggregation / organics. Insight can be gained through direct monitoring systems.
- The water movement within the cover systems is defined by the WRC and k-function, both of which have been estimated based on limited site-specific data and theoretical models, and hence considered to be assumed material properties.
- The movement of gas through the cover system is also based on theoretical diffusion models and estimated material properties. Oxygen consumption from pyrite oxidation was not explicitly simulated. Moreover, gas transport in coarser textured material is challenging to accurately represent.
- It is noted that the numerical simulations only accounted for diffusive oxygen ingress. The ELFs themselves will be built in short lifts to minimize the potential for advective ingress. Robust quality assurance and construction quality control is required to prevent the development of advective airflow pathways.
- Modelling completed was 1D, meaning any influence of slopes was not explicitly incorporated. In particular, any potential lateral drainage is not accounted for.

The key advantage to the numerical modelling results summarised herein is the ability to enhance judgment. Hence, rather than a focus on the absolute results predicted, it is recommended that the modelling results be viewed as a tool to understand key processes and characteristics that will influence performance of the cover system for the ESE and MFS sites, and to develop engineering decisions based on this understanding.

Further characterisation works, field trials, and field response modelling would increase confidence in expected performance and better inform management decisions.

5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

- Cover system model results suggested the following NP varied between approximately 15% and 60% of annual rainfall, with lower values achieved by a lower permeability GML. Runoff and NP were sensitive to the permeability of this layer.
- The favourable water retention properties of the GML and high rainfall enable this layer to typically retain a high degree of saturation. As a result, mean annual oxygen ingress was simulated to fall within the low to medium category, ranging between approximately 100 and 230 g/m^2/yr, with exceedances of 320 g/m^2/yr (high category) occurring at a rate of 10% or less of the time.
- Better performance (lower oxygen ingress) was achieved with finer textured mine rock and to a lesser extent a finer textured and/or thicker GML. A higher degree of saturation with finer textured mine rock limited oxygen ingress when the GML desaturated during dry periods.
- A sensitivity scenario that represented compacted running surfaces showed promising results, with very low oxygen ingress. Further work is required to confirm this level of performance is achievable at the landform scale.

5.2 Recommendations

Instrumented cover system field trials are recommended to confirm modelling results are representative of field conditions and improve confidence in expected as-built performance post-closure. Ideally these trials are established early on in the project development (e.g., with 2 years of development) to (i) allow for sufficient data to be collected and (ii) allow for sufficient time for designs alternatives to be adapted (if needed). Design alternatives could include for example, barrier type systems (e.g., compacted clay liner) to reduce water ingress, or inclusion of moisture retention layers (similar in concept to the compacted running surface sensitivity scenario considered in this report) to reduce oxygen ingress.

In addition to field trials, it is recommended the full-scale constructed cover system be instrumented to allow for direct performance monitoring and confirmation the system is performing to expectations on built. If it is found through monitoring that the system is not performing , contingency measures can be considered, such as a longer active treatment period or increased semi-passive treatment capacity, or changes to the cover system. Completion of adequately designed and constructed field trials and appropriate construction quality assurance and construction quality control will improve the likelihood of the full-scale constructed cover system performing to expectations and achieving closure objectives.

6 REFERENCES

Aachib, M., Mbonimpa, M., Aubertin, M., 2004. Measurement and prediction of the oxygen diffusion coefficient in unsaturated media, with applications to soil covers. Water, Air, and Soil Pollution 156: 163-193. 2004.

Bathurst Resources Limited (BRL), 2024. Rainfall-altitude gradient, SH67 to Mt Rochford, Denniston Plateau. Technical memorandum prepared by M. Chater.

Bathurst Resources Limited (BRL), 2026a. BPCP Rehabilitation Management Plan.

Bathurst Resources Limited (BRL), 2026b. BPCP AMD Engineered Landform Management Plan.

Earth Science New Zealand (ESNZ, 2026). Buller Plateaux Continuation Project - Assessment of Environmental Effects: Aquatic Ecology.

ecoLogical Solutions, 2024. Buller Coal Plateau Contextual Study. Technical report prepared for Bathurst Resources Ltd.

Fredlund, D. and Xing, A., 1994. Equations for the soil-water characteristic curve. Canadian Geotechnical Journal, 31, 521-532.

Fredlund, D., Xing, A. and Huang, S., 1994. Predicting the permeability function for unsaturated soils using the soil-water characteristic curve. Canadian Geotechnical Journal, 31(4), 533-546.

Herasymuik, G M, 1996. Hydrogeology of a sulphidic waste rock dump, MSc thesis, University of Saskatchewan, Saskatchewan.

Hoffman, G. and Van Genuchten, M., 1983. Soil Properties and Efficient Water Use: Water Management for Salinity Control. ASA, CSSA, and SSSA Books, 73–85.

INAP, 2017. Global Cover System Design - Technical Guidance Document. Dated November 2017.

Mine Waste Management (MWM), 2026. Escarpment Reconsenting Cover System Field Investigation. Technical memorandum prepared for Bathurst Resources Ltd. Report Number: J-NZ0349-004-M-FINAL.

Ministry for the Environment (MfE) 2018. Climate Change Projections for New Zealand: Atmosphere Projections Based on Simulations from the IPCC Fifth Assessment, 2nd Edition.

Ministry for the Environment (MfE), 2021. Wetland delineation hydrology tool for Aotearoa New Zealand. Dated July 2021.

Morbidelli, R., Saltalippi, C., Flammini, A., and RS Govindaraju, 2008. Role of slope on infiltration: a review. Journal of Hydrology

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.

Ritchie, J., 1972. Model for predicting evaporation from a row crop with incomplete cover. Water Resources Research, 8(5), 1204–1213.

Scurlock, J. M. O., G. P. Asner, and S. T. Gower., 2001. Worldwide Historical Estimates and Bibliography of Leaf Area Index, 1932-2000. ORNL Technical Memorandum TM-2001/268. Oak Ridge National Laboratory, Oak Ridge, Tennessee, U.S.A

Seequent, 2022. Heat and Mass Transfer Modelling with GeoStudio. Manual by Seequent Limited.

Solid Energy NZ (SENZ), 2007. Report: Zone 3 Material Trial – Duncans Sump. Dated 17 April 2007.

URS, 2005. Dam Construction Material Characterisation – Stockton Opencast Mine. Technical memorandum prepared for Solid Energy NZ. Dated 19 Augst 2005.

7 LIMITATIONS

Attention is drawn to the document “Limitations”, which is included in Appendix B of this report. The statements presented in this document are intended to provide advice on what the realistic expectations of this report should be, and to present recommendations on how to minimise the risks associated with this project. The document is not intended to reduce the level of responsibility accepted by Mine Waste Management, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in doing so.

APPENDIX A COVERS FIELD INVESTIGATION MEMO

[redacted]

MEMORANDUM

Recipient:	[redacted] Bathurst Resources Limited
From:	[redacted], Mine Waste Management Limited
Date:	21 July 2026
Cc:	[redacted] – Hydro Geochem Group Limited [redacted] – Mine Closure Management Inc.
Document Number:	J-NZ0349-004-M-FINAL
Document Title:	Cover System Field Investigation

Bathurst Resource Limited (BRL) is seeking to obtain authorisation through the Fast Track Approvals Act 2024 (FTAA) to progress development and mining of the coal resources across the wider Buller Plateaux. This project is referred to as the Buller Plateaux Continuation Project (BPCP).

Mine Waste Management Limited (MWM) was retained by BRL to complete cover system design works for the Engineered Landforms (ELF) of the proposed BPC Project. The objective of the cover system is to limit the ingress of meteoric water and oxygen to the underlying potentially acid forming mine rock thereby minimising the effects of acid and metalliferous drainage (AMD) on the receiving environment in the short term and facilitate recovery of the environment disturbed by mining over the long term. The cover system and landform will also support the establishment of sustainable vegetation and a stable landform in terms of geomorphic stability to ensure the cover system maintains its functionality.

This factual memorandum documents the field characterisation program carried out to support the cover system design and landform for the BPC Project ELFs. Details of the completed field work and field and laboratory test results as provided.

OBJECTIVE AND SCOPE

The primary objective of the field characterisation program was to supplement existing physical and hydraulic datasets (much of which were from nearby sites) with data reflective of site materials and conditions. The data collected will aid in the development of conceptual models and establishing material properties for cover system assessment and design.

The existing Barren Valley ELF (BV-ELF) and soil stockpiles at Escarpment Mine provide representative analogues of the material that will be used to support cover system construction for the BPC Project. Hydro Geochem Group Ltd (HGG), who are subcontracted by MWM, visited the Escarpment Mine on 15 February 2024 to complete field investigations to support cover system assessment and design.

Field investigations involved:

- Excavation of four (4) test pits in mine rock at the BV-ELF and the soil stockpile.
- Collection of seven (7) total mine rock and soil samples.
- Completion of one (1) standpipe piezometer falling head test (FHT) on the BV-ELF.
- Completion of seven (7) permeameter tests in mine rock and soils.

