MINE WASTE MANAGEMENT

Unit 7, 41 Sir William Pickering Drive,
PO Box 8040, Riccarton 8440,
Christchurch, New Zealand
T. +64 (0)3 242 0221
E. admin@minewaste.com.au

MEMORANDUM 3

Recipient:	Eden Sinclair – BCL
From:	Paul Weber – MWM
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Cc:	Campbell Robertson – BCL, Phil Lindsay – BCL, Will Olds – MWM
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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.

The post closure Tara Gully catchment will be a combination of two continuously discharging water sources that are affected by AMD including the CC02 underdrain and the proposed N02 Pit Pond (discharging via Tara Pond). These two waters combine at a mixing point below the Tara Pond spillway forming a single discharge. This memorandum compares the expected water quality, flow rate, and contaminant loads in the combined discharge. Different scenarios are analysed to compare combined discharge water quality to CRC170541 trigger values. Most of the modelled scenarios focus on the critical low flow periods where the risk of discharge contaminant concentrations exceeding the CRC170541 trigger values is expected to be greatest. Aside from these critical low flow periods, which have management options available, the combined CCM discharge is expected to meet CRC170541 trigger values.

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 mine closure AEE. This is the third (Memorandum 3) of four technical memorandum deliverables and discusses the water quality of combined discharge from Tara Pond 1 and the Tara Mussel Shell Reactor (MSR). The four deliverables discuss:

- Memorandum 1: The Tara MSR treatment system;
- 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 estimated Tara catchment discharge water quality, which is based on the combined CC02 / Tara MSR and N02 Pit Pond discharge water quality, flow rate, and contaminant loads. This memorandum establishes:

- A range of different CC02, Tara MSR, clean water, and N02 Pit Pond discharge water quality and flow rate scenarios and the expected effect on combined CCM discharge water quality meeting CRC170541 water quality criteria under low flow conditions.
- Low flow conditions are the focus of this memorandum, to understand potential failure mechanisms and where compliance limits have a higher probability of being exceeded.
- Model results indicate that at this stage:
    - Tara MSR treatment of CC02 underdrain flows (to remove Fe and Zn), and
    - Dilution with N02 Pit Pond decant flows (to dilute B),

  are required for combined CCM discharge to meet CRC170541 water quality criteria.
- Compliance against CRC170541 water quality criteria without the Tara MSR is anticipated sometime in the post closure phase.
- From a simple rational method runoff model, the Scenario 7 decant rate of 0.48 L/s is considered a reasonable nominal maximum N02 Pit Pond diluting flow capacity, where the frequency of modelled zero decant days is relatively low (modelled at 1.3% of the time) in the context of dilution requirements for the Tara MSR discharge to meet CRC170541 water quality criteria. Higher decant rates are unlikely to be sustainable (with live storage capacity exhausted regularly).
- Based on current (2020) trends in CC02 underdrain contaminant loads it is anticipated that a N02 Pit Pond discharge flow rate of <0.48 L/s could be sufficient at times for CCM discharges to meet CRC170541 compliance limits during low flow conditions while the Tara MSR is operational. However, it is proposed the required post closure N02 Pit Pond decant rate (and effect on storage capacity) will be determined over the closure / post closure period as performance monitoring data becomes available.
- The Tara Gully treated AMD discharge consent (CRC170541) expires in 2032. Performance monitoring data over the initial the ~12-18 months post closure will provide data for estimating the required treatment duration.
- CC02 monitoring data demonstrate a decreasing Zn load trend with time that is attributed to best practicable AMD management on-site. Factoring in the anticipated 0.48 L/s diluting flow provided by the N02 Pit Pond decant a further 38% decrease in CC02 Zn load would be required for CCM combined discharge Zn concentrations to meet CRC170541 compliance limits without MSR treatment (after hardness modification). This CC02 Zn load decay is expected to occur over a treatment period of years to decades post closure.

Performance monitoring data collected over the remaining life of mine and into the post closure period (~12-18 months) will provide a more representative basis for forecasting the required treatment duration.

- Available coal combustion residue (CCR) and CCR / blended waste rock monitoring data (which have been compared to Class B landfill disposal criteria) show that boron is the key contaminant of concern associated with CCR disposal at CCM.
- The current effects of blended CCR and waste rock disposal on leachate chemistry in the Tara Catchment is demonstrated by monitoring data. No additional monitoring is practicable to specifically demonstrate CCR effects. Longitudinal survey water quality data for Tara Gully (CC02-tele, CC03, and CC09 - Figure 10) show that boron concentrations decrease downstream of the controlled mine water discharge points.

