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MEMORANDUM 4

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Date:	19 April 2021
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Document Title:	Canterbury Coal Mine Closure – AMD closure criteria

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.

BCL hold consents to discharge AMD impacted water in both Tara Gully (CRC170541) and Bush Gully (CRC173823) streams. A discussion on proposed closure criteria and performance monitoring is provided based on demonstrating current resource consent water quality targets are consistently achieved post closure. This includes a transition from routine monthly water quality monitoring to TARP monitoring if reliable relationships can be derived from performance monitoring data.

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 fourth (Memorandum 4) of four technical memorandum deliverables and discusses recommended post closure performance monitoring requirements for AMD impacted waters and closure criteria for these waterways.

- 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 recommendations for CCM post closure monitoring and closure criteria from an AMD management perspective including the North ELF and Tara Catchment consents. This memorandum proposes:

- CCM AMD related consents will require performance monitoring data collection over the closure / post closure period to:
    - Confirm water quality targets have been achieved and compliance monitoring can cease; and
    - Support surrender of consents as targets are consistently met.

North ELF Catchment

- The CC24 site (downstream of the North ELF) water quality has met CRC173823 water quality compliance trigger limits for AMD related effects since construction of the North ELF in mid-2017. Furthermore, the CRC173823 criteria have been met at the CC20 site at the toe of the North ELF since ~2019.

This suggests that once the North ELF is fully rehabilitated an exceedance of CRC173823 water quality criteria at CC24 due to North ELF AMD discharge is unlikely and surrender of North ELF AMD-related water quality consents could be considered at the end of the initial ~12-18 month post closure period.

It is proposed that AMD management in Tara Catchment is split into three phases:

- Operational Phase – this is defined as the phase where active management is being undertaken including the pumping of water and current resource consent related monitoring is ongoing.
- Post closure AMD treatment / management phase – This includes the period where passive treatment of CC02 underdrain discharge is required for combined discharges to meet CRC170541 criteria. The duration of the treatment phase is anticipated to be years to decades (discussed in MWM, 2021c). It is proposed that through this phase an initial period of routine water monitoring coupled with telemeter logging of stage height (i.e., water height) and EC is expected to demonstrate the AMD management system performance. It is proposed that this will be followed by a further time period where water quality sampling (and reporting to the regulator) only occurs when triggered (i.e., routine monitoring may not be required when system performance is monitored by stage height and EC loggers).
- Longer-term AMD management phase – this includes the period when passive treatment is no longer required for combined discharges to meet CRC170541 criteria, where consents can be surrendered and no monitoring is required.

BACKGROUND

The post closure AMD drainage types have been divided into two groups. The groups are based on whether the drainage contains functioning AMD management infrastructure post closure or not. These drainages are described as:

- Potential AMD drainages; and
- Non-AMD drainages.

Potential AMD Drainages

The Potential AMD drainages include infrastructure to control AMD, specifically underdrain networks to collect seepage and convey it to collection ponds for treatment or managed discharge. The two Potential AMD drainages remaining post closure are:

- The North ELF drainage including the components shown in Figure 1 reporting to the North ELF ponds and discharging at CC20 (with compliance measured at CC24); and
- The Tara Pond 1 drainage (shown as 6.56 ha; Figure 1) and the N02 Pit Pond drainage (shown as 12.95 ha in Figure 1) as both discharge above the CRC170541 water quality compliance monitoring site CC02-tele. AMD infrastructure within this drainage includes underdrains reporting to both CC02 and the N02 Pit Pond.

Non-AMD Drainages

The Non-AMD drainages have no AMD or water management structures (other than lined drains) post closure. These drainages will therefore behave naturally with periodic surface runoff during rain events and potentially shallow surficial seepage flow. Once these drainages reach their rehabilitation closure criteria (i.e., for surface vegetated cover) it is anticipated that they will comply with the permitted activity status of the Regional Plan. As such, closure criteria (for AMD) have not been discussed in this memorandum for Non-AMD drainages.

Other CCM water investigation sites are shown in Figure 2 for reference.