SITE CONDITIONS

Weather and soil conditions on the day of the field work were relatively wet. Periods of heavy showers and wind gusts occurred throughout the day, with an average air temperature of 17 °C. A minor amount of BV-ELF surface runoff generation was noted following the showers but ceased within an hour or so. Runoff was primarily generated from compacted surfaces and flowed via localised erosion channels, with no observable runoff associated with less compacted coarser areas such as batter slopes (Figure 1). Total rainfall for the day, as measured at the Lake Brazil meteorological station, was 6.2 mm. Peak rainfall intensity was recorded as 1.8 mm in 10 mins (or $3x10^{-6}$ m/s). There had been no rain recorded over the four days prior. Over the preceding two weeks, a total of 160 mm of rainfall was recorded, most of which (122 mm, or 76 %) occurred in one day (04/02/2024).

Figure 1: Runoff example.

VEGETATION OBSERVATIONS

Examples of some vegetation types to be reestablished post-closure of the final BPC Project ELFs are shown in Figure 2.

Pakihi Vegetation

Manuka Shrub

Figure 2: Post-closure vegetation examples.

PHYSICAL PROPERTIES TESTING PROGRAM

Methodology

Two (2) test pits into the surface of the BV-ELF were excavated with a Hitachi four tonne excavator with a spade bucket (i.e., without teeth). Test pit locations were chosen to target one area that was thought to be subject to heavy equipment traffic (based on visual observation of tighter packed surface rock) and one area with notably less equipment compaction (ESC-TP-02 and ESC-TP-01, respectively). Photographs of test pits sites are shown in Figure 3 showing different levels of compaction. ESC-TP-02 also visually appeared to have less coarse material. For comparison, Figure 4 shows the batter slope of the ELF with little to no compaction.

ESC-TP-01

ESC-TP-02

Figure 3: Post-closure vegetation examples.

Figure 4: Batter slope surface example.

Each test pit was excavated to approximately 1.5 m depth. Excavated depth intervals were placed in separate piles to allow sampling from specific horizons of interest for cover design works. Depth intervals were approximately:

- 0 to 0.2 m
- 0.2 to 0.5 m
- 0.5 to 1.5 m

Material was placed in piles approximately 1 m high to avoid particle size segregation.

Two shallow hand dug test pits were created in the Escarpment Mine weed-free soil stockpile. BRL (Campbell Robertson, pers. comm.) noted that stockpile material was of a general mix of soil from pre-stripping areas. Soil strip depth was approximately 0.5 m.

In total, seven (7) samples were collected for analysis to define the physical characteristics of the topsoil and mine rock. Samples were collected in 20 L pails). The physical properties testing was conducted by Central Testing Services, which involved particle size distribution (PSD), water content, and solid density. Table 1 summarises the characterisation program for samples collected during the field investigation.

Table 1: Physical properties characterisation program.

SAMPLE ID	MATERIAL	LOCATION	EASTING*	NORTHING*	DEPTH (m)
ESC-Soil-01	Soil	Weed-free soil stockpile	1499635	5374829	0.05 to 0.2
ESC-Soil-02	Soil	Weed-free soil stockpile	1499634	5374817	0.05 to 0.2
ESC-TP-01a	Mine Rock	BV-ELF (moderately-trafficked)	1499071	5374379	0.0 to 0.15
ESC-TP-01b	Mine Rock	BV-ELF (moderately-trafficked)			0.15 to 0.8
ESC-TP-01c	Mine Rock	BV-ELF (moderately-trafficked)			0.8 to 1.5
ESC-TP-02a	Mine Rock	BV-ELF (trafficked)	1499080	5374446	0.0 to 0.2
ESC-TP-02b	Mine Rock	BV-ELF (trafficked)			0.2 to 0.7

**Note: coordinate reference system used was NZTM, collected with a handheld GPS unit.*

Laboratory Results

Full laboratory testing reports are provided in Attachment A as provided by Central Testing Services. Photos of excavated sample piles are provided in Attachment B.

Figure 6 shows the PSD curves for samples collected during test pit excavation. The PSD of a given material indicates the relative proportions of the different particle sizes that make up the material on a mass basis and provides an understanding of:

- Material grading (i.e., whether it's well graded, poorly graded, or gap-graded).
- Potential for segregation during handling and placement procedures.
- Material structure (i.e., grain or matrix-supported).
- Anticipated hydraulic characteristics.

Figure 5: Investigation locations.

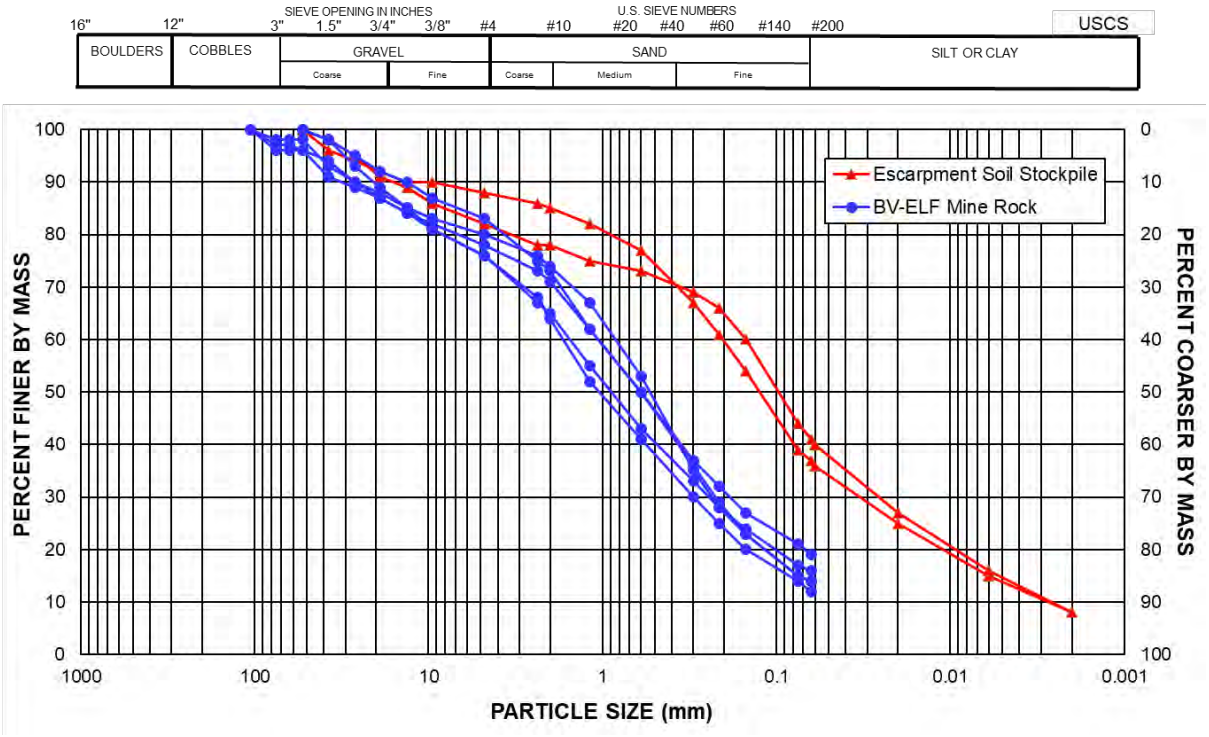


Figure 6: Particle size distribution curves for the mine rock and soil stockpile.

Textural triangles are utilised to augment the comparison of multiple PSD curves by simplifying the grain size distribution curve of a sample to a single data point. The sides of the textural triangle are scaled for the percentage of cobble and gravel, sand, and silt and clay-size particles. Figure 7 shows the PSDs of the materials encountered during the investigation. The soil was well-graded, consisting of approximately 18% cobbles and gravel, 40% sand, and 42% silt and clay size particles, based on the Unified Soil Classification System. The mine rock was also a well-graded material. On average the BV-ELF mine rock consists of approximately 28% cobbles and gravel, 56% sand, and 16% silt and clay-size particles. It is noted that the sampling cutoff for the laboratory PSD method was 106 mm.

Both the soil and BV-ELF mine rock plot within the domain classified as matrix-supported. Within a matrix-supported material the larger fragments, or clasts, are separated from each other within a finer-grained matrix, conversely, in a grain-supported material, the larger fragments, or clasts, provide the structural support and are in direct contact with each other. Visual estimates of the proportion of rock larger than this is approximately 5 to 10%, which is not anticipated to change the conclusion of matrix support vs grain supported.

The PSD data for mine rock samples are tabulated in Table 2. The trafficked surface (ESC-TP-02a) had a slightly higher fines content than the deeper sample at the same location (21 vs 17%, respectively), while there was little variation in fines content with depth at ESC-TP-01.

Table 2: Mine rock sample fines content.