BACKGROUND

The post closure Tara Gully catchment will be a combination of two continuously discharging water sources, the CC02 underdrain (discharging via the Tara MSR) and the proposed N02 Pit Pond (discharging via Tara Pond). These two waters combine at a mixing point below the Tara Pond spillway forming a single discharge. The objective or goal to ensure ‘a continuous low flow that would be expected from an unmined catchment’ (equivalent to a minimum annual low flow (MALF)) through the Tara wetland can be met coincidentally by:

- The need to continuously discharge CC02 underdrain / Tara MSR water (due to a lack of feasible storage capacity in the natural channel below the CC02 underdrain); and
- The need to simultaneously discharge a diluting flow from the N02 Pit Pond, such that the combined Tara MSR discharge and N02 Pit Pond water quality meets the CRC170541 water quality criteria.

BCL advise that the diluting base flow from N02 Pit Pond will be provided by a decanting pipe (or pipes) installed in the N02 Pit Pond Spillway structure. The decanting pipe will allow the N02 Pit Pond water level to be drawn down by 0.5 m below the spillway elevation and provides a design live storage volume of 3,743 m^3. During high flow conditions (and once the live storage capacity is exceeded) excess flows will overtop the spillway and be conveyed down to the Tara Catchment discharge point via the proposed Boxcut drain and Tara drain system (Figure 1).

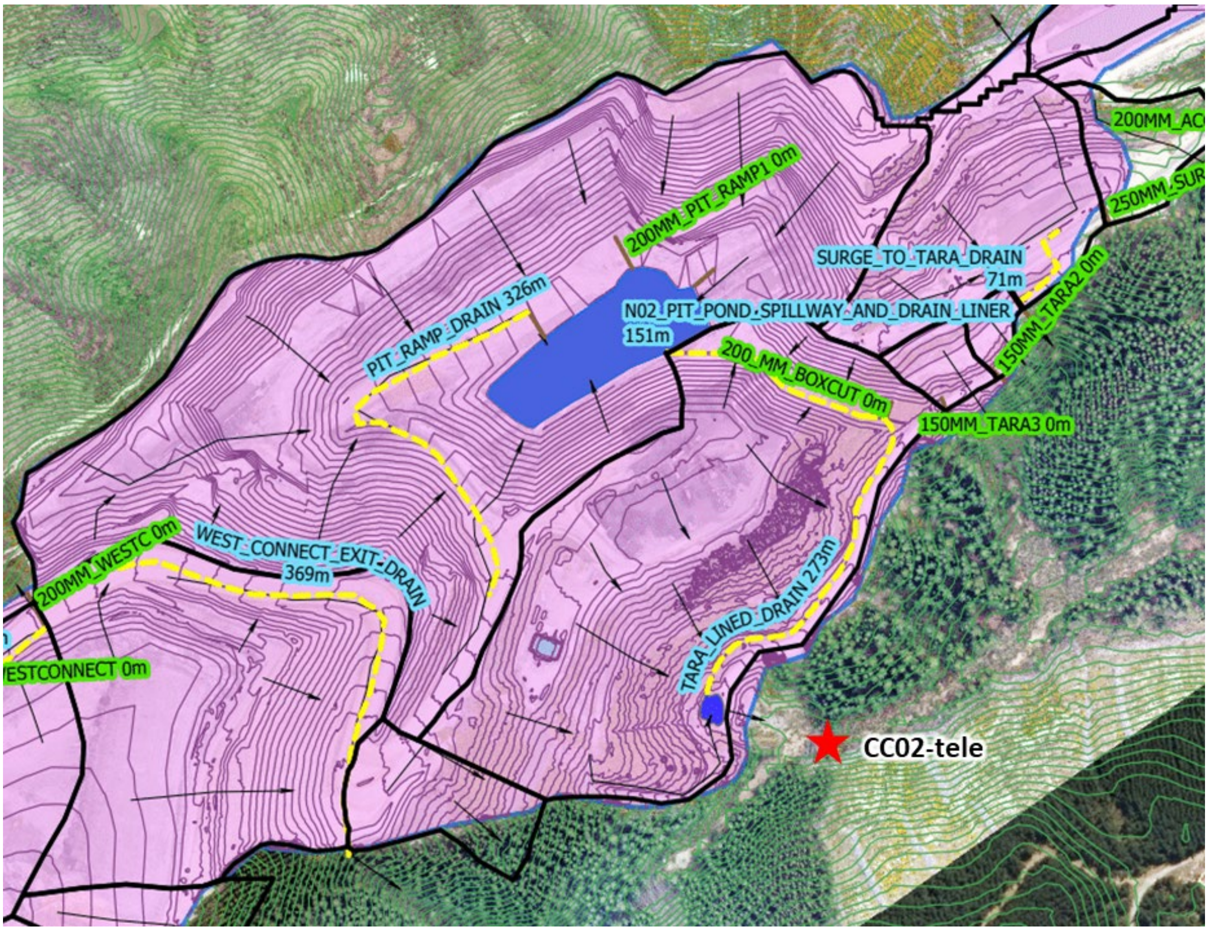

Figure 1. N02 Pit Pond drainage and drainage channels

The water quality and flow rate of the two continuously discharging water sources is critical to determining whether the combined discharges will meet resource consent compliance criteria post closure. Water quality has previously been derived for the water sources for a range of flow conditions:

- Tara MSR discharge water quality (treating the CC02 underdrain flow) was derived in Memorandum 1 (MWM, 2021a); and
- N02 Pit Pond discharge water quality for a range of flow conditions was derived in Memorandum 2 (MWM, 2021b).

