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MEMORANDUM 2

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INTRODUCTION

As part of a best practicable approach to the management of acid and metalliferous drainage (AMD), Bathurst Coal Limited (BCL) have undertaken considerable efforts to characterise materials and implement material management options to prevent oxidation and reduce contaminant loads from the site, including reducing historical legacy discharges and downstream effects. AMD affected waters have been controlled at site to specific discharge points and minor additional management and treatment of impacted waters are required to maintain compliance with resource consent conditions. This will be supported by performance monitoring and trigger action response plans (TARPs) that will be part of an adaptive management approach for mine closure.

This memorandum estimates the water quality in the N02 Pit using analogue models to determine the water quality during the mine operational and closure periods where:

- Current water quality is associated with the existing N02 Pit Sump and monitoring data;
- Future N02 Pit Sump water quality, which is based on Oyster Sump (CC57) being representative of peak operational activity in the catchment; and
- N02 Pit Pond water quality, which is based on the North Elf Pond (CC20), when the N02 Pit Pond is full and discharging via the box cut during the Post Closure phase.

This memorandum demonstrates that CC57 and CC20 sites are reasonable analogue sites and that these data indicate that the forecast N02 Pit Pond water quality post closure would meet CRC170541 water quality criteria with sufficiently low contaminant concentrations to be an effective diluting waterbody for the Tara MSR.

Mine Waste Management Ltd (MWM) were engaged by BCL to complete a technical work scope that can be referenced in an assessment of environmental effects (AEE) for Canterbury Coal Mine (CCM) closure consents. The work scope relates to AMD management, water quality compliance, and adaptive management aspects of the closure AEE. This is the second (Memorandum 2) of four technical memorandum deliverables and discusses the No 2 Pit Pond water quality forecast. The four deliverables discuss:

- Memorandum 1: The Tara mussel shell reactor (MSR) treatment system design;

- Memorandum 2: The N02 Pit Pond water quality forecast;
- Memorandum 3: The water quality of combined CCM discharge from Tara Pond 1 and Tara MSR discharge; and
- Memorandum 4: Recommendations for post closure monitoring requirements and relinquishment criteria from an AMD management perspective.

SUMMARY

This memorandum presents the N02 Pit Pond water quality forecast, which has been assessed using analogue models based on site-specific empirical data. These analogue models are based on:

- Oyster Sump (water quality investigation site CC57) water quality data as representative of the N02 Pit Sump operational phase; and
- North ELF Pond 2 (water quality investigation site CC20) water quality data (from 2020 onwards) as representative of the N02 Pit Pond post closure phase.

This memorandum establishes that:

- The CC57 and CC20 sites are reasonable analogue sites, based on available N02 Pit Sump water quality monitoring data;
- The forecast N02 Pit Pond water quality post closure would meet CRC170541 water quality criteria with sufficiently low contaminant concentrations to be an effective diluting waterbody for the Tara MSR;
- The analogue model is supported by additional materials management implemented by BCL to manage AMD risks in the N02 Pit Pond catchment, which may differ from analogue site drainages. This includes:
    - Waste rock scheduling based on geochemical characterisation to prevent PAF materials being disposed in areas with a greater risk of generating AMD;
    - Alkaline amendments to reduce sulfide mineral oxidation / acidity generation through the backfill period; and
    - Specification of a 1 m NAF cover for the majority of reshaped pit walls.
- The analogue model is also supported by the relatively large N02 Pit Pond water storage capacity relative to the analogue model catchment area. The N02 Pit Pond 3,743 m^3 live storage capacity has the potential to store a greater proportion of surface runoff flows than the CC20 analogue (which has a live storage of ~1,000 m^3) potentially leading to more efficient surface water ‘harvesting’ and lower contaminant concentrations.
- BCL have proposed using a passive NaOH dosing system as part of a TARP to maintain the N02 Pit at approximately pH 7.5, if required. Monitoring data indicate that NaOH dosing to pH 7.5 would be sufficient for N02 Pit water quality to meet the CRC170541 limits for Mn and Zn concentration, if required.

BACKGROUND

The N02 Pit Pond is a key component of the post closure water management infrastructure at CCM. A pond will form in the mined out N02 Pit and support sediment management for the site during the closure and post closure phases. Once closure criteria are met for surface water the pond will discharge via a free draining spillway and boxcut drain into the Tara drain, Tara Pond, and then discharge offsite. A continuously discharging decant constructed into the spillway will provide the base flow required for dilution of elevated Boron (B) discharging from the Tara MSR. The Tara MSR will treat the continuously flowing CC02 underdrain discharge by reducing Fe, Mn, and Zn concentrations (discussed in Memorandum 1 (MWM, 2021a)). The decant will be installed ~0.5 m below the spillway crest creating a live storage volume of 3,743 m^3. The maximum designed N02 Pit Pond storage volume (including live storage) is ~19,000 m^3.

The N02 Pit Sump/Pond water quality has been assessed using analogue models based on site-specific empirical data. These analogues are based on:

- Oyster Sump (CC57) water quality data as representative of the N02 Pit Sump operational phase; and
- North ELF Pond 2 (CC20) water quality data (from 2020 onwards) as representative of the N02 Pit Pond post closure phase.

The location of these analogue water quality monitoring sites (along with other CCM investigation sites) is shown in Figure 1.