SAMPLE ID	DEPTH (M)	COBBLE AND GRAVEL	SAND	CLAY AND SILT
ESC-TP-01a	0.0 to 0.15	32%	54%	14%
ESC-TP-01b	0.15 to 0.8	27%	58%	15%
ESC-TP-01c	0.8 to 1.5	24%	61%	15%
ESC-TP-02a	0.0 to 0.2	25%	54%	21%
ESC-TP-02b	0.2 to 0.7	33%	50%	17%

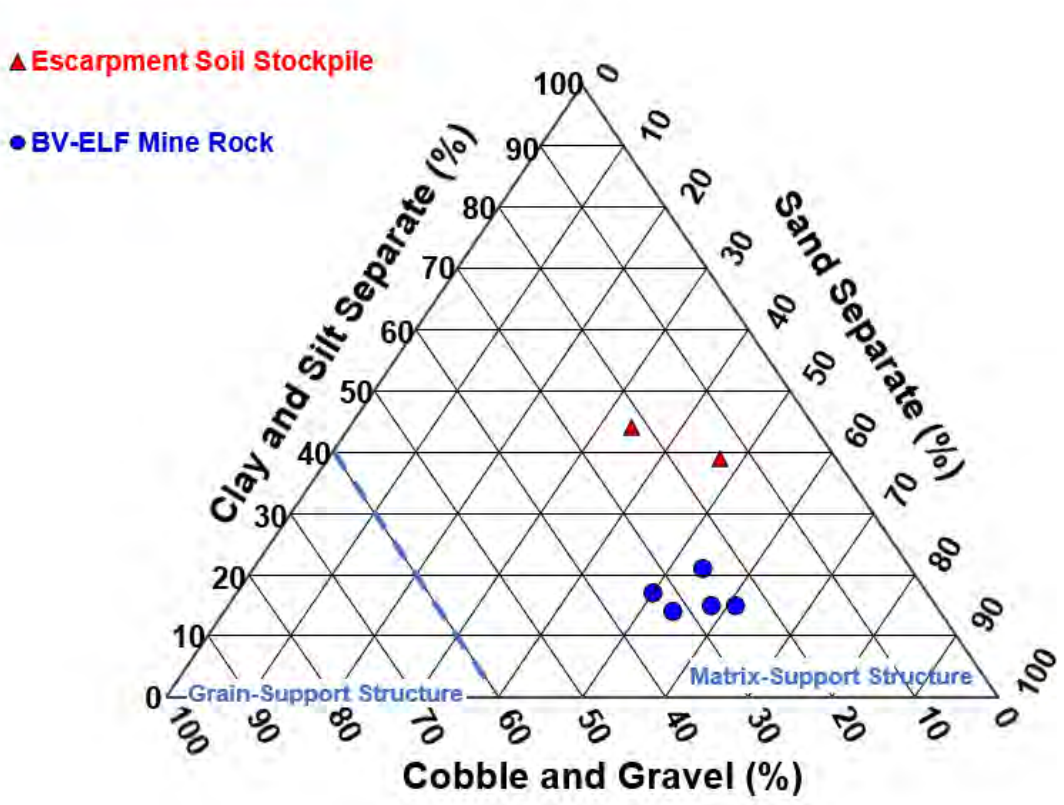


Figure 7: Textural triangle illustrating the texture of the mine rock and stockpile soil.

Note: Grain vs matrix supported structure based on Herasymuik (1996).

Water content and solid density of the samples are provided in Table 3. Average properties were as follows:

- Gravimetric water content (NZS 4402:1986, Test 2.1) for the soil was higher (~24%) than mine rock (~9%).
- Specific gravity or solid density (NZS 4402:1986, Test 2.7.1) was 2.54 t/m^3 on average for mine rock, and 2.46 t/m^3 for soil.
- Average estimated degree of saturation was 56% for mine rock and 80% for soil, assuming a bulk dry density of 1.8 t/m^3 and 1.4 t/m^3, respectively.

Table 3: Water content and solid density lab results.

SAMPLE ID	MATERIAL TYPE	WATER CONTENT (%)	SOLID DENSITY (t/m^3)	ESTIAMTED DEGREE OF SATURATION (%)
ESC-Soil-01	Soil	24.0	2.53	75
ESC-Soil-02	Soil	24.7	2.38	84
ESC-TP-01a	Mine Rock	9.0	2.46	60
ESC-TP-01b	Mine Rock	11.1	2.50	71
ESC-TP-01c	Mine Rock	9.5	2.64	54
ESC-TP-02a	Mine Rock	8.2	2.56	50
ESC-TP-02b	Mine Rock	7.2	2.55	44

FALLING HEAD TEST

Methodology

A single FHT was completed on a standpipe previously installed at the top of the BV-ELF (~7 years ago, C. Roberston, pers. comm.). The standpipes were understood to be pounded in with an excavator. Another standpipe was present too, but standing water was sitting in the base of the standpipe (while the BV-ELF surface and other standpipe were dry) suggesting some kind of blockage, with plastic bags found inside. As such, testing was not completed on this standpipe with a perceived blockage as testing results would be unlikely to be representative of mine rock properties.

Details of the standpipe tested were as follows:

- Material: steel pipe.
- Method of placement: advanced with excavator bucket (pers. comm. Cambell Roberton).
- Stick up of 1.02 m diameter of 0.2794 m (11 inch).
- Length below surface: ~0.78 assuming a 1.8 m total length of pipe (W. Olds, pers. Comm.).
- Mine rock depth (inside pipe): approximately BV-ELF surface, or 1.02 m from top of pipe.
- GPS coordinates: E: 1499084, N: 5374362 (NZTM).

A Solinist Levelogger 5 (M10) was suspended approximately 0.85 m from the top of the pipe with non-stretch cable and set to record every 5 seconds. The test was initiated with ~60 L of water at 12.43 pm. Manual measurements of water level decline were also recorded. The test ended at 3 pm.

The analysis method followed a modified ASTM D6391 Method B, Calculation Procedure 1 as follows:

$$K_{fs} = \frac{R_T G}{t_2 - t_1} \ln \frac{H_1}{H_2}$$

$$G = \frac{\pi}{11} \frac{D}{m} + L$$

$$R_T = 2.2902 \frac{0.9842^T}{T^{0.1702}}$$

Where:

- K_{fs} is field saturate hydraulic conductivity.
- G is a shape factor for the geometry of the test setup.
- R_T is the reservoir temperature.
- H_1 is the head displacement at t_1. Based on pressure transducer records.
- H_2 is the head displacement at t_2. Based on pressure transducer records.
- t_1 is the time at beginning of increments. Based on pressure transducer records.
- t_2 is the time at end of increments. Based on pressure transducer records.
- D is the diameter of the pipe. Measured as 0.2794 m.
- L is the length of the material within the pipe. Estimated as 0.78 m.
- m is the is anisotropy ratio. Assumed to be 1.0 (isotropic media).
- T is temperature in °C. Based on pressure transducer records.

Modification to the ASTM D6391 method was related to the shape factor (G) used. ASTM D6391 used a shape factor for a standpipe without material inside it. The shape factor used for this analysis used the Case E from Hvorslev (1951) to account for identified material inside the standpipe. Use of the shape factor as reported in ASTM D6391 resulted in K_{fs} estimates about an order of magnitude lower.

Analysis Results

Mine rock K_{fs} based on the FHT analysis was estimated to be 5×10^{-6} m/s, which is similar to those estimated from the permeameter tests (see next section). Estimates over time are shown in Figure 8, where a relatively stable period is reach after approximately 1,000 seconds.

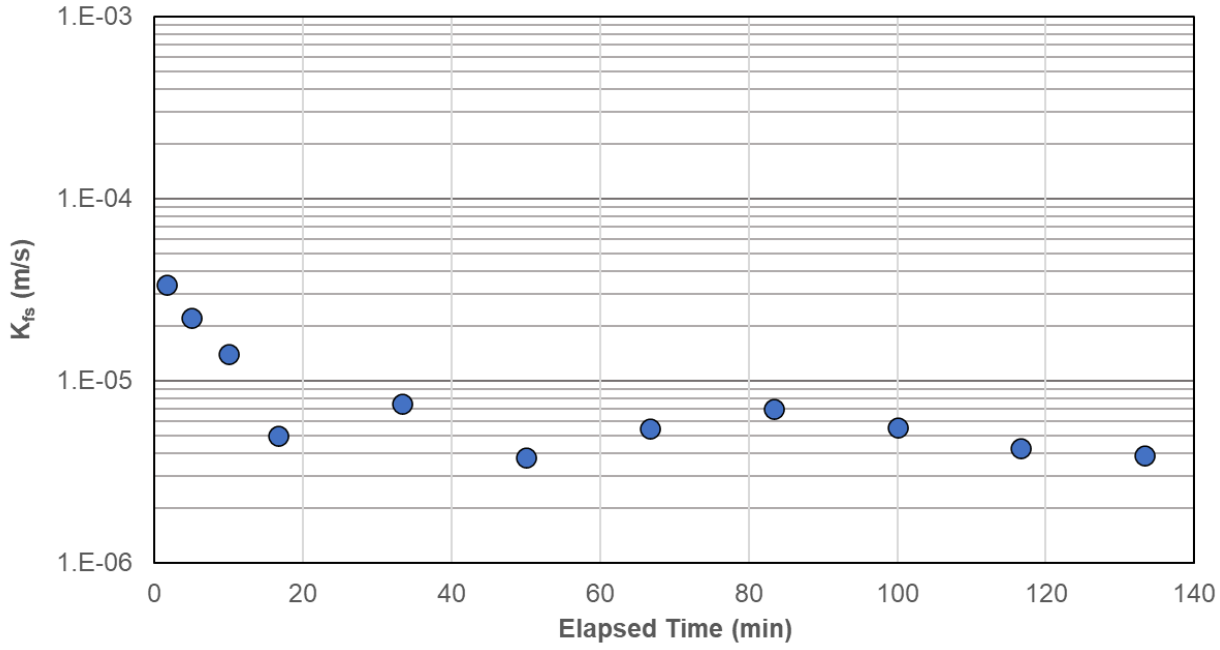


Figure 8: FHT analysis results for the mine rock.