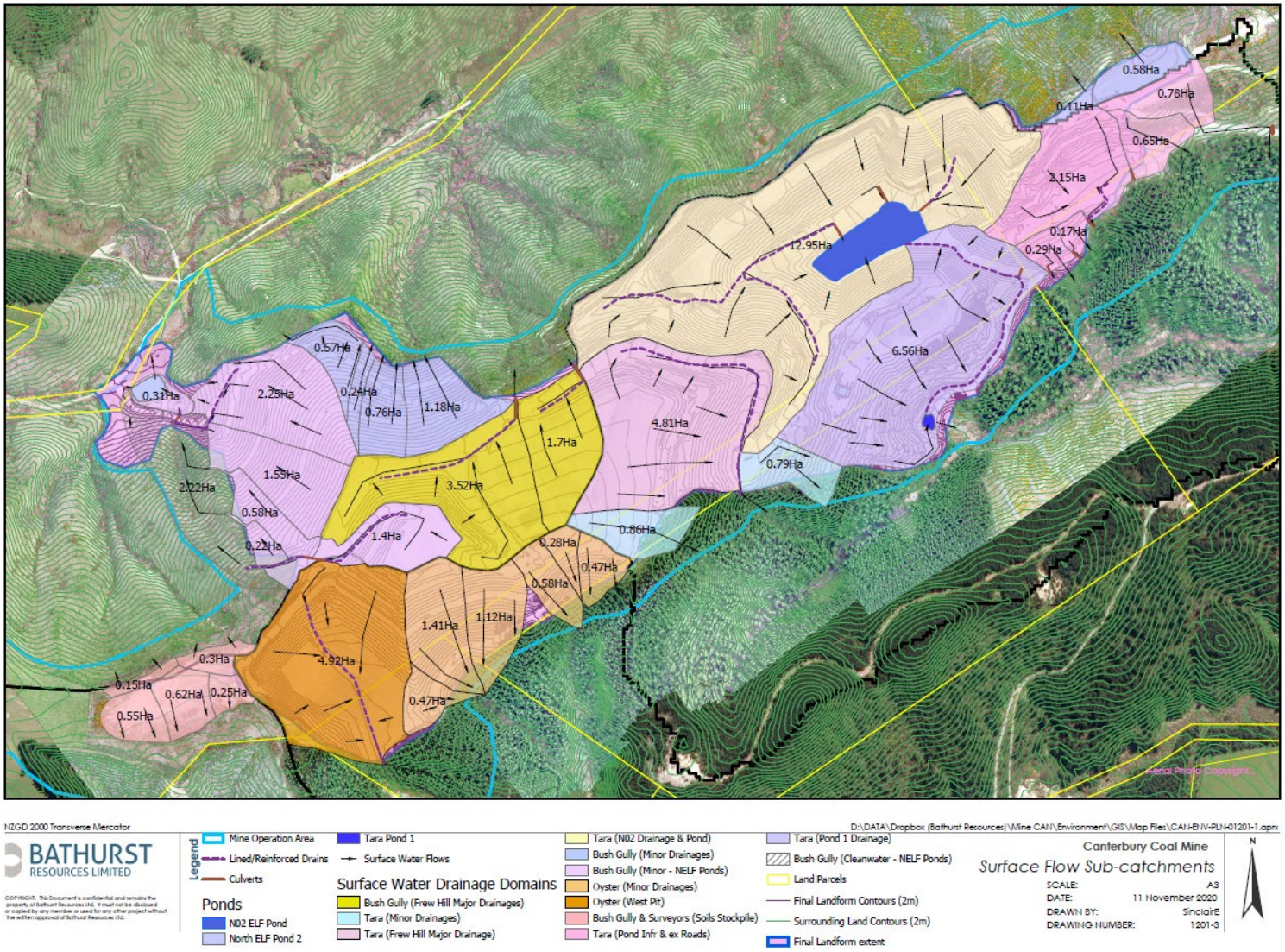

Figure 1. Final landform drainage domain areas.