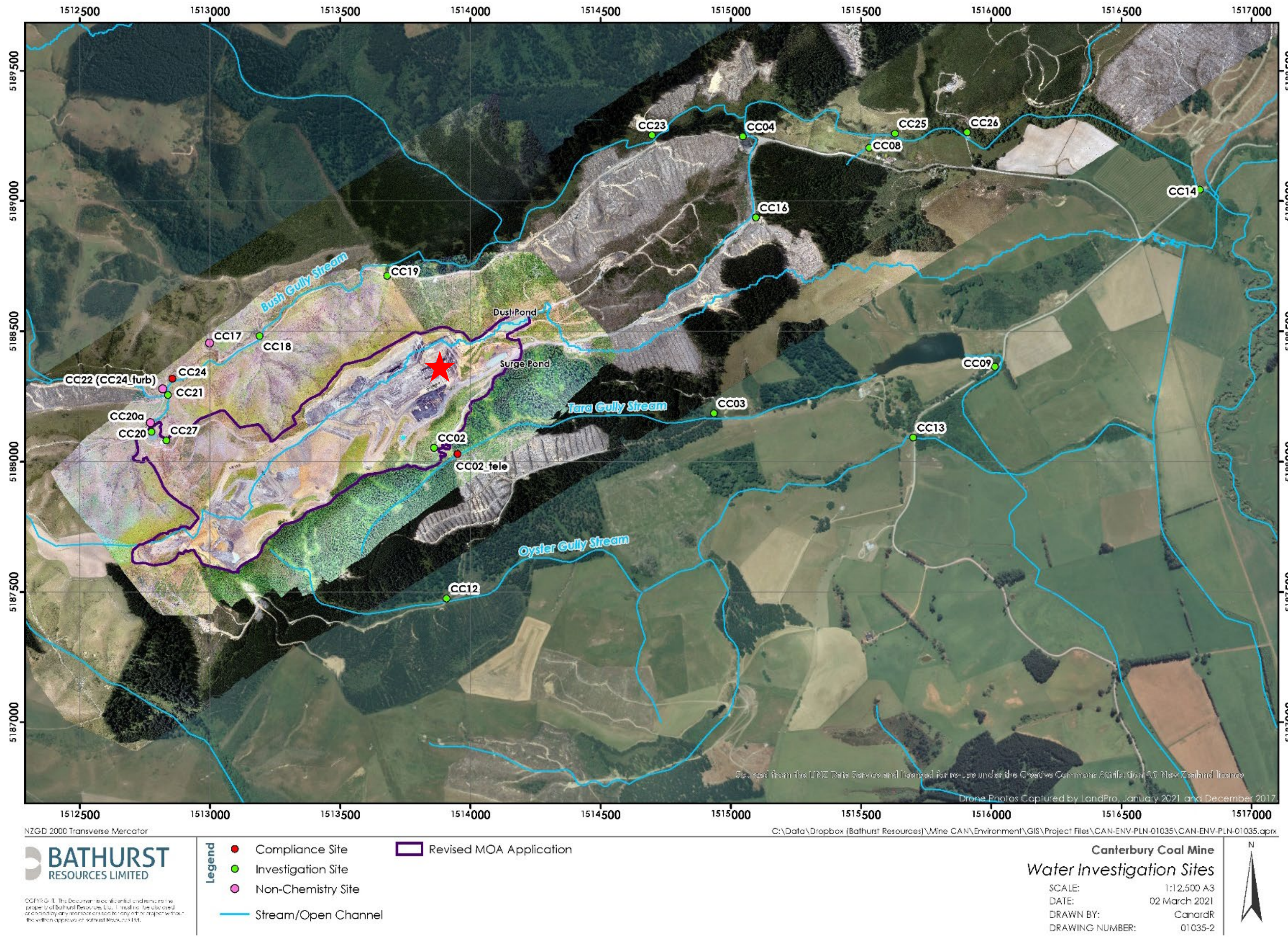

Figure 1. CCM water investigation sites. Approximate N02 Pit location shown as red star.

These analogues are considered appropriate for forecasting N02 Pit Pond water quality as they represent catchment effects from large landforms that were constructed according to the CCM Environmental Management Plan (BRL, 2018) controls. The trends in these water quality datasets are considered more representative than other alternative modelling approaches that would derive water quality estimates from laboratory data and/or geochemical modelling.

The analogue model applicability is discussed with reference to a range of mitigating strategies associated with specific areas within the N02 Pit Pond catchment. This includes waste rock segregation (by AMD classification) and alkaline amendments as appropriate. The effect of these mitigation strategies was not incorporated into the N02 Pit Pond water quality forecast to simplify the modelling process (there is no framework within the N02 Pit Pond analogue model to assess the effects of mitigation strategies at a sub-drainage level within the N02 Pit final landform). However, the mitigation strategies are acknowledged as supporting the use of an analogue model on the assumption that the net effect on water quality will be ‘not worse’ than observations in the North ELF drainage (at CC20).

SCOPE OF WORKS

The work scope provided to MWM requested the following items be addressed:

- Provide an estimate of N02 Pit Pond water quality post closure considering:
    - Available N02 Pit Sump water quality and flow data;
    - Use of other sites as analogues (e.g., North ELF drainage water quality, and Oyster Sump); and
    - NAF/PAF balance of disturbed material within the final landforms and rehab schedule.
- Summarise recommendations for lime addition where compaction may not meet management plan specifications.

N02 PIT SUMP WATER QUALITY

The available N02 Pit Sump water quality data to date are summarised in Figure 2. Overall, the N02 Pit Sump water quality data to date are comparable (data presented in the next section) to Oyster Sump (CC57) water quality, and the North ELF Pond 2 (CC20) water quality observed during the most active construction period (late 2017 to early 2019). Laboratory reporting of N02 Pit Sump water quality data in these ranges indicates that the N02 Pit Sump geochemical behaviour is typical of that observed at other active mining areas at CCM, validating the use of analogue models for forecasting water quality.

Observations from initial N02 Pit Sump water quality data include:

- Early monitoring data indicate N02 Pit Sump water quality would meet the current CRC170541 compliance limits, with the exception of B which was elevated above the 1.5 mg/L trigger value in two of the samples (NB: B compliance is assessed based on the three-month rolling average B concentration);
- High boron concentrations at CCM have been associated with pit wall exposures of upper units of the Broken River Coal Measures (as well as historic workings (e.g., water quality investigation site CC08)). Lower units of the footwall have not resulted in elevated B in

drainage monitoring data. Boron concentrations of between 0.5 and 3 mg/L were recorded in the Oyster Sump (CC57), with most of the recent measured concentrations at the lower end of that range. This suggests any further increase to N02 Pit Sump B concentration may be minor.

- Initial sulfate concentrations are ~200-300 mg/L indicating an immediate influence by AMD processes. As N02 Pit construction occurs, pit wall exposure increases, and backfill volumes in the N02 Pit catchment increase, the load and concentration of sulfide associated contaminants (e.g., nickel (Ni), zinc (Zn), sulfate (SO_4), etc.) is expected to increase (particularly during dry periods). An increase in Zn concentration is also anticipated as Zn has been elevated at analogue sites CC20 and CC57 through the operational period. It is assumed that the Ni and Zn concentrations can be managed during the operational and initial closure phases using current active treatment methodologies; and
- The Mn concentration in the N02 Pit Sump is anticipated to increase, with values of up to 2 to 3 mg/L expected, as observed at analogue sites CC20 and CC57 through the operational period. Mn concentrations can also be managed during the operational and closure phases using current active treatment methodologies.