PERMEAMETER TESTS

Methodology

Seven (7) permeameter tests were completed as part of the field investigation and are as follows:

- Two (2) tests in soil stockpile material.
- Six (6) tests in BV-ELF mine rock material.

The K_{fs} test locations, depth, and observations are summarised in Table 4. For each test, the borehole was excavated with a hand auger that produced a borehole 8.3 cm in diameter. The standard PASK Permeameter (ETC, 2022) was used to conduct the permeameter tests with the constant head method. The change in water level in the permeameter reservoir was recorded as time elapsed for each test until a relatively stable rate (i.e., steady state) of change was reached.

Table 4: Permeameter test details.

TEST ID	BOREHOLE DEPTH (m)	MATERIAL DESCRIPTION / OBSERVATIONS	ESTIAMTED K_{fs} (m/s)
ESC-Soil-01	0.25	Top of Escarpment soil stockpile; loamy material with some clay. Vegetation naturally re-established after less than 7 years of placement.	$4x10^{-7}$
ESC-Soil-02	0.24	Top of Escarpment soil stockpile; loamy material with some clay. Vegetation naturally re-established after less than 7 years of placement.	$2x10^{-7}$
ESC-TP-01_1	0.24	Mine Rock: Sandstone material, high sand content. Less surface compaction than ESC-TP-02_1a/b noted.	$9x10^{-7}$
ESC-TP-01_2	1.0	Mine Rock: Sandstone material, high sand content.	$4x10^{-6}$
ESC-TP-02_1a*	0.18	Mine Rock: Majority gravel, sand, cobbles; darker colour compared to ESC-TP-01. Relatively difficult to auger borehole as tightly packed cobbles impeded advancement. Higher compaction than ESC-TP-01_1 noted.	$<1x10^{-7}$
ESC-TP-02_1b*	0.18	As per ESC-TP-02_1a	$<1x10^{-7}$
ESC-TP-02_2	0.9	Mine rock, less pure sandstone, darker material, more angular.	$3x10^{-6}$

**Note: Due to time constraints, ESC-TP-02_1a could not be completed to reach steady rate of change; the rate of change was very slow, indicating a K_{sf} of $<10^{-7}$ m/s. ESC-TP-02_1b was completed adjacent to ESC-TP-02_1a to confirm the very low rate of change observed.*

K_{fs} was calculated based the following equation from Reynolds (1993):

$$K_{fs} = \frac{CQ}{2\pi H^2 + C\pi a^2 + \left(2\pi {}^{H}/_{\alpha^*}\right)}$$

Where:

- C is the shape factor for the borehole dimensions (dimensionless). A value of 1.3 was adopted[1];
- Q is the quasi-steady state water flow rate. It is a product of the stabilised rate of fall of water in permeameter reservoir (*R*) and cross-sectional area of permeameter reservoir, *X* (53.46 cm^2).
- H is the height of the pressure head above the borehole base. A depth of 15 cm is the recommended standard for the PASK Permeameter.
- a is the borehole radius (4.15 cm).
- $\alpha^*$is a visually estimated soil structure/texture parameter. A value of 0.12 cm^{-1} was adopted based on the material description[2].

Analysis results were not particularly sensitive to variation in assumed values of C and α^*.

Analysis Results

Analysis results are summarised in Table 4 and compared to sample fines content in Figure 9

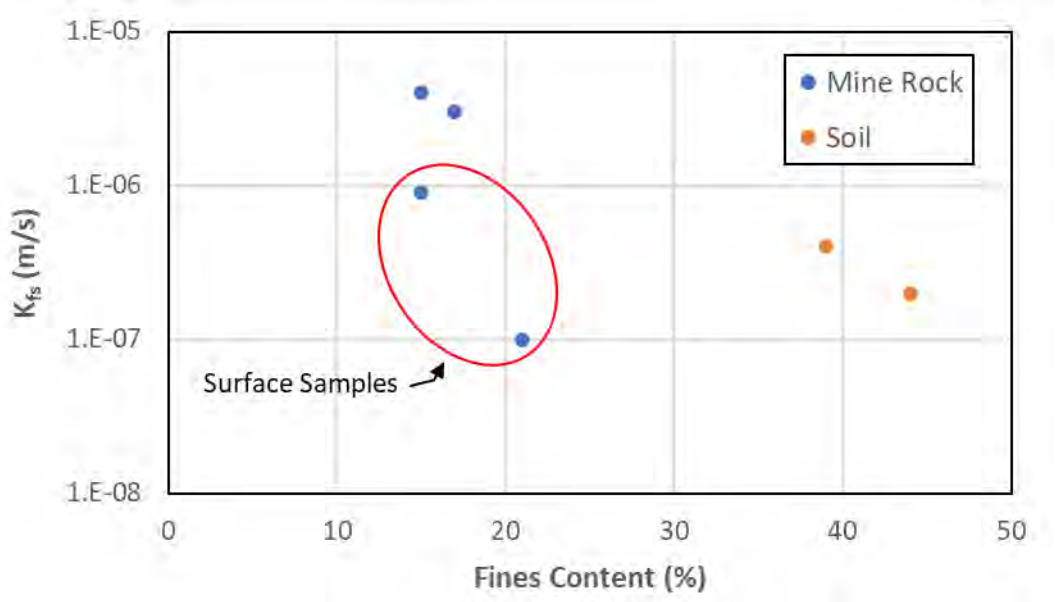


Figure 9: K_{fs} variation with fines content.

[1] *Based on Reynolds (2008), this values typically ranges between 1.2 and 1.4 for the borehole dimension created by the hand auger.*

[2] *Value typically ranges between 0.01 and 0.36 for a variety of material properties (Reynolds, 2008 and Reynolds et al., 2015).*

The following interpretations are made based on the permeameter testing results:

- The soil material has a relatively low K_{fs} values, approximately $3x10^{-7}$ m/s, which is consistent with the higher fines content for soil.
- Near surface mine rock K_{fs} was lower compared to values at greater depth (e.g., ESC-TP-01_1 vs ESC-TP-01_2a/b), varying between one half of an order of magnitude and a one order of magnitude.
- Mine rock at approximately one meter depth showed moderate K_{fs} values of $4x10^{-6}$ m/s on average. These values are consistent with the results from the FHT analysis.
- Variation in K_{fs} values is typically in line with what would be expect where values decease as fines content increases. Note, the two lower mine rock K_{fs} values are representative of surface samples which were subjected to traffic compaction, thus it is difficult to attribute lower K_{fs} values solely to fines content variation alone. Both aspects (i.e., compaction and fines content) likely contribute to the lowest K_{fs} value of $<1x10^{-7}$ m/s for ESC-TP-02_1a/b, while great compaction at surface can explain the lower ESC-TP-01_1 K_{fs} ($9x10^{-7}$ m/s) given similar fines content to deeper samples in this test pit.
- Observations of surface runoff from the rainfall event with a maximum intensity of $3x10^{-6}$ m/s are consistent with near surface permeameter results. Compacted surfaces with a K_{sf} lower than the maximum intensity (e.g., ESC-TP-01a and ESC-TP-02a) generated runoff via infiltration excess processes. Other surfaces with less compaction and/or coarser material (e.g., batter slopes) did not generate observable surface runoff, suggesting K_{sf} higher than $3x10^{-6}$ m/s, and potentially similar to deeper mine rock permeameter results.

FINDINGS SUMMARY

Findings from the field investigation are summarised as follows:

- Soil from the Escarpment soil stockpile was well-graded, consisting of approximately 18% cobbles and gravel, 40% sand, and 42% silt and clay size particles on average, based on the Unified Soil Classification System.
- The mine rock is also a well-graded material. On average (n=4) the BV-ELF mine rock consists of approximately 28% cobbles and gravel, 56% sand, and 16% silt and clay-size particles. Note that clasts >106 mm were not accounted for in these proportions due to lab testing limitations. Visual estimates place this unaccounted fraction to be in the range of 5 to 10%, which is unlikely to change findings of this investigation.
- Gravimetric water content for the soil was higher (~24%) than mine rock (~9%) reflecting greater capillarity forces of the finer textured soil.
- Solid density was 2.54 t/m^3 on average for mine rock, and 2.46 t/m^3 for soil.
- Average degree of saturation was estimated to be ~56% for mine rock and ~80% for soil.
- Soil material K_{fs} was estimated to be $3x10^{-7}$ m/s.
- Mine rock K_{fs} varied by depth/level of compaction, and fines content:

  - Shallow depth of mine rock was estimated to have an average K_{fs} of $4x10^{-6}$ m/s.
  - The near surface layer of mine rock, which appeared compacted, provided a K_{fs} that was approximately one half of an order of magnitude to one order of magnitude lower than material deeper in the test pit. The lower K_{fs} at surface were attributed to both compaction level and fines content variation.