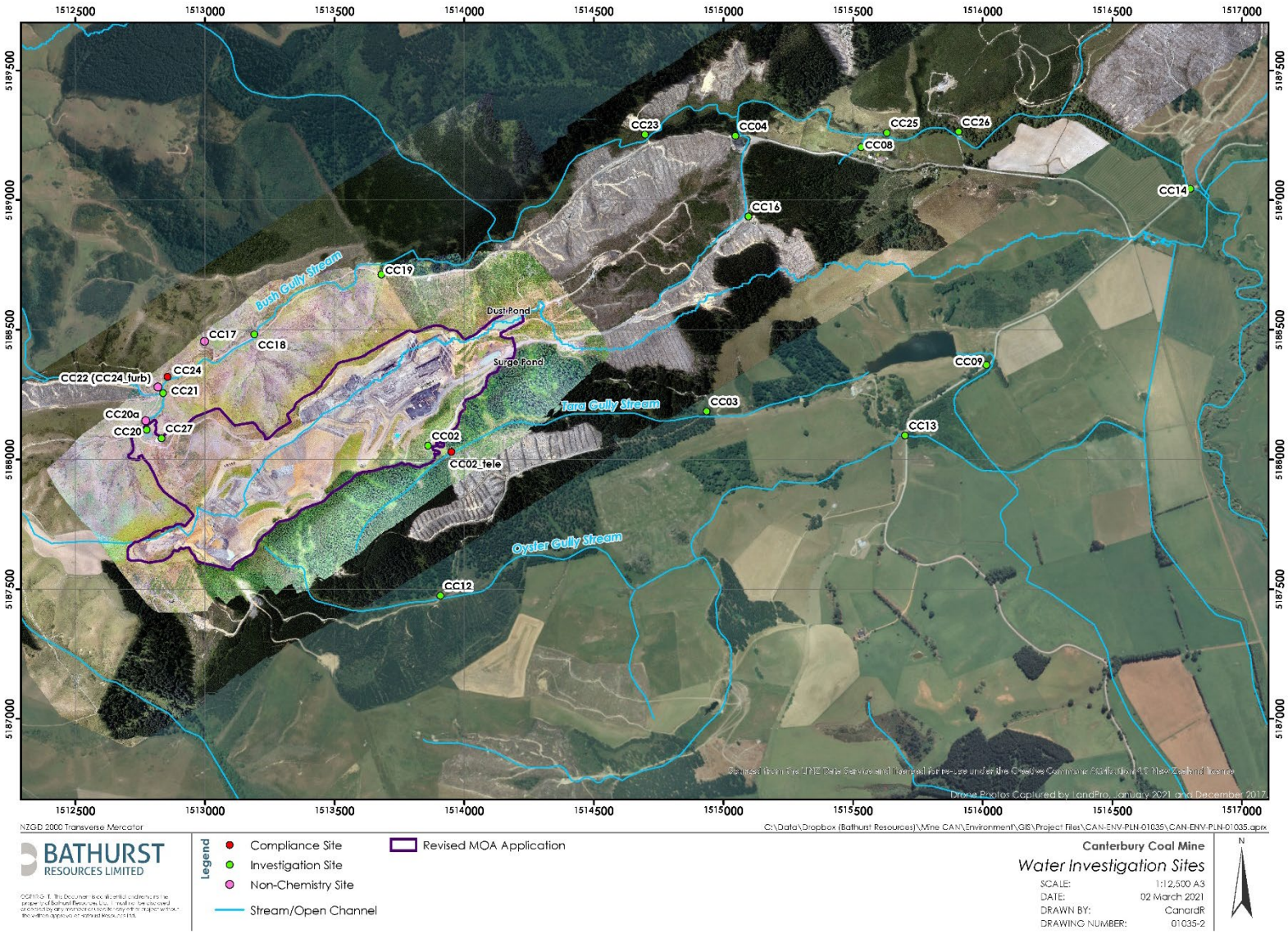

Figure 2. CCM water investigation sites

SCOPE OF WORKS

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

- Propose consent closure criteria (from an AMD perspective) for Bush Gully Stream (CC24 monitoring site); and
- Propose consent closure criteria (from an AMD perspective) for Tara Gully Stream (CC02-tele monitoring site).

A discussion on closure criteria is provided based on demonstrating current resource consent water quality targets are consistently achieved post closure with minimal monitoring.

NORTH ELF CLOSURE CRITERIA

Background

The North ELF underdrain discharge and surface water are currently collected in two settling ponds located at the landform toe. Currently all water discharges the North ELF drainage via Pond 2, which is monitored at site CC20. The CC20 water quality samples are either:

- Collected where the Pond 2 decant / riser water discharge exits the culvert pipe / enters the natural channel below the Pond 2 embankment; or
- When no discharge is occurring, the sample is collected directly from the Pond 2 water surface.

However, as the receiving Bush Gully Stream is considered a continuously flowing water body, the North ELF water quality compliance monitoring site is located at CC24 (~200 m downstream of the CC20 discharge point). The CRC173823 monitoring suite and resource consent compliance limits are summarised in Table 1 for water monitoring site CC24. BCL also undertake continuous monitoring (15-minute intervals) of pH, turbidity, and EC.

Table 1. CRC173823 water quality compliance limits at CC24

Contaminant	Unit	Frequency	Limit
pH	pH	Monthly	6-9*
Turbidity	(NTU)	Monthly	<50 NTU increase from CC22
Boron	(mg/L)	Monthly	1.5**
Manganese	(mg/L)	Monthly	1.9
Nickel	(mg/L)	Monthly	0.011***
Zinc	(mg/L)	Monthly	0.008***
Iron	(mg/L)	Monthly (if pH is <4.5)	1
Aluminium	(mg/L)	Monthly (if pH is <5.5 or >7.5)	0.055
Total Suspended Solids	(mg/L)	Monthly	

** Unless modified in accordance with CRC173823 conditions 30-32; ** Modified in accordance with CRC173823 conditions 24-29 on 3rd February 2020, with compliance assessed on a 3-month rolling average basis; *** Where the compliance limit (ANZECC 95% TV) is modified by the hardness algorithm: HMTV = TV(H/30)$^{0.85}$*

The CC24 water quality monitoring data and a comparison against CRC173823 compliance limits is shown in Figure 3.