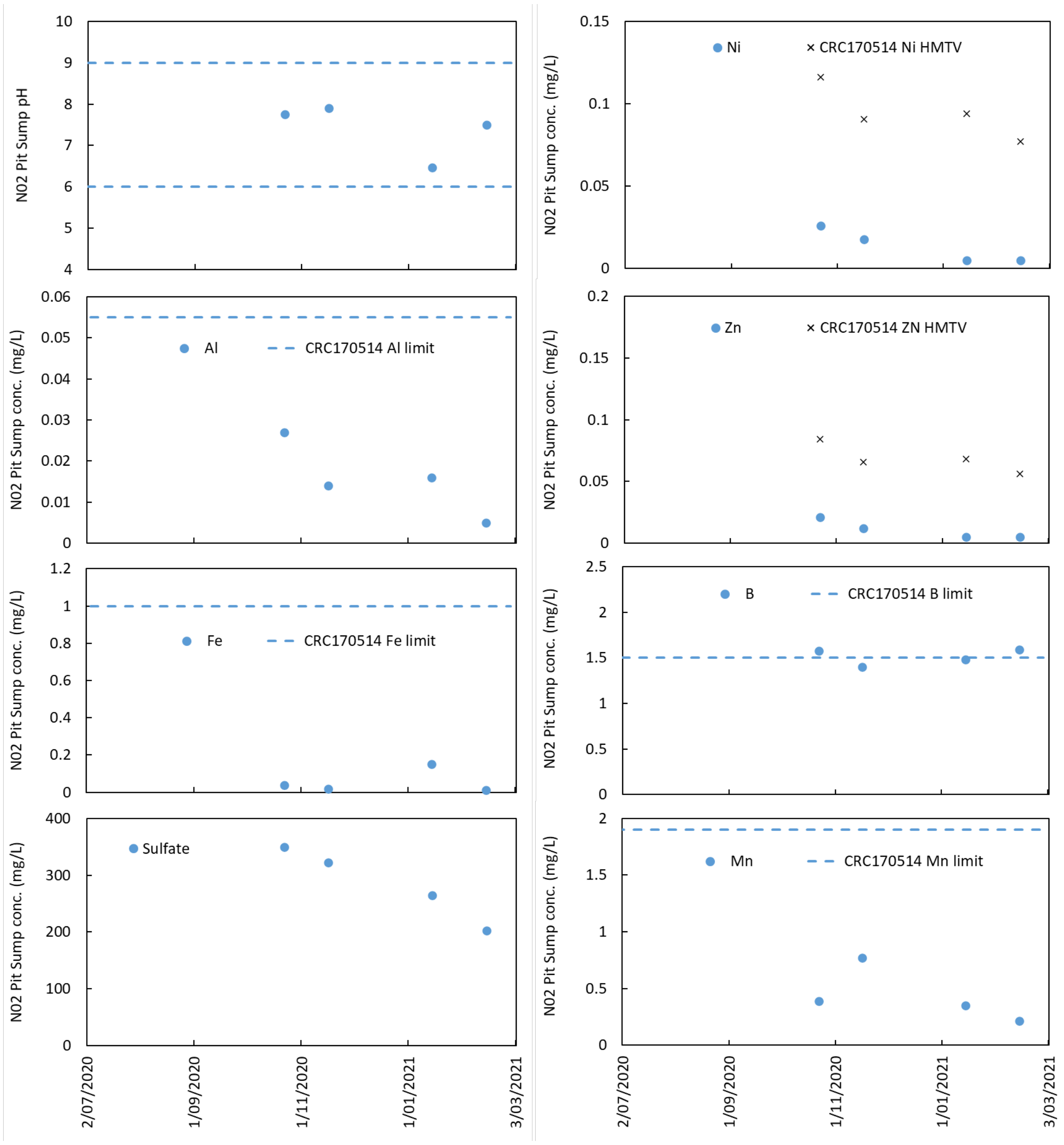

Figure 2. N02 Pit Sump measured water quality

No 2 PIT SUMP/POND WATER QUALITY FORECAST

Operational Mine Phase

Throughout the remaining ~ 6-12 month operational period the N02 Pit Sump water quality is expected to deteriorate slightly to match the Oyster Sump (CC57) water quality signature. This reflects the similarities between the Oyster Sump and N02 Pit catchments which include:

- Effectively 100% disturbance of drainage surface area, indicating all runoff will contact disturbed surfaces;

- Significant pit wall exposure in the drainage area, indicating a portion of runoff will contact exposed coal measures and the potential for seepage from in-situ coal measures to report to the N02 Pit Sump;
- Exposure of potentially acid forming coal measures on the upper bench of the southern highwall; and
- Significant volume of backfilled waste rock in the drainage area, indicating the potential for backfill seepage to report to the N02 Pit Sump, including from encapsulated potentially acid forming (PAF) backfill materials.

Throughout the remaining operational and closure periods N02 Pit Sump water quality can be managed using current active treatment methodologies (e.g., $Ca(OH)_2$ dosing to increase pH prior to discharge) as per the CCM EMP (BRL 2018).

Post Closure Phase

The final rehabilitated N02 Pit Pond catchment will be significantly different to the operational phase catchment:

- Reshaping of all in-situ highwalls to geotechnically stable slopes that will meet landowner final landform criteria;
- Placement of a minimum 1 m layer of NAF material against all final backfill / reshaped surfaces (including highwalls) preventing in-situ coal measure exposure to the atmosphere;
- Placement of significant volumes of compacted backfill against other previously exposed coal measures;
- Effectively 100% rehabilitation of the catchment surface area (excluding the N02 Pit Pond water surface and access roads), indicating the majority of runoff will contact revegetated ground (as opposed to mining disturbed surfaces) minimising runoff contamination;
- Full removal of historic underground workings within the No 2 Pit Pond catchment; and
- Residual potential for backfill seepage to report to No 2 Pit Pond, including from encapsulated potentially acid forming (PAF) backfill materials and areas above an underdrain installed in the N02 Pit footwall buttress that will discharge sub aqueously.

The proposed management practices within the N02 Pit Pond catchment are expected to reduce post closure contaminant loads resulting in N02 Pit Pond water quality comparable to the North ELF Pond 2 site (as measured at CC20 in the dataset from 2020 onwards, below the largely rehabilitated North ELF). This reflects the expected similarities between the current CC20 and proposed N02 Pit final landform drainages.

Water Quality Forecasts

The expected operational and post closure N02 Pit Pond water quality analogues are compared to measured N02 Pit Sump water quality data in Figure 3. Ongoing monitoring by BCL will extend the N02 Pit water quality dataset over the remaining construction and into post closure phases. N02 Pit Sump/Pond water quality forecasts for three project stages are presented, and include:

- ‘Current’ N02 Pit Sump water quality – derived from available N02 Pit sump monitoring data;
- ‘Operations peak’ N02 Pit Sump water quality – derived from CC57 monitoring data and reflecting a slight deterioration in ‘Current’ N02 Pit Sump water quality as N02 Pit disturbance peaks at the end of the operational phase; and
- ‘Post Closure’ N02 Pit Pond water quality – derived from CC20 monitoring data and reflecting an improvement in water quality as the N02 Pit catchment is rehabilitated and revegetated.