- Observed runoff that occurred during the investigation was consistent with estimates of near surface K_{fs}. The lack of runoff observed on batter slopes suggest a K_{fs} for this portion of the BV-ELF to be greater than the maximum rainfall intensity (i.e., $>3x10^{-6}$ m/s).

The field test results will be interpreted to inform on the conceptual model of cover system and landform performance in further stages of the assessment and design program.

CLOSING REMARKS

Please do not hesitate to contact [redacted] should you wish to discuss our memorandum in greater detail.

Attachments: Attachment A – Lab Testing Report
Attachment B – Excavated Sample Piles

REFERENCES

Engineering Technologies Canada (ETC), 2022. User Guide, ETC PASK (constant head well) permeameter for in-situ measurement of soil field saturated hydraulic conductivity. 33 pages. Dated April 2022.

Hvorslev, M.J., 1951. Time Lag and Soil Permeability in Ground-Water Observations, Bull. No. 36, Waterways Exper. Sta. Corps of Engrs, U.S. Army, Vicksburg, Mississippi, pp. 1-50.

Herasymuik, G M, 1996. Hydrogeology of a sulphidic waste rock dump, MSc thesis, University of Saskatchewan, Saskatchewan.

Reynolds, 1993. Saturated hydraulic conductivity: field measurement. In Carter, M.R. (ed.) Soil Sampling and Methods of Analysis. Canadian Society Soil Science. Lewis Publishers, Boca Raton, FL, USA. pp.599-613

Reynolds, 2008, Saturated Hydraulic Properties: Well Permeameter. In Carter, M.R. and Gregorich, E.G. (Eds.), Soil Sampling and Methods of Analysis (2nd ed.). Canadian Society of Soil Science. CRC Press, Boca Raton, FL., USA, pp. 1025-1042.

Reynolds. and Galloway. and Radcliffe, 2015. The relationship between perc time and field-saturated hydraulic conductivity for cylindrical test holes. Proceedings of the Annual Conference of the National Onsite Wastewater Recycling Association, West Virginia Beach, West Virginia. November 2015.

ATTACHMENT A – LAB TESTING REPORT

Central Testing Services [redacted]

Reference No: 24/838

Date: 15 April 2024

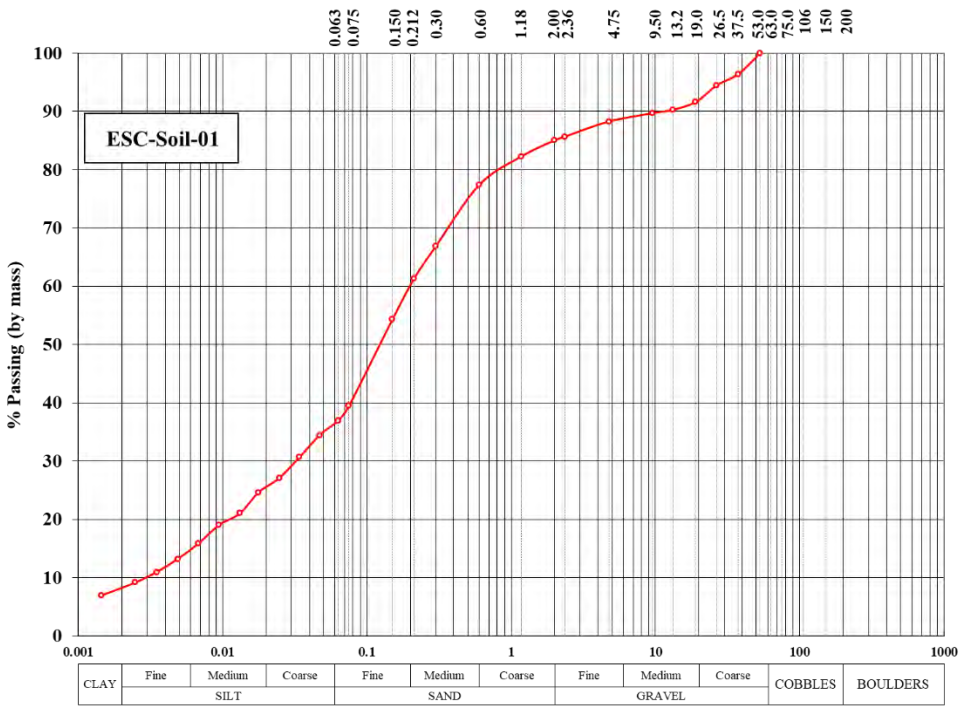
TEST REPORT – ESC COVER DESIGN FIELD INVESTIGATIONS

Client Details:	**Bathurst Resources Limited,** [redacted]	**Attention:**	[redacted]
Job Description:	**ESC Cover Design Field Investigation**		
Sample Description:	**SILT & SAND with some gravel & minor clay with trace of deleterious organics present (roots)**	**Client Order No:**	**539528**
Sample Source: (cs)	**ESC-Soil-01**	**Sample Depth: (cs)**	**0.05m - 0.20m**
Date & Time Sampled: (cs)	**15-Feb-24**	**Sampled By: (cs)**	[redacted]
Sample Method:	**Unknown**	**Date Received:**	**12-Mar-24**

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1 & 2.8.4)

Test Sieve (mm)	% Passing (by mass)
53.0	100
37.5	96
26.5	94
19.0	92
13.2	90
9.50	90
4.75	88
2.36	86
2.00	85
1.18	82
0.60	77
0.30	67
0.212	61
0.150	54
0.075	39
0.063	37

Fraction Size	Interpolated % Passing
60 µm	36
20 µm	25
6 µm	15
2 µm	8



The sample was received in a natural state. The percentage passing the 63µm test sieve was obtained by difference. The pH of the hydrometer suspension was 9.0. Sodium hexametaphosphate was used as a dispersant.

PARTICLE SIZE ANALYSIS & HYDROMETER ANALYSIS RESULTS - NZS 4402:1986, Test 2.8.1 & 2.8.4

Description	Fraction Range	% Within Range	Description	Fraction Range	% Within Range
Coarse Gravel	60.0 mm to 20.0 mm	8	Fine Sand	200 µm to 60 µm	24
Medium Gravel	20.0 mm to 6.0 mm	3	Coarse Silt	60 µm to 20 µm	11
Fine Gravel	6.0 mm to 2.00 mm	4	Medium Silt	20 µm to 6 µm	10
Coarse Sand	2.00 mm to 600 µm	8	Fine Silt	6 µm to 2 µm	7
Medium Sand	600 µm to 200 µm	17	Clay	< 2 µm	8

WATER CONTENT & SOLID DENSITY RESULTS - NZS 4402:1986, Test 2.1 & 2.7.1

Water Content: ("All In" As Received)	**24.0 %**
Solid Density: (-37.5mm Fraction)	**2.53 t/m^3**
Note: The sample was received in a natural state.	

Notes:

- ***Information contained in this report which is Not IANZ Accredited relates to the sample description based on NZ Geotechnical Society Guidelines 2005, the client supplied information (cs) and sampling.***
- ***This report may not be reproduced except in full.***

[redacted]

Date: 25-Mar-24 to 10-Apr-24

ACCREDITED IANZ TESTING LABORATORY №434

Test results indicated as not accredited are outside the scope of the laboratory's accreditation

Central Testing Services [redacted]

Reference No: 24/838

Date: 15 April 2024

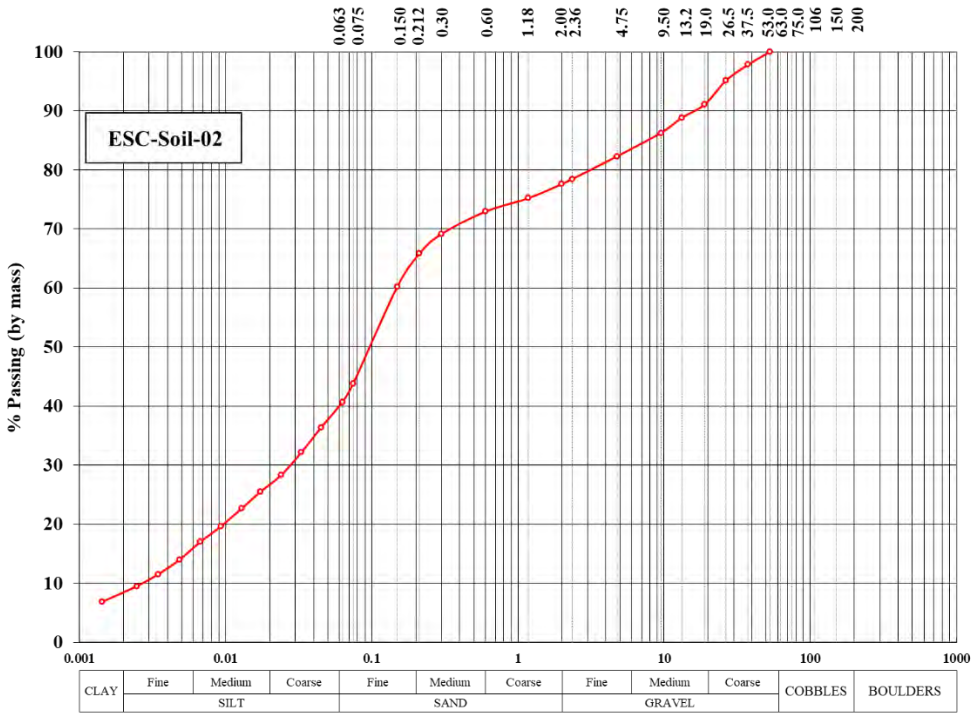
TEST REPORT – ESC COVER DESIGN FIELD INVESTIGATIONS