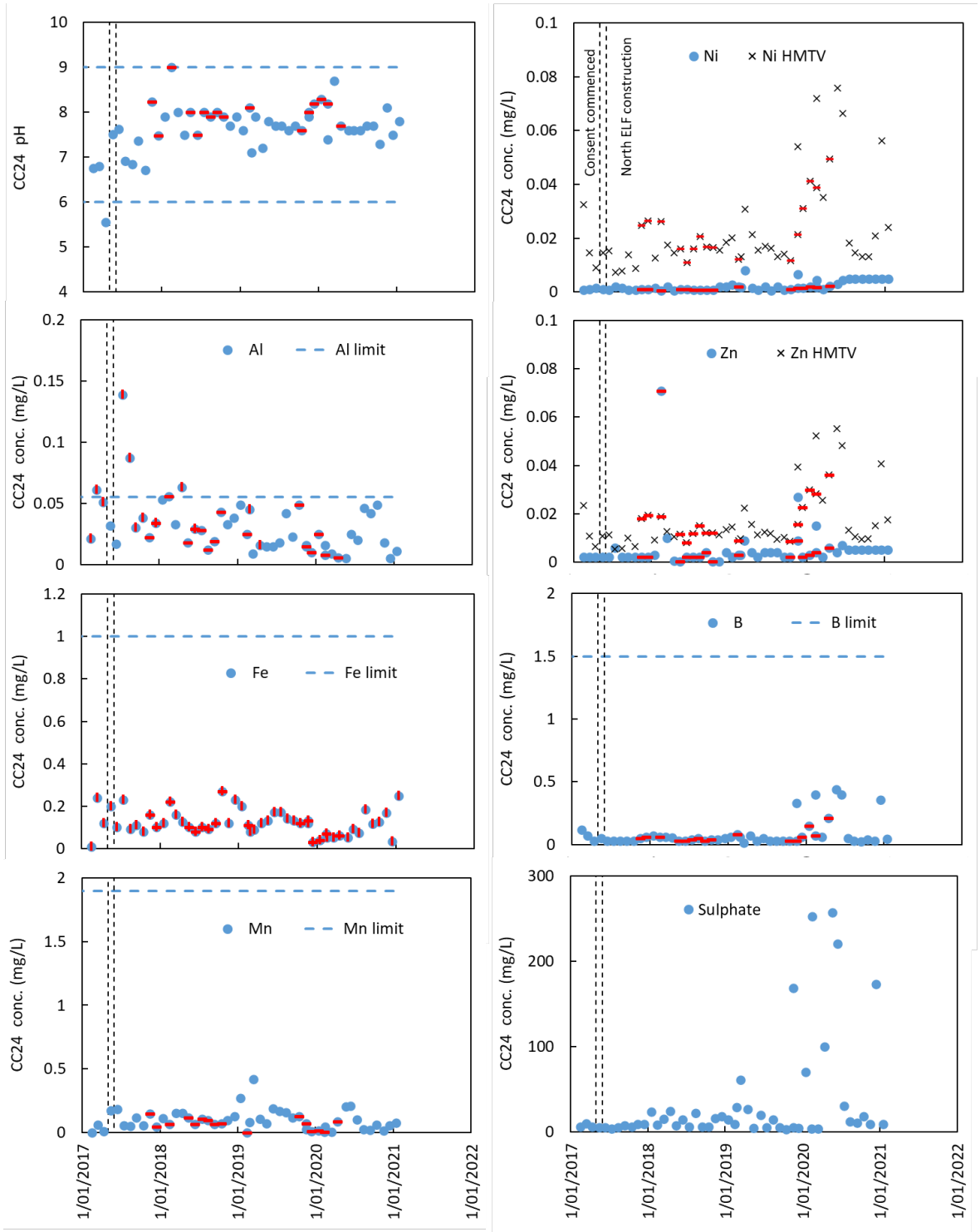

Figure 3. CC24 water quality and CRC173823 compliance limit comparison

Samples from days when the site were not actively discharging are shown with a horizontal red bar (–). Samples from days when pH was outside the ranges for reporting for Fe and Al are shown with a vertical red bar (|).

CC24 discharges have met AMD-related compliance limits since construction of the North ELF in mid-2017. The CC24 boron (B) and sulfate concentrations have been relatively high through 2020, which probably coincides with periods of minimal dilution between CC20 and CC24 (as CC20 concentration have remained similar; Figure 5) and is likely to be amplified by controlled higher flow discharges from

the Pond 2 decant system during periods of low flow in receiving Bush Gully stream (which draws down the water level in preparation for the next rainfall event).

Aluminium concentrations at CC24 are regularly approaching the 0.055 mg/L compliance limit. As CC24 generally exceeds the pH 7.5 cut off (where amphoteric Al may become soluble again), these Al concentrations are reported to the regulator. BRL notes that once closure criteria for total suspended sediment (TSS) is achieved the poly-aluminium chloride (PAC) dosing for sediment control will cease, which is expected to reduce Al concentrations.

Furthermore, the Upper Bush Gully longitudinal survey shows these elevated Al concentrations are unlikely to be completely attributed to discharge from the North ELF. CC24 Al concentrations are either:

- Regularly higher than CC20 Al concentrations (Figure 4), indicating background Al concentrations in the Bush Gully catchment are relatively high compared to compliance limits during some periods; or
- Regularly lower than the CC20 Al concentrations, indicating there is sufficient dilution of CC20 Al loads to meet the CC24 target of 0.055 mg/L during some periods.

As such, the majority of Al concentration data in the CC20 vs CC24 scatter plot (Figure 4) do not plot on the CC20 = CC24 Al line. This suggests that CC20 discharges have a relatively minor influence on CC24 Al concentration.