For each water quality parameter of interest and project stage (Current, Operations peak, and Closure) there are three data points presented in a vertical line. These data points correspond to the 10th, median, and 90th percentile measured contaminant concentration over the appropriate analogue site dataset. The concentration variability is attributed to:

- Seepage derived contaminant concentration accumulation and increase within the Oyster Sump / North ELF Pond during relatively dry periods; versus
- Contaminant concentration attenuation and decrease in the Oyster Sump / North ELF Pond during relatively wet periods.

As such, the data points generally correspond to:

- Top data point – 90th percentile contaminant concentration considered representative of low flow / dry period conditions;
- Middle data point – median contaminant concentration considered representative of normal conditions; and
- Bottom data point – 10th percentile contaminant concentration considered representative of high flow / wet period conditions.

The exception to this order is pH, which is not expected to be correlated with either dry or wet periods. Recent data from the North ELF underdrain proxy water investigation site (CC27) show high seepage pH value (pH 7-8) trends, which would not contribute to acidification of the N02 Pit Pond during dry periods (when other contaminant concentrations are accumulating). Thus, pH is shown in Figure 3 as a range rather than individual data points.

A summary of the forecast N02 Pit Sump/Pond water quality is shown in Table 1. These concentration data are presented in Figure 3.

Table 1. N02 Pit sump/pond water quality forecast

Analogue phase	**Current (Pit Sump)**			**Operations Peak (Pit Sump)**			**Post Closure (Pit Pond)**		
Analogue site	N02 Pit Sump			CC57 Sump			CC20 Pond		
Analogue period (dataset)	2020 onwards			2019 onwards			2020 onwards		
Flow condition	High	Normal	Low	High	Normal	Low	High	Normal	Low
pH	6.8 - 7.9			4.5 – 5.6			7.1 – 7.7		
Calc acidity	0.08	0.19	0.44	0.50	1.96	4.74	0.08	0.13	0.23
Sulfate	222	294	342	267	421	558	195	299	328
Al	0.008	0.015	0.024	0.063	0.191	0.486	0.005	0.010	0.025
B	1.42	1.53	1.59	0.67	1.30	2.52	0.40	0.45	0.60
Fe	0.014	0.030	0.118	0.010	0.045	0.068	0.020	0.030	0.070
Mn	0.26	0.37	0.66	1.08	1.61	3.12	0.03	0.09	0.44
Ni	0.005	0.012	0.024	0.034	0.064	0.110	0.004	0.006	0.011
Zn	0.005	0.009	0.018	0.105	0.264	0.430	0.005	0.009	0.020
Hardness	315	367	449	243	382	510	202	313	362

All units in mg/L except for pH (unitless); and Calc. Acidity and Hardness are in mg $CaCO_3$/L equivalent

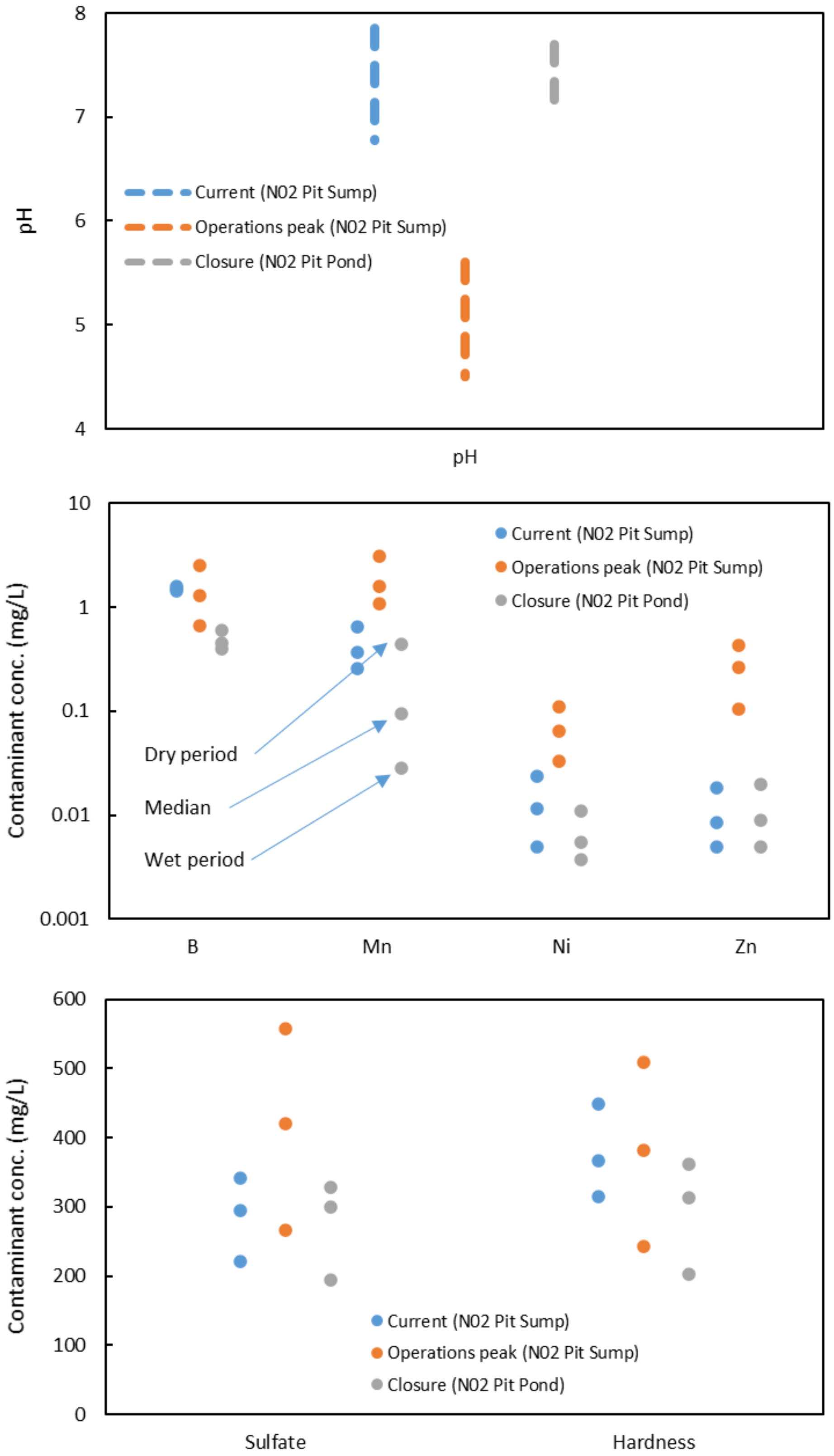

Figure 3. Indicative N02 Pit Sump/Pond water quality through mine operations and closure phases

ANALOGUE MODEL DISCUSSION

The forecast of N02 Pit Sump/Pond water quality uses an analogue model approach. The analogue sites selected for the N02 Pit Sump/Pond water quality forecast provide site specific empirical data at the landform scale that is directly applicable to the modelling process. These sites are representative of both the operational (CC57) and closure (CC20) phases of a CCM mining domain.