Client Details:	**Bathurst Resources Limited,** [redacted]	**Attention:**	[redacted]
Job Description:	**ESC Cover Design Field Investigation**		
Sample Description:	**Gravelly SILT & SAND with minor clay with trace of deleterious organics present (roots)**	**Client Order No:**	**539528**
Sample Source: (cs)	**ESC-Soil-02**	**Sample Depth: (cs)**	**0.05m - 0.20m**
Date & Time Sampled: (cs)	**15-Feb-24**	**Sampled By: (cs)**	[redacted]
Sample Method:	**Unknown**	**Date Received:**	**12-Mar-24**

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1 & 2.8.4)

Test Sieve (mm)	% Passing (by mass)
53.0	100
37.5	98
26.5	95
19.0	91
13.2	89
9.50	86
4.75	82
2.36	78
2.00	78
1.18	75
0.60	73
0.30	69
0.212	66
0.150	60
0.075	44
0.063	41

Fraction Size	Interpolated % Passing
60 µm	40
20 µm	27
6 µm	16
2 µm	8



The sample was received in a natural state. The percentage passing the 63µm test sieve was obtained by difference. The pH of the hydrometer suspension was 9.0. Sodium hexametaphosphate was used as a dispersant.

PARTICLE SIZE ANALYSIS & HYDROMETER ANALYSIS RESULTS - NZS 4402:1986, Test 2.8.1 & 2.8.4

Description	Fraction Range	% Within Range	Description	Fraction Range	% Within Range
Coarse Gravel	60.0 mm to 20.0 mm	8	Fine Sand	200 µm to 60 µm	25
Medium Gravel	20.0 mm to 6.0 mm	9	Coarse Silt	60 µm to 20 µm	13
Fine Gravel	6.0 mm to 2.00 mm	5	Medium Silt	20 µm to 6 µm	11
Coarse Sand	2.00 mm to 600 µm	5	Fine Silt	6 µm to 2 µm	8
Medium Sand	600 µm to 200 µm	8	Clay	< 2 µm	8

WATER CONTENT & SOLID DENSITY RESULTS - NZS 4402:1986, Test 2.1 & 2.7.1

Water Content: ("All In" As Received)	**26.7 %**
Solid Density: (-37.5mm Fraction)	**2.38 t/m^3**

Note: The sample was received in a natural state.

Notes:

- ***Information contained in this report which is Not IANZ Accredited relates to the sample description based on NZ Geotechnical Society Guidelines 2005, the client supplied information (cs) and sampling.***
- ***This report may not be reproduced except in full.***

[redacted]

Date: 25-Mar-24 to 10-Apr-24

ACCREDITED IANZ TESTING LABORATORY №434

Test results indicated as not accredited are outside the scope of the laboratory's accreditation

Central Testing Services [redacted]

Reference No: 24/838

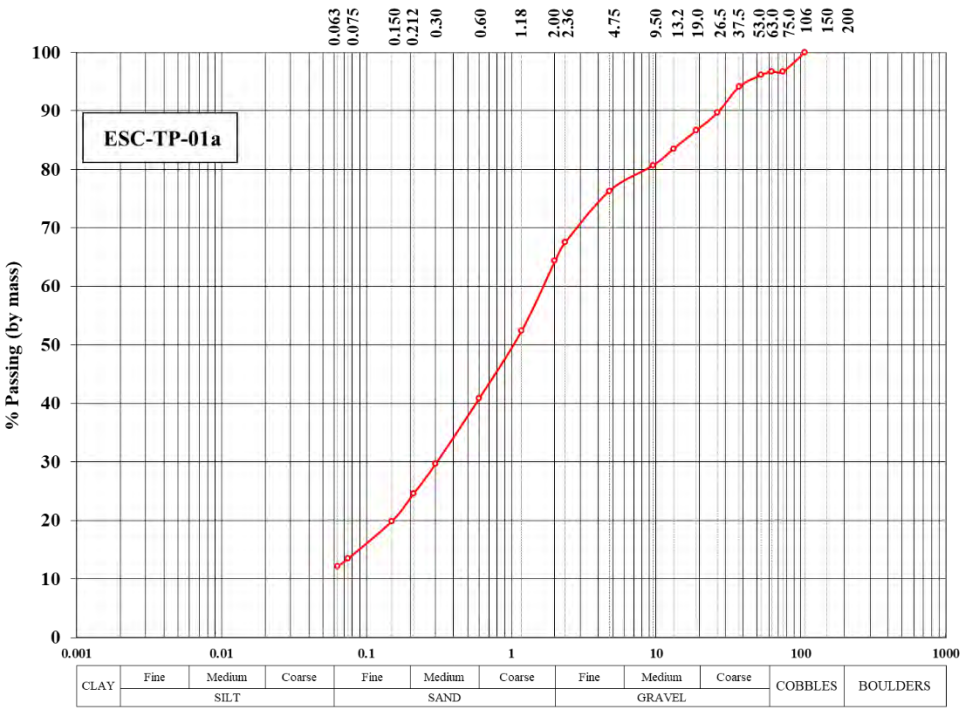
Date: 15 April 2024

TEST REPORT – ESC COVER DESIGN FIELD INVESTIGATIONS

Client Details:	**Bathurst Resources Limited,** [redacted]	**Attention:**	[redacted]
Job Description:	**ESC Cover Design Field Investigation**		
Sample Description:	**Gravelly SAND with some silt & trace of cobbles with trace of deleterious organics present (coal)**	**Client Order No:**	**539528**
Sample Source: (cs)	**ESC-TP-01a**	**Sample Depth: (cs)**	**0.00m - 0.15m**
Date & Time Sampled: (cs)	**15-Feb-24**	**Sampled By: (cs)**	[redacted]
Sample Method: (cs)	**Test Pit**	**Date Received:**	**12-Mar-24**

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1)

Test Sieve (mm)	% Passing (by mass)
106	100
75.0	97
63.0	97
53.0	96
37.5	94
26.5	90
19.0	87
13.2	84
9.50	81
4.75	76
2.36	68
2.00	64
1.18	52
0.60	41
0.30	30
0.212	25
0.150	20
0.075	14
0.063	12



The sample was received in a natural state. The percentage passing the 63µm test sieve was obtained by difference.

WATER CONTENT & SOLID DENSITY RESULTS - NZS 4402:1986, Test 2.1 & 2.7.1	
Water Content: ("All In" As Received)	**9.0 %**
Solid Density: (-37.5mm Fraction)	**2.46 t/m^3**
Note: The sample was received in a natural state.	

Notes:

- *Information contained in this report which is Not IANZ Accredited relates to the sample description based on NZ Geotechnical Society Guidelines 2005, the client supplied information (cs) and sampling.*
- *This report may not be reproduced except in full.*

[redacted]

Date: **25-Mar-24 to 10-Apr-24**

ACCREDITED IANZ TESTING LABORATORY №434

Test results indicated as not accredited are outside the scope of the laboratory's accreditation

Central Testing Services [redacted]