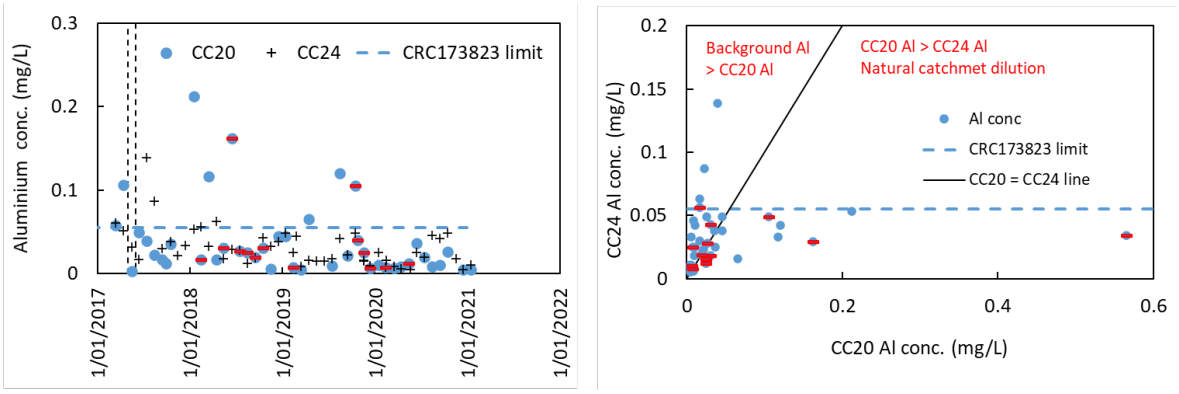

Figure 4. Bush Gully longitudinal survey of Al concentration

The CC20 water quality data has also been reviewed as an indicator of North ELF CRC173823 non-compliance risk. The CC20 North ELF discharge water quality is shown in Figure 5. This dataset shows that the CC20 site has met the CRC173823 water quality criteria for all parameters since ~2019, with the exception of five Zn samples through the most active construction period (year 2018). Since 2019 residual contaminant concentrations have been low. This suggests that once the North ELF is fully rehabilitated CC20 contaminant concentrations are unlikely to exceed CRC173823 compliance limits. As such, a CRC173823 exceedance at CC24 due to North ELF AMD discharge is unlikely.

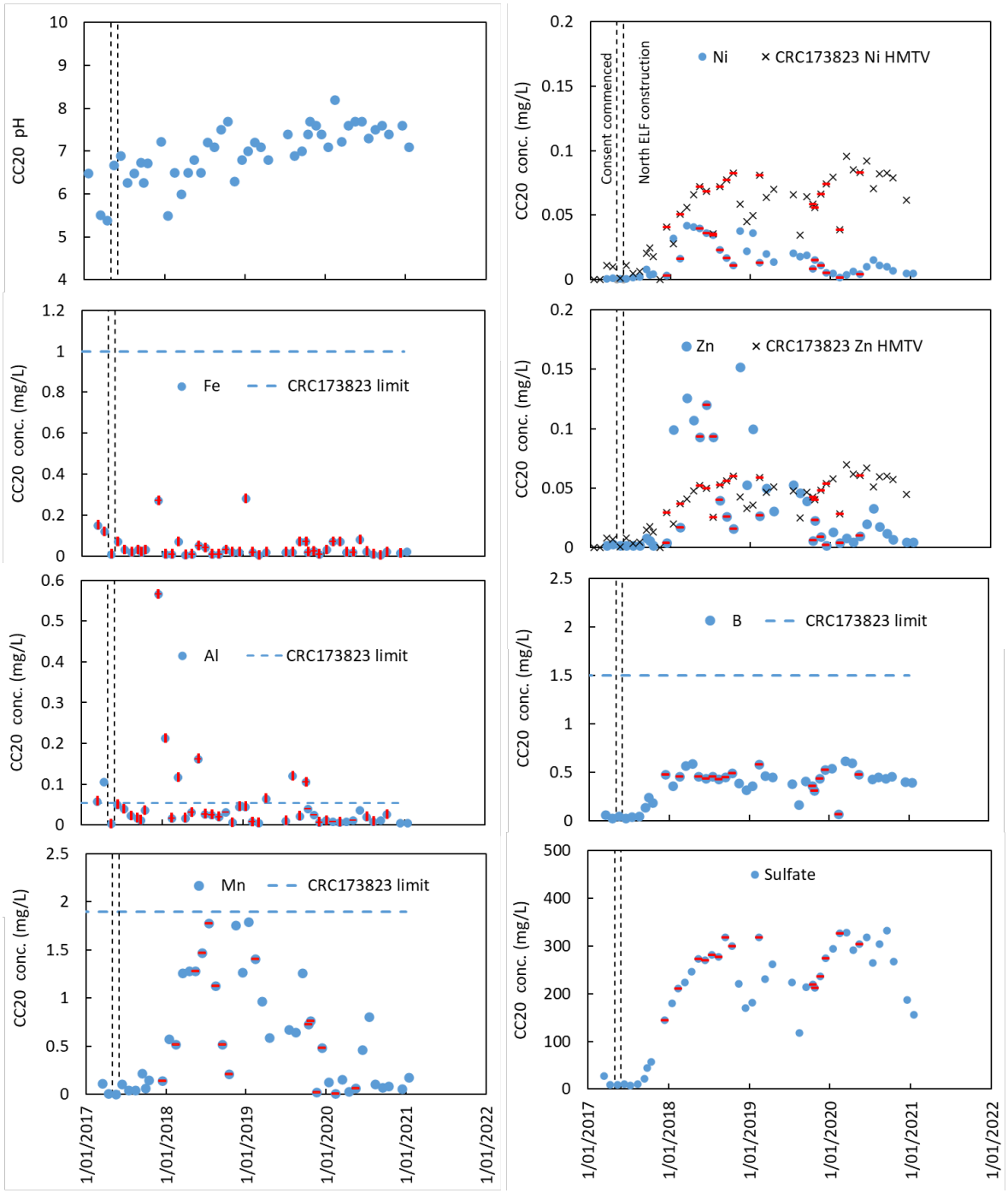

Figure 5. CC20 water quality comparison against CRC173823 limits. 'No-discharge' at CC20 data shown by (–).

North ELF closure criteria

MWM recommend that BCL continue routine performance monitoring for water quality at CC20 and CC24 through the first ~12-18 months of the post closure period. This additional period of monitoring data will provide a total of ~3 years of continuous monitoring data from when the North ELF construction neared completion (post mid 2019).

MWM propose that the AMD related water quality consents could be removed for the North ELF if the ~3 year dataset shows:

- Consistent compliance with CC24 consent conditions;
- No regular ongoing anomalous elevated contaminants at CC24; and
- A plateau or ongoing decreasing trend in CC20 contaminant concentrations.