This section discusses the analogue model applicability to the N02 Pit Sump/Pond water quality forecast, specifically identifying zones within the N02 Pit catchment that potentially differ from the analogue catchments. BCL have developed specific techniques for managing the risks associated with these zones. As a result, these zones are not anticipated to have a meaningful effect on the analogue model validity.

PAF Waste Rock Management

Key aspect of best practicable AMD management that need to be considered for the management of PAF waste rock include:

- Prediction of effects / risks (materials characterisation);
- Prevention of sulfide mineral oxidation; and
- Minimisation of AMD load by reducing water flow through material domains (e.g., Engineered landforms; ELFs).

These approaches are discussed for the N02 Pit catchment area to understand relevance for using analogue models for water quality predictions.

In general, waste rock backfill in the N02 Pit catchment will be undertaken as described in the CCM EMP (BRL, 2018) backfill methodology. The North ELF is the best landform scale analogue for a landform constructed using the EMP methodology. BCL are undertaking additional management in certain critical zones to minimise the risk of AMD generation. These are discussed in the following sub-sections.

Legacy AMD Management

The historic North / Shearers dump (now rehandled and backfilled to the pit) was a poorly constructed PAF waste rock dump and generated significant acidity (~2,500 mg $CaCO_3$/L) and acid soluble contaminant concentrations. Effectively managing PAF rock in the N02 Pit catchment is critical to minimising acidity and contaminant loads reporting to N02 Pit Pond.

The removal of this legacy PAF dump and placement of these materials in an ELF, designed to minimise ongoing sulfide mineral oxidation and mobilisation of contaminants is an example of proactive best practicable approach for legacy issues (created prior to BCL taking over the site).

N02 Pit Block Model and Materials Characterisation

The waste rock block model forecast material volumes for the N02 Pit backfill / landform construction (from December 1st 2020 until mine closure) are summarised in Table 2. This assessment shows that only a small proportion (~3%) of the N02 Pit materials schedule is PAF. The low risk material volume is significant (~45%) but the majority of this material (with the exception of Backfill #3 discussed in the next subsection) will be placed following the EMP (2018) guidelines. As such, geochemical outcomes are expected to be similar to that observed at the North ELF were best practicable AMD management options have minimised effects on downstream water quality.

Table 2: N02 Pit construction phase materials schedule

Materials classification	Total volume
	(bcm)
Acid neutralising (AN)	1,798
Non-acid forming (NAF)	132,450
Low risk	118,038
Potentially acid forming (PAF)	8,195
Total	**260,480**

A process flow acid base accounting (ABA) classification scheme is used to define waste rock geochemical class at CCM. This is described in detail in the CCM EMP (BRL, 2018) and shown in Figure 4, where moderate sulfur materials are classified according to their net acid production potential (NAPP) that considers acid generation capacity and acid neutralisation capacity.

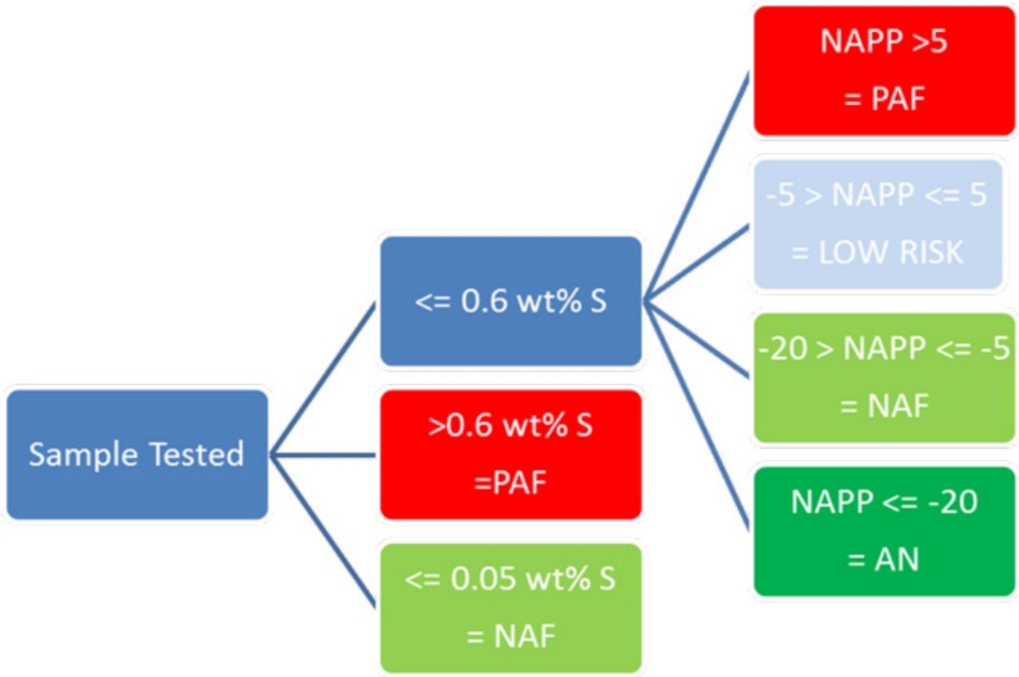

Figure 4. Process flow ABA classification used at CCM

Backfill #3

The 'Backfill #3' area within the N02 Pit catchment was constructed with less compaction than specified in the CCM EMP (BCL, 2018). This was due to pit shell geometry constraining the ability for loaded trucks to traffic the Backfill #3 surface and hence the normal standards of compaction could not be achieved. Through this period Mine Planning ensured any PAF or low risk material was placed in Backfill #1 or #2 areas located at the bottom of the pit (Figure 5).