Reference No: 24/838

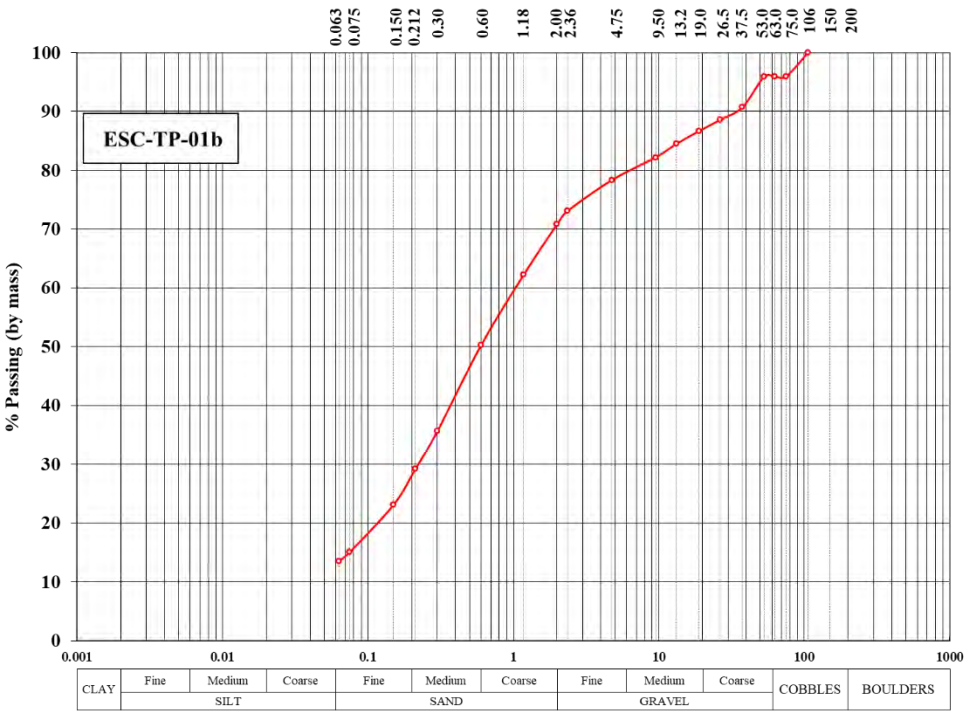
Date: 15 April 2024

TEST REPORT – ESC COVER DESIGN FIELD INVESTIGATIONS

Client Details:	**Bathurst Resources Limited,** [redacted]	**Attention:**	[redacted]
Job Description:	**ESC Cover Design Field Investigation**		
Sample Description:	**Gravelly SAND with some silt & trace of cobbles with trace of deleterious organic present (coal / roots)**	**Client Order No:**	**539528**
Sample Source: (cs)	**ESC-TP-01b**	**Sample Depth: (cs)**	**0.15m – 0.80m**
Date & Time Sampled: (cs)	**15-Feb-24**	**Sampled By: (cs)**	[redacted]
Sample Method: (cs)	**Test Pit**	**Date Received:**	**12-Mar-24**

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1)

Test Sieve (mm)	% Passing (by mass)
106	100
75.0	96
63.0	96
53.0	96
37.5	91
26.5	89
19.0	87
13.2	84
9.50	82
4.75	78
2.36	73
2.00	71
1.18	62
0.60	50
0.30	36
0.212	29
0.150	23
0.075	15
0.063	14



The sample was received in a natural state. The percentage passing the 63µm test sieve was obtained by difference.

WATER CONTENT & SOLID DENSITY RESULTS - NZS 4402:1986, Test 2.1 & 2.7.1	
Water Content: ("All In" As Received)	**11.1 %**
Solid Density: (-37.5mm Fraction)	**2.50 t/m^3**
Note: The sample was received in a natural state.	

Notes:

- *Information contained in this report which is Not IANZ Accredited relates to the sample description based on NZ Geotechnical Society Guidelines 2005, the client supplied information (cs) and sampling.*
- *This report may not be reproduced except in full.*

[redacted]

Date: 25-Mar-24 to 10-Apr-24

ACCREDITED IANZ TESTING LABORATORY №434

Test results indicated as not accredited are outside the scope of the laboratory's accreditation

Central Testing Services [redacted]

Reference No: 24/838

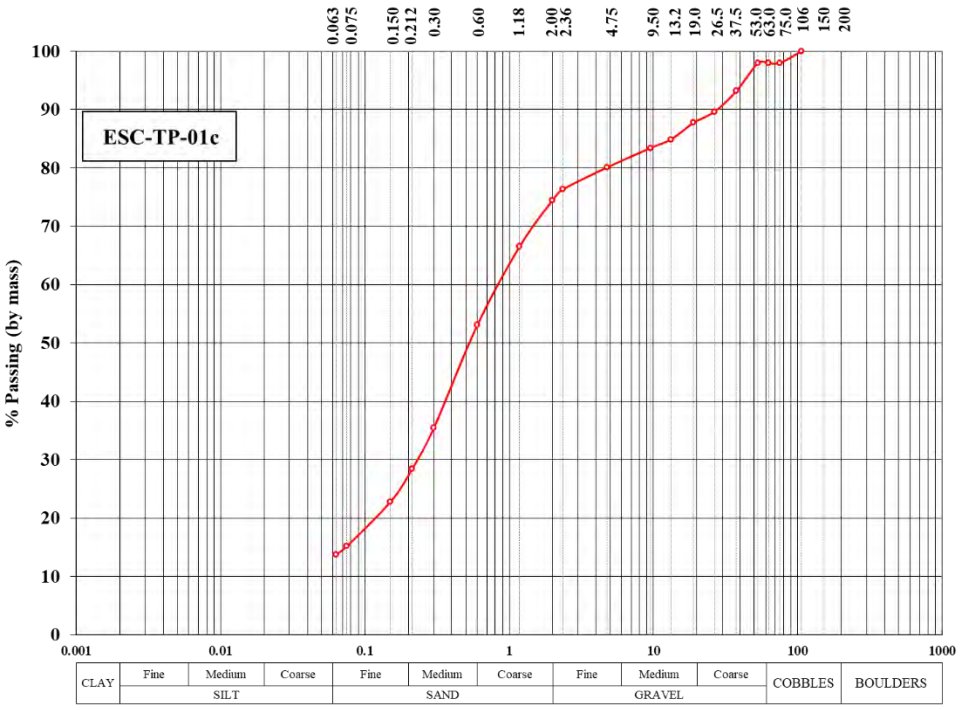
Date: 15 April 2024

TEST REPORT – ESC COVER DESIGN FIELD INVESTIGATIONS

Client Details:	**Bathurst Resources Limited,** [redacted]	**Attention:**	[redacted]
Job Description:	**ESC Cover Design Field Investigation**		
Sample Description:	**Gravelly SAND with some silt & trace of cobbles with trace of deleterious organics present (coal)**	**Client Order No:**	**539528**
Sample Source: (cs)	**ESC-TP-01c**	**Sample Depth: (cs)**	**0.80m - 1.50m**
Date & Time Sampled: (cs)	**15-Feb-24**	**Sampled By: (cs)**	**R. Burgess**
Sample Method: (cs)	**Test Pit**	**Date Received:**	**12-Mar-24**

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1)

Test Sieve (mm)	% Passing (by mass)
106	100
75.0	98
63.0	98
53.0	98
37.5	93
26.5	90
19.0	88
13.2	85
9.50	83
4.75	80
2.36	76
2.00	74
1.18	67
0.60	53
0.30	35
0.212	28
0.150	23
0.075	15
0.063	14



The sample was received in a natural state. The percentage passing the 63µm test sieve was obtained by difference.

WATER CONTENT & SOLID DENSITY RESULTS - NZS 4402:1986, Test 2.1 & 2.7.1	
Water Content: ("All In" As Received)	**9.5 %**
Solid Density: (-37.5mm Fraction)	**2.64 t/m^3**
Note: The sample was received in a natural state.	

Notes:

- *Information contained in this report which is Not IANZ Accredited relates to the sample description based on NZ Geotechnical Society Guidelines 2005, the client supplied information (cs) and sampling.*
- *This report may not be reproduced except in full.*

[redacted]

Date: 25-Mar-24 to 10-Apr-24

ACCREDITED IANZ TESTING LABORATORY №434

Test results indicated as not accredited are outside the scope of the laboratory's accreditation

Central Testing Services [redacted]

Reference No: 24/838

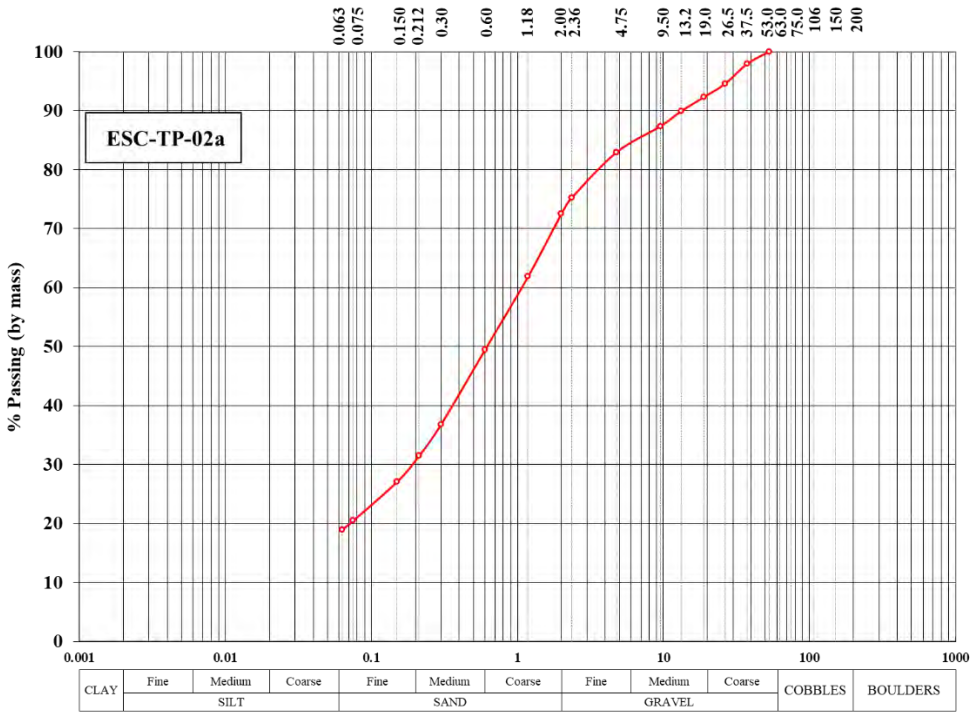
Date: 15 April 2024

TEST REPORT – ESC COVER DESIGN FIELD INVESTIGATIONS

Client Details:	**Bathurst Resources Limited,** [redacted]	**Attention:**	[redacted]
Job Description:	**ESC Cover Design Field Investigation**		
Sample Description:	**Gravelly SAND with some silt with trace of deleterious organics present (coal)**	**Client Order No:**	**539528**
Sample Source: (cs)	**ESC-TP02-a**	**Sample Depth: (cs)**	**0.00m - 0.20m**
Date & Time Sampled: (cs)	**15-Feb-24**	**Sampled By: (cs)**	[redacted]
Sample Method: (cs)	**Test Pit**	**Date Received:**	**12-Mar-24**