TARA CATCHMENT CLOSURE CRITERIA

Background

The Tara Catchment discharge monitoring site CC02-tele is located below the Green ELF at the point where the CCM impacted tributary meets the main Tara Gully Stream alignment. The CRC170541 monitoring suite and resource consent compliance limits are summarised in Table 2 for site CC02-tele. BCL also undertake continuous monitoring (15-minute intervals) of pH, turbidity, and EC.

Table 2. CRC170541 water quality compliance limits at CC02-tele

Contaminant	Unit	Frequency	Limit
pH	pH	Monthly	6-9*
Turbidity	(NTU)	Monthly	50 NTU
Boron	(mg/L)	Monthly	1.5**
Manganese	(mg/L)	Monthly	1.9
Nickel	(mg/L)	Monthly	0.011***
Zinc	(mg/L)	Monthly	0.008***
Iron	(mg/L)	Monthly (if pH is <4.5)	1
Aluminium	(mg/L)	Monthly (if pH is <5.5 or >7.5)	0.055
Total Suspended Solids	(mg/L)	Monthly	

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The Tara Catchment discharges are expected to require water treatment / management for years to decades post closure, until contaminant loads decrease such that discharge criteria can be met without treatment. The components required throughout this water treatment / management period include:

- Passive treatment of the continuously flowing CC02 underdrain using a mussel shell reactor with periodic (10 - 20 yearly) maintenance for an expected duration of years to decades post closure (discussed in MWM Memorandum 1 (MWM, 2021a);
- Storage of water in the N02 Pit Pond to provide a constant decanting flow to dilute elevated B concentrations in the CC02 discharge (discussed in MWM Memorandums 2 and 3 (MWM, 2021b; 2021c)); and
- Implementation of other adaptive management options, if required, to maintain compliance (discussed in MWM Memorandum 3; MWM 2021c) including:
    - Use of NaOH dosing for treatment of N02 Pit Pond (primarily to increase N02 Pit Pond pH and decrease Zn concentrations); and

- Vary live storage capacity of N02 Pit Pond by use of a syphon or other means to draw additional diluting flows out of N02 Pit Pond below the free draining decant elevation.

The post closure Tara catchment AMD management could therefore be separated into two phases:

- Post closure AMD treatment / management phase (expected to last a period of years to decades post closure, with a more definitive estimate provided by monitoring data through the initial closure period) with the Tara MSR required for removal of Fe and Zn from CC02 underdrain discharges and N02 Pit Pond dilution of residual B loads discharging the Tara MSR; and
- Longer-term AMD management phase with no ongoing treatment requirements and CRC170541 water quality criteria achieved by N02 Pit Pond dilution of any residual contaminant loads discharging from the CC02 underdrain.

Post closure AMD treatment / management phase

MWM propose that BCL continue routine water quality monitoring at CC02, N02 Pit Pond, and CC02-tele through the first ~12-18 months of the post closure period. This monitoring programme should include:

- Routine monthly water quality monitoring at sites including N02 Pit Pond, Tara Pond 1, MSR influent (sampled from CC02 underdrain pipe outlet), MSR effluent, CC02-tele, and CC03;
- Continuous telemetered monitoring of N02 Pit Pond stage height, pH, and electrical conductivity;
- Continuous telemetered monitoring of Tara Pond 1 stage height, pH, and electrical conductivity;
- Continuous telemetered monitoring of Tara MSR stage height (to identify potential water overtopping); and
- The CC02-tele telemetered monitoring site should also be maintained through this period.

<u>Performance monitoring validation of models</u>

The performance monitoring data collected over the ~12-18-month post closure period will be used to validate the modelled outcomes discussed in Memorandum 3 (MWM, 2021c), specifically confirming:

- The operating Tara MSR provides effective removal of Fe and Zn, sufficient to meet CRC170541 criteria;
- The Tara MSR sludge accumulation rate and effect on stage height (driving head requirements) is consistent with the proposed 10 - 20 yearly desludging frequency;
- Runoff volumes generated from the N02 Pit Pond drainage are sufficient to maintain live storage volumes while decanting at the required rates.;

- N02 Pit Pond water provides effective dilution (when combined with Tara MSR discharge) for combined discharges to meet CRC170541 water quality criteria. Conversely, if N02 Pit Pond water quality is not sufficient through the initial ~12-18-month period, any improving water quality trends would be indicative of when compliance is expected in future; and
- Seasonal trends in both the volume and water quality (measured directly in water samples and indirectly through pH and EC telemeter data) at key sites N02 Pit Pond, Tara Pond 1, Tara MSR, and CC02-tele.

A key outcome of the initial ~12-18-month post closure performance monitoring period will be establishing indirect relationships between telemetered data (particularly stage height and EC) that can be used to identify any issues in the AMD management process (i.e., adaptive management). The telemetered N02 Pit Pond water quality data will be used to validate the modelled outcomes discussed in Memorandum 3 (MWM, 2021c) including:

- Stage height data – to show the live storage response to different intensity rain events and non-rain event storage change (possibly due to seepage gain, seepage loss, evaporation, decant discharge, etc.). This will demonstrate the likelihood of decant discharge ceasing and could be used to trigger activation of adaptive management options. A stage height versus discharge flow calibration curve (using manually measured flow gauging data) will also be developed to quantify N02 Pit Pond discharge flow rates for a given stage height.
- Electrical conductivity (EC) data – to show general trends in EC and identify peaks during dry periods that may not be represented in the monthly manual measurement dataset (if sampling does not coincide with the peak EC measurements). The N02 Pit Pond EC is likely to be a good indicator of B concentration, as shown by CC20 data in Figure 6. It may therefore be possible to use EC as a trigger for adaptive management if N02 Pit Pond dilution becomes ineffective.