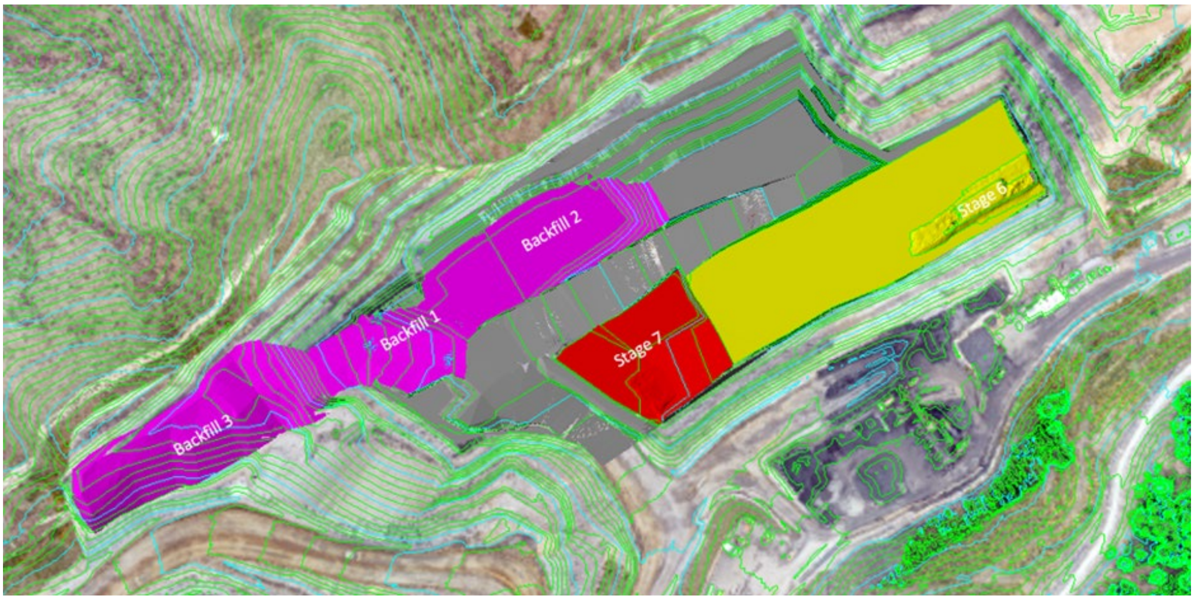

Figure 5. Relative location of Backfill #1, #2, and #3

BCL have provided a summary of outputs from the ABA geological model for the November/December 2020 period when Backfill #3 was being constructed. For that period:

- The average ANC was 14.5 kg $CaCO_3$/t;
- The MPA was 5.8 kg $CaCO_3$/t (total sulfur 0.189 wt%);
- The majority of material was classified as NAF (85,818 bcm NAF from a total 118,988 bcm backfilled); and
- Of this total, 49,556 bcm of NAF was placed in Backfill #3.

A limestone amendment equivalent to two 'truck and trailer' loads (i.e. ~88 t) was made to Backfill #3 material during construction. This equates to an additional 1 kg $CaCO_3$/t alkalinity through limestone amendment and was applied to suppress sulfide oxidation / acidity generation during the construction phase. This limestone amendment was made in addition to 288 m^3 of coal ash disposal, which is equivalent to ~200 dry tonnes of ash. This coal ash would contribute a further 10 t $CaCO_3$ alkalinity (recent coal ash ABA testing data indicated an ANC of 50 kg/t).

MWM recommend compaction of the final waste rock surface (after reshaping and prior to topsoiling / rehabilitation) where possible across the Backfill #3 area to minimise infiltration. This would minimise net percolation of water into the Backfill #3 area and maximise relatively clean surface runoff volumes reporting to N02 Pit.

<u>The Boxcut Drain / Closure and Rehabilitation Earthworks</u>

The majority of closure phase earthworks will consist of a boxcut drain to be constructed to create the N02 Pit Pond spillway and drainage channel which connects to the Tara lined drain. This includes removal of approximately 100 kbcm of material. Five rock samples from the N02 Pit highwall have been analysed for ABA characteristics (Table 3), which are assumed to be representative of the box-cut drain.

Table 3: N02 Pit highwall rock sample ABA properties

Sample	Total S	MPA	ANC	NAPP
	(wt%)	(kg $CaCO_3$/t)	(kg $CaCO_3$/t)	(kg $CaCO_3$/t)
ABA001	0.042	1.3	6	-5
ABA002	0.02	0.6	9	-8
ABA003	0.537	16	3	13
ABA004	0.039	1.2	5	-4
ABA005	0.056	1.7	7	-5

BCL indicate that the boxcut cuts through a zone of structural deformation which is difficult to define in the AMD block model. The zone of structural deformation has been modelled using an average of the Table 3 results, which results in these materials being classified as Low-risk.

The waste rock block model forecast material volume production during the closure and rehabilitation phase (Table 4). This assessment shows that only a small proportion (~4%) of closure and rehabilitation phase materials schedule is PAF. The low risk material volume is significant due to the volume of materials within the structural deformation area.

Table 4: Closure and rehab phase (including boxcut) materials schedule

Materials Classification	Total volume
	(bcm)
Acid neutralising (AN)	1,512
Non-acid forming (NAF)	38,934
Low risk	87,438
Potentially acid forming (PAF)	5,883
Total	**133,767**

BCL intend to manage this heterogeneity (and potential risk of encountering PAF material not identified in the block model) using an equivalent 4 kg $CaCO_3$/t limestone addition for material disposed in higher risk backfill areas (e.g. backfill to the Surge Pond and Dust Pond) with the intention of reducing sulfide mineral oxidation / acidity generation through the backfill period. Approximately 25 kbcm of the box cut material could potentially be used to backfill the surge and dust ponds (which will be capped, compacted, contoured, and topsoiled before revegetation as described in the CCM Draft Closure and Rehabilitation Strategy (BRL, 2020)) and will not drain back to N02 Pit / Tara Ponds.

The remaining material will be placed in the bottom of the Pit below the water level to minimise exposure to atmospheric oxygen.

Pit wall and box cut wall management

Upon completion of mining in the N02 pit and the West Pit the remaining pit walls will be flattened to designs that provide long term stability and meet landowner requirements for closure. Once the final contour is achieved a 1 m thick NAF cover will be spread over the slope (or in-situ NAF areas ripped to a 1 m depth) and topsoiled before revegetation (BRL, 2020). This vegetated NAF and topsoil cover will provide a barrier between atmospheric oxygen and in-situ coal measures exposed in the highwall. The exception is for the very upper-level batters of the N02 Pit footwall, which may not have additional fill placed due to inability to access. BCL indicate these upper highwall materials are generally NAF and are therefore considered a lower risk of generating AMD.