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1)

Test Sieve (mm)	% Passing (by mass)
53.0	100
37.5	98
26.5	95
19.0	92
13.2	90
9.50	87
4.75	83
2.36	75
2.00	73
1.18	62
0.60	50
0.30	37
0.212	32
0.150	27
0.075	21
0.063	19



The sample was received in a natural state. The percentage passing the 63µm test sieve was obtained by difference.

WATER CONTENT & SOLID DENSITY RESULTS - NZS 4402:1986, Test 2.1 & 2.7.1	
Water Content: ("All In" As Received)	**8.2 %**
Solid Density: (-37.5mm Fraction)	**2.56 t/m^3**
Note: The sample was received in a natural state.	

Notes:

- ***Information contained in this report which is Not IANZ Accredited relates to the sample description based on NZ Geotechnical Society Guidelines 2005, the client supplied information (cs) and sampling.***
- ***This report may not be reproduced except in full.***

[redacted]

Date: 25-Mar-24 to 10-Apr-24

ACCREDITED IANZ TESTING LABORATORY №434

Test results indicated as not accredited are outside the scope of the laboratory's accreditation

Central Testing Services [redacted]

Reference No: 24/838

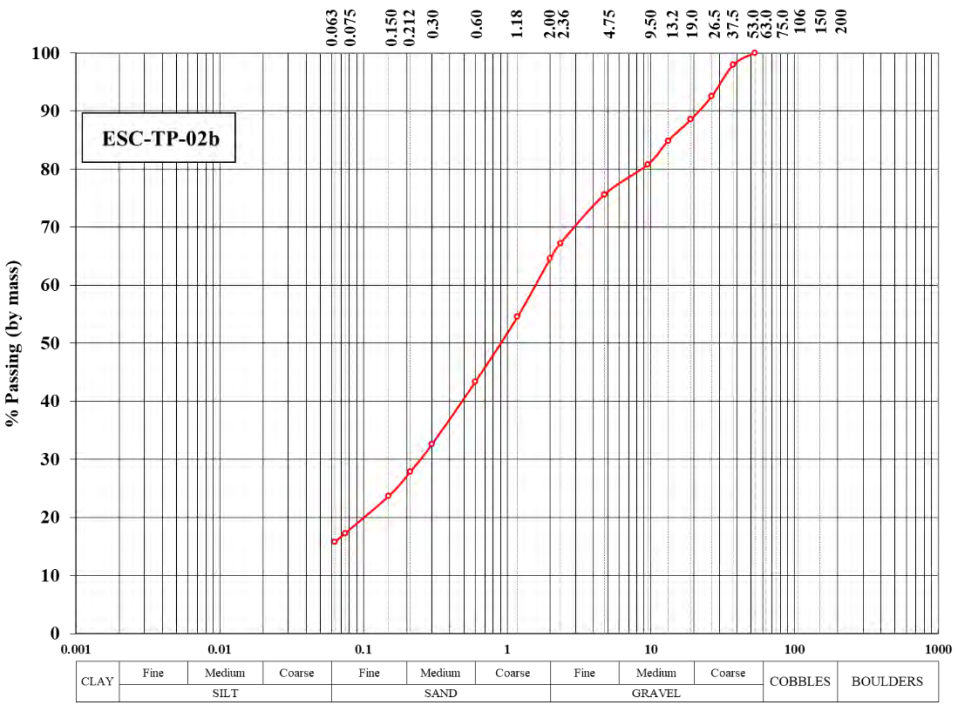
Date: 15 April 2024

TEST REPORT – ESC COVER DESIGN FIELD INVESTIGATIONS

Client Details:	**Bathurst Resources Limited,** [redacted]	**Attention:**	[redacted]
Job Description:	**ESC Cover Design Field Investigation**		
Sample Description:	**Gravelly SAND with some silt with race of deleterious organics presents (coal)**	**Client Order No:**	**539528**
Sample Source: (cs)	**ESC-TP-02b**	**Sample Depth: (cs)**	**0.20m - 0.70m**
Date & Time Sampled: (cs)	**15-Feb-24**	**Sampled By: (cs)**	[redacted]
Sample Method: (cs)	**Test Pit**	**Date Received:**	**12-Mar-24**

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1)

Test Sieve (mm)	% Passing (by mass)
53.0	100
37.5	98
26.5	93
19.0	89
13.2	85
9.50	81
4.75	76
2.36	67
2.00	65
1.18	55
0.60	43
0.30	33
0.212	28
0.150	24
0.075	17
0.063	16



The sample was received in a natural state. The percentage passing the 63µm test sieve was obtained by difference.

WATER CONTENT & SOLID DENSITY RESULTS - NZS 4402:1986, Test 2.1 & 2.7.1	
Water Content: ("All In" As Received)	**7.2 %**
Solid Density: (-37.5mm Fraction)	**2.55 t/m^3**
Note: The sample was received in a natural state.	

Notes:

- ***Information contained in this report which is Not IANZ Accredited relates to the sample description based on NZ Geotechnical Society Guidelines 2005, the client supplied information (cs) and sampling.***
- ***This report may not be reproduced except in full.***

[redacted]

Date: 25-Mar-24 to 10-Apr-24

ACCREDITED IANZ TESTING LABORATORY №434

Test results indicated as not accredited are outside the scope of the laboratory's accreditation

ATTACHMENT B – EXCAVATED SAMPLE PILES

ESC-TP-01: Surface

ESC-TP-01: 0 to 0.2 m

Note: card in image is approximately 90 mm in length.

ESC-TP-01: 0.2 to 0.7 m

Note: card in image is approximately 90 mm in length.

ESC-TP-01: Excavation profiled to 160 cm.

ESC-TP-02: Surface

ESC-TP-02: 0 to 0.2 m

Note: card in image is approximately 90 mm in length.

ESC-TP-02: 0.2 to 0.7 m

Note: card in image is approximately 90 mm in length.

ESC-TP-02: Excavation profile to 70 cm.

APPENDIX B LIMITATIONS

This Document has been provided by Mine Waste Management Ltd (MWM) subject to the following limitations:

This Document has been prepared for the particular purpose outlined in MWM's proposal and no responsibility is accepted for the use of this Document, in whole or in part, in other contexts or for any other purpose.

The scope and the period of MWM's services are as described in MWM's proposal, and are subject to restrictions and limitations. MWM did not perform a complete assessment of all possible conditions or circumstances that may exist at the site referenced in this Document. If a service is not expressly indicated, do not assume it has been provided. If a matter is not addressed, do not assume that any determination has been made by MWM in regards to it.

Conditions may exist which were undetectable given the limited nature of the enquiry MWM was retained to undertake with respect to the site. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account in the Document. Accordingly, additional studies and actions may be required.

In addition, it is recognised that the passage of time affects the information and assessment provided in this Document. MWM's opinions are based upon information that existed at the time of the production of this Document. It is understood that the services provided allowed MWM to form no more than an opinion of the actual conditions of the site at the time the site was reviewed and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings, or any laws or regulations.

Any assessments made in this Document are based on the conditions indicated from published sources and the investigation described. No warranty is included, either express or implied, that the actual conditions will conform exactly to the assessments contained in this Document.

Where data supplied by the client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by MWM for incomplete or inaccurate data supplied by others.

MWM may have retained subconsultants affiliated with MWM to provide services for the benefit of MWM. To the maximum extent allowed by law, the Client acknowledges and agrees it will not have any direct legal recourse to, and waives any claim, demand, or cause of action against, MWM's affiliated companies, and their employees, officers and directors.

This Document is provided for sole use by Bathurst Resources Limited and is confidential to it and its professional advisers. No responsibility whatsoever for the contents of this Document will be accepted to any person other than the Client. Any use which a third party makes of this Document, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. MWM accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this Document.

MWM acknowledges that this report will be relied on by a Panel appointed under the Fast-track Approvals Act 2024 and these disclaimers do not prevent that reliance.

MINE WASTE MANAGEMENT

GREENROAD GROUP