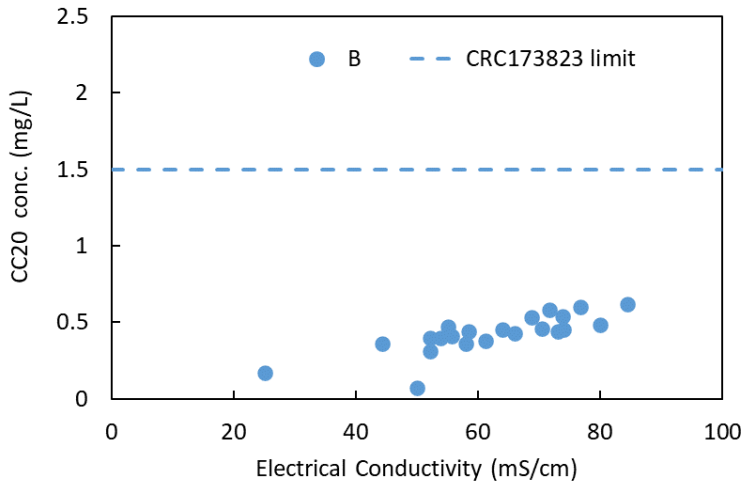

Figure 6. CC20 correlation between EC and B concentration

- pH data – to show general trends in pH and identify periods where NaOH dosing may be required. The N02 Pit Pond pH is likely to be a good indicator of Zn concentration and compliance against the hardness modified Zn criteria. The pH versus Zn concentration and

hardness modified Zn trigger values for CC20 is shown in Figure 7. BCL experience shows pH monitoring sondes can be unreliable in neutral pH environments and when regular calibration is not possible. If monitoring data indicate the N02 Pit Pond Zn concentration is a low risk of not achieving CRC170541 criteria then pH will not be adopted as a trigger for AMD management.

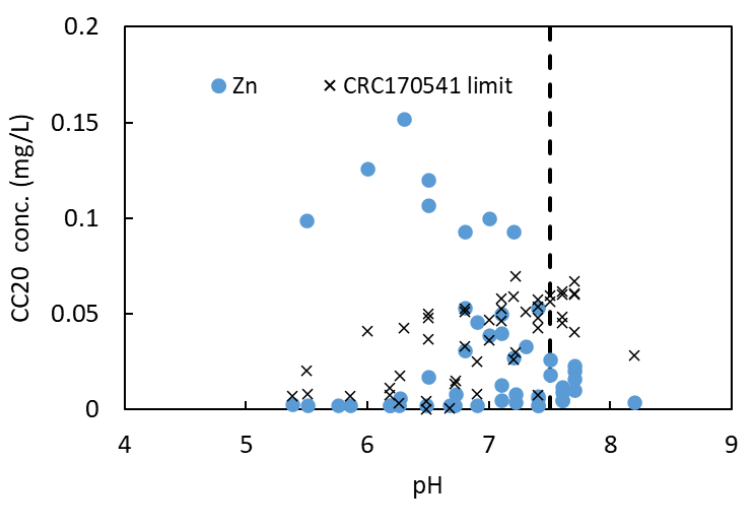

Figure 7. CC20 Zn concentration versus pH

Duplicating these telemetered datasets down at the Tara Pond 1 site will allow for a comparison of N02 Pit Pond outflow and Tara Pond 1 discharge characteristics. This will identify any changes to water quality between the N02 Pit Pond spillway and Tara Pond 1 (i.e., due to addition of any potential seepages or surface runoff flows from the Green ELF/box cut drainage). Also, the Tara Pond 1 Stage height (and corresponding discharge flow) are likely to be more representative of the actual diluting flow available to combine with Tara MSR outlet flows at the CCM discharge point.

Development of telemetered triggers

As BCL compile performance monitoring data, a series of N02 Pit Pond specific triggers (linked to telemetered data) should be developed with appropriate AMD management responses (i.e., TARPs). Using the CC20 data as an example, these triggers are likely to include:

- Stage height logger with alert if N02 Pit Pond water level is trending towards the decant level (323.5 mRL design) and N02 Pit Pond discharge ceases / falls below the expected decant flow rate – alert to trigger management options;
- A second stage height logger with alert if Tara Pond 1 water level falls below the expected dilution flow rate level;
- Electrical conductivity logger with an alert if N02 Pit Pond EC reaches a threshold where the boron concentration is elevated such that consent conditions could be exceeded. This TARP needs to be developed during closure activities using suitable geochemical relationships (e.g., CE versus B).
- pH logger (if the logger provides a reliable pH record with infrequent maintenance) with alert if N02 Pit Pond pH falls below the threshold where residual Zn concentration could

exceed the hardness modified trigger value (e.g., when pH decreases below ~ 7.5 in Figure 7 – alert to trigger NaOH dosing of the N02 Pit Pond to control decant Zn concentration).