Figure 6 shows the N02 Pit final landform including:

- Areas covered by bulk backfill shaded grey;
- The underlying in-situ geochemical block model material classification for areas not covered by backfill (but reshaped prior to NAF cover); and
- The N02 Pit Pond water level at post closure.

The majority of the pit wall / floor not covered by backfill is classified as either acid neutralising or non-acid forming. Thus, the majority of the pit walls are a relatively low risk from an AMD perspective.

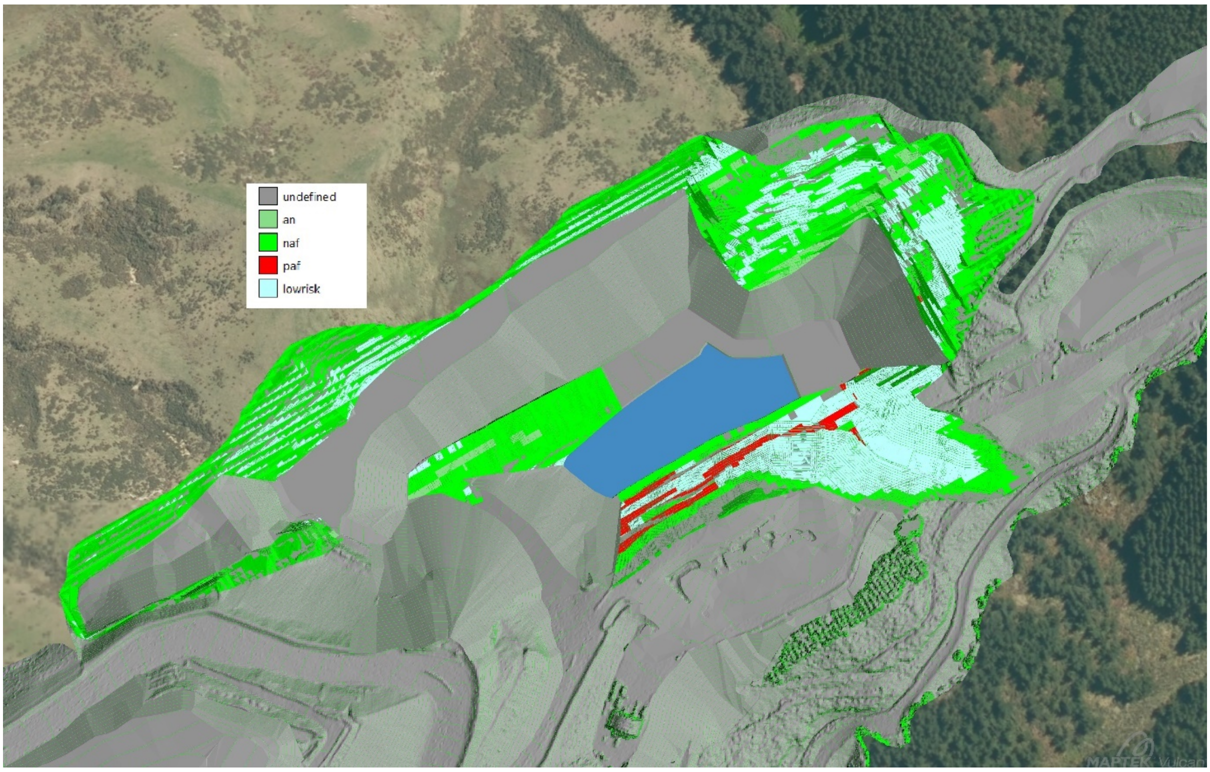

Figure 6. Geochemical block model pit wall / floor geochemical classification

N02 Pit surface runoff to storage volume comparison

This section compares the current analogue site (CC20 and CC57) drainage area versus sump / pond storage volume to the post closure N02 Pit drainage area to storage volume. The ratio of the drainage area to sump / pond storage volume is expected to be a key variable influencing N02 Pit water quality. Drainages with a large water storage capacity will be able to retain a greater proportion of surface runoff (with relatively low contaminant concentration) to minimise the effect that seepage flows (with relatively high contaminant concentration) have on sump contaminant concentration and load accumulation over dry periods. This effect may be partially reflected in the CCM analogue sites with:

- Relatively large variation in CC57 water quality (as shown in Figure 3 ‘Operations peak’ dataset) for a drainage with relatively small storage volume; versus
- Relatively small variation in CC20 water quality (as shown in Figure 3 ‘Closure’ dataset) for a drainage with relatively large storage volume.

The ratio of drainage area to pit / pond storage volume for N02 Pit and analogue sites is summarised in Table 5. The CC20 and CC57 drainage areas and pond volumes equate to the current (early 2021) sizes while the N02 Pit drainage areas and pond volumes relate to the post closure state.

Table 5: CC02 design parameters

Analogue site	**Drainage area**	**Sump / pond volume**	**Ratio pond volume to drainage area**
	(ha)	(m^3)	(m^3/ha)
CC57	8.5	>500	~59
CC20 (Pond 1 and 2)	10.8	2,800 (incl. ~1,000 m^3 live storage)	~260
N02 Pit Pond (final landform)	13	19,000 (incl. 3,743 m^3 live storage)	~1,500

The proposed N02 Pit Pond has a much higher ratio of pond volume to drainage area than CC20. Thus, water quality variability in the N02 Pit Pond may be even less than what is observed in the CC20 dataset. Furthermore, the 3,743 m^3 live storage capacity has the potential to store a greater proportion of surface runoff flows than the CC20 analogue (live storage of ~1,000 m^3) potentially leading to lower contaminant concentrations.

It should be noted that the Oyster Pond is able to hold much larger volumes than 500 m^3. However, after being filled by a rain event the sump is generally quickly drawn down by pumping (to the Surge Sump for treatment) and left as a relatively ‘dry basin’ most of the time (to provide storage capacity for subsequent rain events). This may further exaggerate the variability between CC57 water quality measurements by decreasing the effective storage of surface runoff in Oyster Pond.

N02 PIT AMD MANAGEMENT - CONTINGENCY

BCL have proposed using a passive NaOH dosing system as part of a TARP to maintain the N02 Pit Pond at approximately pH 7.5, if required. Monitoring data from the key analogue sites (CC57 and CC20) and CC02-tele (which is currently treated by minor $Ca(OH)_2$ dosing) show this should be sufficient for N02 Pit Pond discharge water quality to meet the CRC170541 limits for Mn and Zn concentration (Figure 7). Conversely, B concentration is not correlated with pH and therefore will not be managed by the NaOH dosing treatment contingency. Datapoints where CC02-tele samples were collected but BCL were not discharging from CCM are identified as ‘No-discharge’ at CC02-tele, shown by (–).

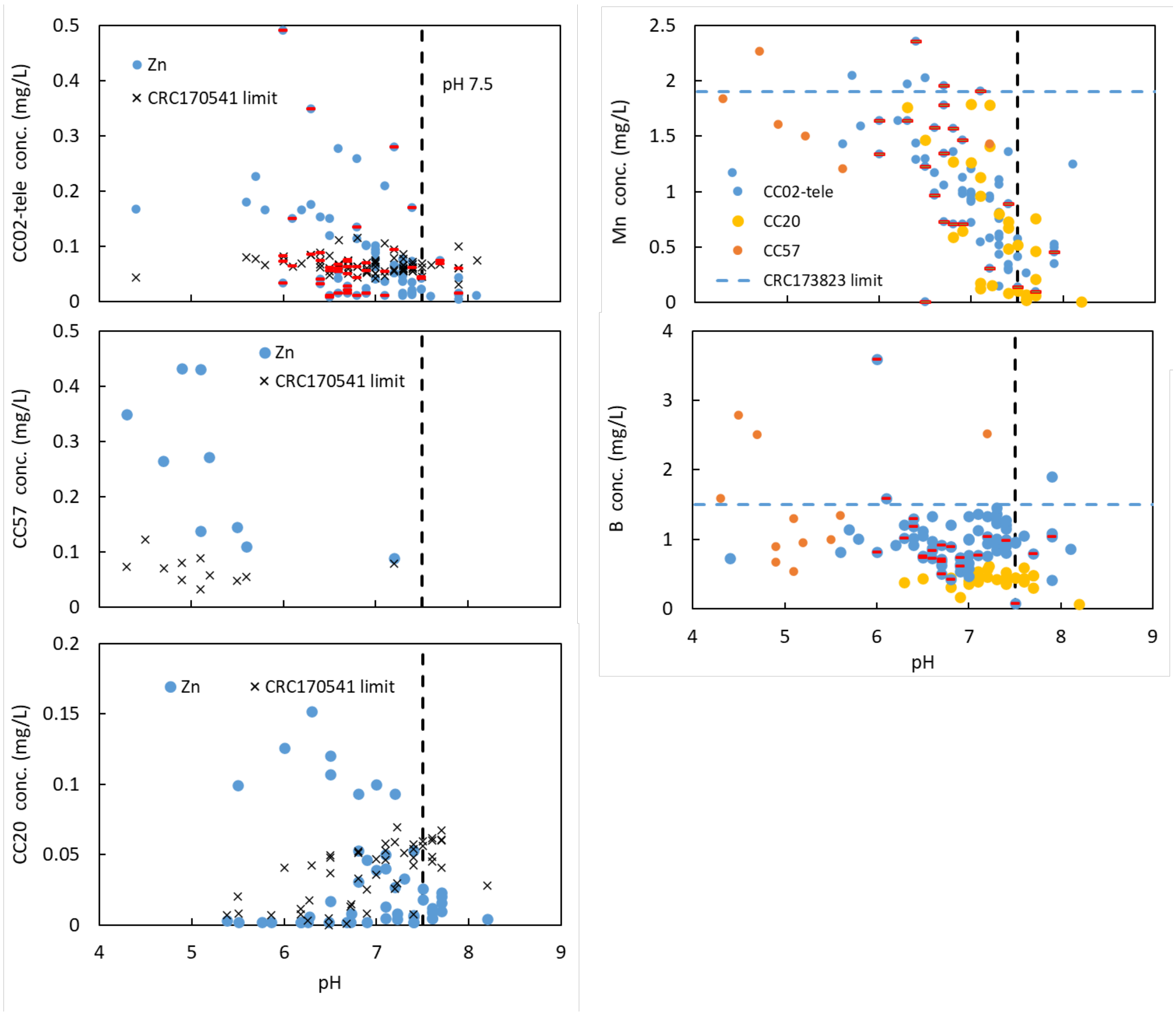

Figure 7. Mn, Zn, and B versus pH against CRC170541 compliance limits. 'No-discharge' at CC02-tele data shown by (**–**).

RECOMMENDATIONS

To advance the N02 Pit Pond water quality component of closure preparations, MWM recommend:

- Continue monitoring N02 Pit Sump water quality regularly, including flow gauging where possible; and
- Development of a trigger action response plan to describe the process for triggering implementation of the N02 Pit Pond NaOH treatment contingency and/or other adaptive management opportunities.

ADAPTIVE MANAGMENENT

It is proposed that Adaptive Management will be used for mine closure activities at Canterbury Coal Mine where uncertainty exists for key AMD related risks, which have been identified by BCL through a risk review workshop. Adaptive management is a recognised management option under the Resource Management Act (RMA) (e.g., Leckie, 2017). Effective adaptive management is supported by understanding the nature and duration of possible events that could occur, monitoring these events, and then having options in place should there be variance from the expected condition. This requires:

- Understanding the risks;
- Monitoring (as early warning, i.e., performance monitoring);
- Variance planning; and
- Trigger Action Response Plans (TARPS).

For the proposed long term management of the AMD effects on the N02 Pit Pond the following adaptive management is proposed.

1. Understand Risk
    a. The risks associated with AMD within the proposed N02 Pit Pond are understood, although there is currently limited data available (3 datapoints).
    b. Data indicates that PAF materials will be encountered during final earthworks, which is in an area of geological complexity.
2. Conduct Performance Monitoring
    a. Continue monitoring of flow and quality to understand trends within the N02 Pit Sump and flow and quality following closure for discharge from the N02 Pit Pond.
    b. Conduct regular QA/QC of materials being excavated to ensure PAF materials are managed in an appropriate manner and will not be left exposed at the surface at the end of mine life.
    c. Review data at cessation of mine closure earthworks (after active closure period) to consider geochemical trends and any changes to the expected water quality trends / management requirements.
3. Plan
    a. Develop an adaptive management plan for the N02 Pit Pond water quality, which should be based on performance monitoring. This plan should include TARPS.

REFERENCES

BRL, 2018. Canterbury Coal Mine Environmental Management Plan. BCL document number: CAN-ENV-PLN-001 updated to version 3.2 in October 2018.

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Leckie, J.M.G., 2017. Environmental effects management and assessment- Adaptive management in the mining context. New Zealand Annual AusIMM Branch Conference, Christchurch, 10 - 13 September, p 96-104.

MWM, 2021a. Canterbury Coal Mine Closure (Memorandum 1) – Tara mussel shell reactor treatment system design. Memorandum produced for Bathurst Coal Limited by Mine Waste Management Limited. 19 March 2021. Report No. J-NZ0130-002-M-Rev0.