It may be possible to develop similar telemetered EC and pH for Tara Pond 1. However, the additional variability in these parameters at Tara Pond 1 due to Green ELF surface runoff flows is likely to make these triggers less reliable over a wide range of flow conditions.

As these data are compiled BCL will be able to demonstrate the hypothetical effectiveness that implementation of these triggers and responses would have on compliance at CC02-tele. This will allow for refinement of the trigger values and also provide an indication of how often the post closure AMD management system is operating as expected versus significant variance and the need for TARP conditions.

Throughout this period, it will be critical to note changes to site water management that may affect the contaminant concentration, flow rate, and contaminant loads reporting to the CCM discharge. Specific milestones will include:

- Commissioning of the Tara MSR with B dilution flows likely to be provided from the Malvern Hills Scheme prior to N02 Pit Pond water quality being available for dilution;
- Rehabilitated surfaces meeting closure criteria with surface runoff diverted into natural runoff pathways as opposed to directed into N02 Pit Pond for sediment management; and
- Establishment of the fully operational Tara MSR and N02 Pit Pond diluting flow, as per the Post Closure AMD management plan.

These transitions may interrupt data trends requiring further interpretation or modification of the Post Closure AMD management plan.

<u>Post Closure AMD treatment / management phase resource consent parameter suite</u>

The resource consent parameter suite prescribed in CRC170541 is considered appropriate during the post closure AMD treatment / management phase. However, the frequency and type of Post Closure water monitoring should be decreased to align with TARP requirements, once they have been developed. This process is expected to involve:

- A change in type of telemetered sondes required from EC, pH, and Turbidity to EC and flow
- Ongoing routine (monthly) monitoring over the initial ~12-18-month post closure period or until CRC170541 conditions are consistently met under the proposed Post Closure AMD management plan; and
- Ongoing monitoring of key water bodies (e.g., N02 Pit Pond, Tara Pond 1, MSR influent (sampled from CC02 underdrain pipe outlet), MSR effluent, and CC03), as required, until:
    - Reliable and defensible correlations can be developed between system performance (e.g., water quality, diluting flow volumes, etc) and telemeter triggers; or
    - Monitoring data show contaminant concentration trends are not anomalous, have stabilised, or are on a regular downwards trend.

Once sufficient data has been compiled to show consistent compliance and that the various triggers are fairly representing the potential to monitor for non-compliance, the requirement for routine monthly water quality monitoring could be reduced or removed, perhaps in a staged manner.

Further compliance monitoring would occur when triggered by the various telemetered installations (i.e., TARPs). This has the benefit of focussing compliance monitoring on periods when non-compliance risk is highest (e.g., probably during prolonged dry periods) and reduces the cost and volume of monitoring data produced through periods when non-compliance risk is lowest.

The TARP process will be refined over the first ~12-18-months post closure as monitoring data sets become more comprehensive. However, the trigger process is likely to involve:

- Trigger alert sent to the consent holder;
- Site visit by consent holder (or representative) within a specified time frame to confirm a genuine trigger event or re-calibration of instruments required;
- If a genuine trigger has occurred (as validated by manual measurements / site inspection) then sampling at CC02-tele would be triggered; and
- Targeted sampling of affected waterbodies (NB: it may not be necessary to sample all waterbodies) to determine the cause of non-compliance.

LONGER-TERM AMD MANAGEMENT PHASE

The CC02 underdrain contaminant load is expected to define the treatment duration for the Tara MSR. Once the CC02 underdrain contaminant load decreases such that Zn and B compliance can be achieved by dilution from the N02 Pit Pond only, the Tara MSR treatment of CC02 underdrain can cease. Memorandum 3 (MWM 2021c) estimate the CC02 Zn load would have to decrease by 38% from the currently modelled 'low flow' load for N02 Pit Pond dilution at 0.48 L/s to be sufficient for combined discharge to meet CRC170541 water quality criteria. Removal of the Tara MSR will be supported by performance monitoring data demonstrating the AMD management effectiveness.

CRC170541

The CRC170541 discharge permit expires in January 2032. A discussion is included in Memorandum 3 (MWM 2021c) on factors influencing whether the Tara MSR will be required beyond 2032. Performance monitoring data over the initial ~12-18 months post closure will support definition of the required treatment duration.

RECOMMENDATIONS

To advance the AMD consent surrender component of closure preparations, MWM recommend:

- Consider staged surrender of drainages that achieve closure criteria.
- Installing additional telemeter monitoring stations (Tara Pond 1, N02 Pit Pond, and Tara MSR) as soon as practicable to maximise the overlap of routine (monthly) monitoring data and telemeter data records;

- As various sites reach their closure state undertake additional water quality sampling if high EC periods occur. This will increase the range of EC versus contaminant concentration relationships that can be used in the TARP; and
- Develop TARPs for AMD management Post Closure, including transitions to the telemeter triggered monitoring and reduced monitoring phases.

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. Key AMD risks 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). An adaptive management plan should be developed for mine closure using the proposed performance monitoring processes discussed in this memorandum.

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MWM, 2021c. Canterbury Coal Mine Closure (Memorandum 3) – Tara catchment discharge water quality. Memorandum produced for Bathurst Coal Limited by Mine Waste Management Limited. 19 March 2021. Report No. J-NZ0130-004-M-Rev0.