Any additional water quality estimates for a given flow condition are derived within this memorandum.

The 6.56 ha 'Green Engineered Landform (ELF) / Boxcut' drainage (shown in Figure 2) located below the N02 Pit Pond discharge point will provide intermittent surface runoff flows to Tara Pond 1. These surface flows are expected to provide further dilution of Tara Catchment discharges but have not been incorporated into the discharge water quality assessment. The Green ELF / Boxcut drainage discharge during the critical low flow periods are expected to be negligible, therefore having no effect on overall compliance / non-compliance risk and are not considered further in this assessment.

Other CCM water investigation sites are shown in Figure 3 for reference.

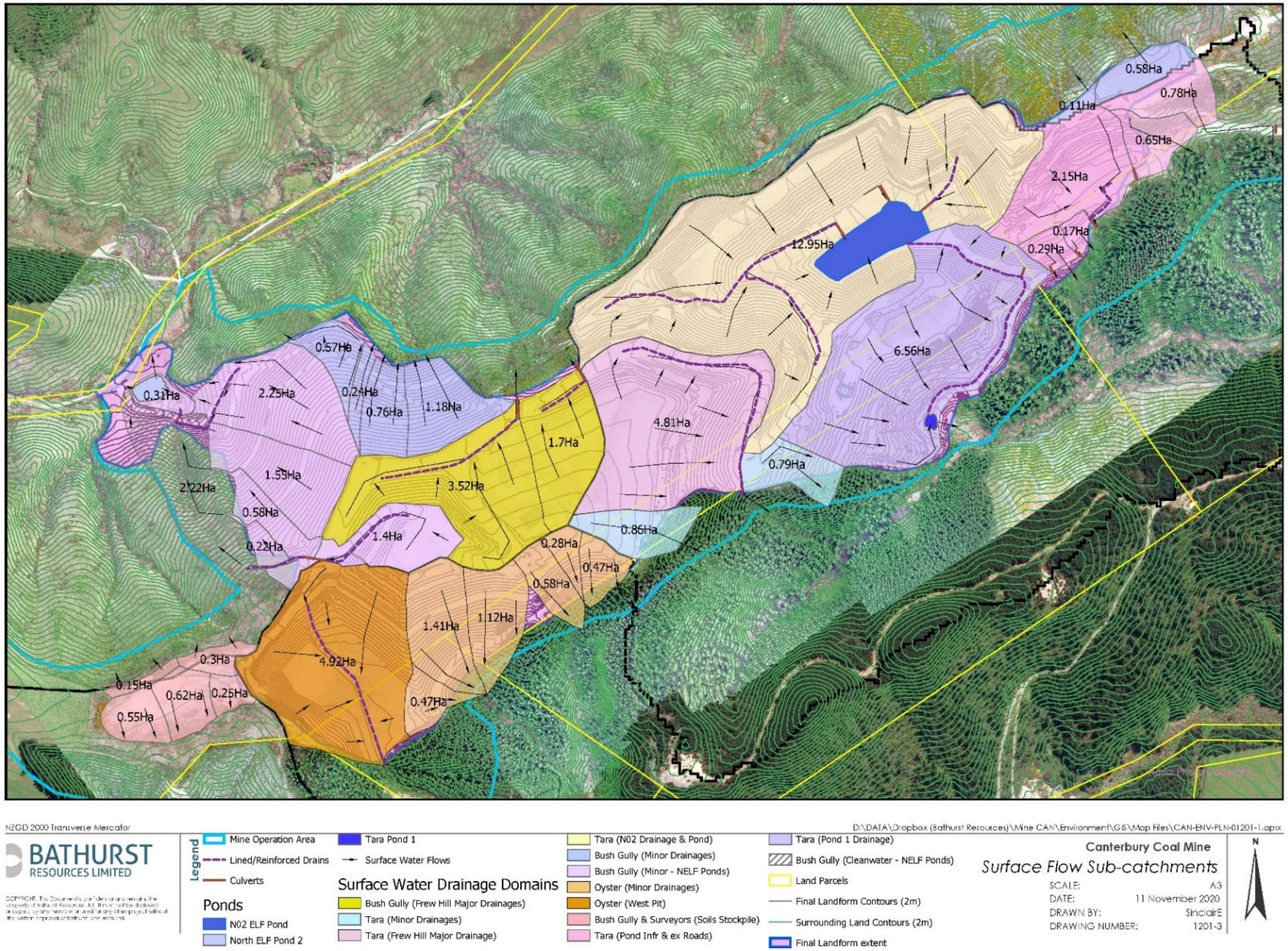

Figure 2. Post closure surface water drainage domains

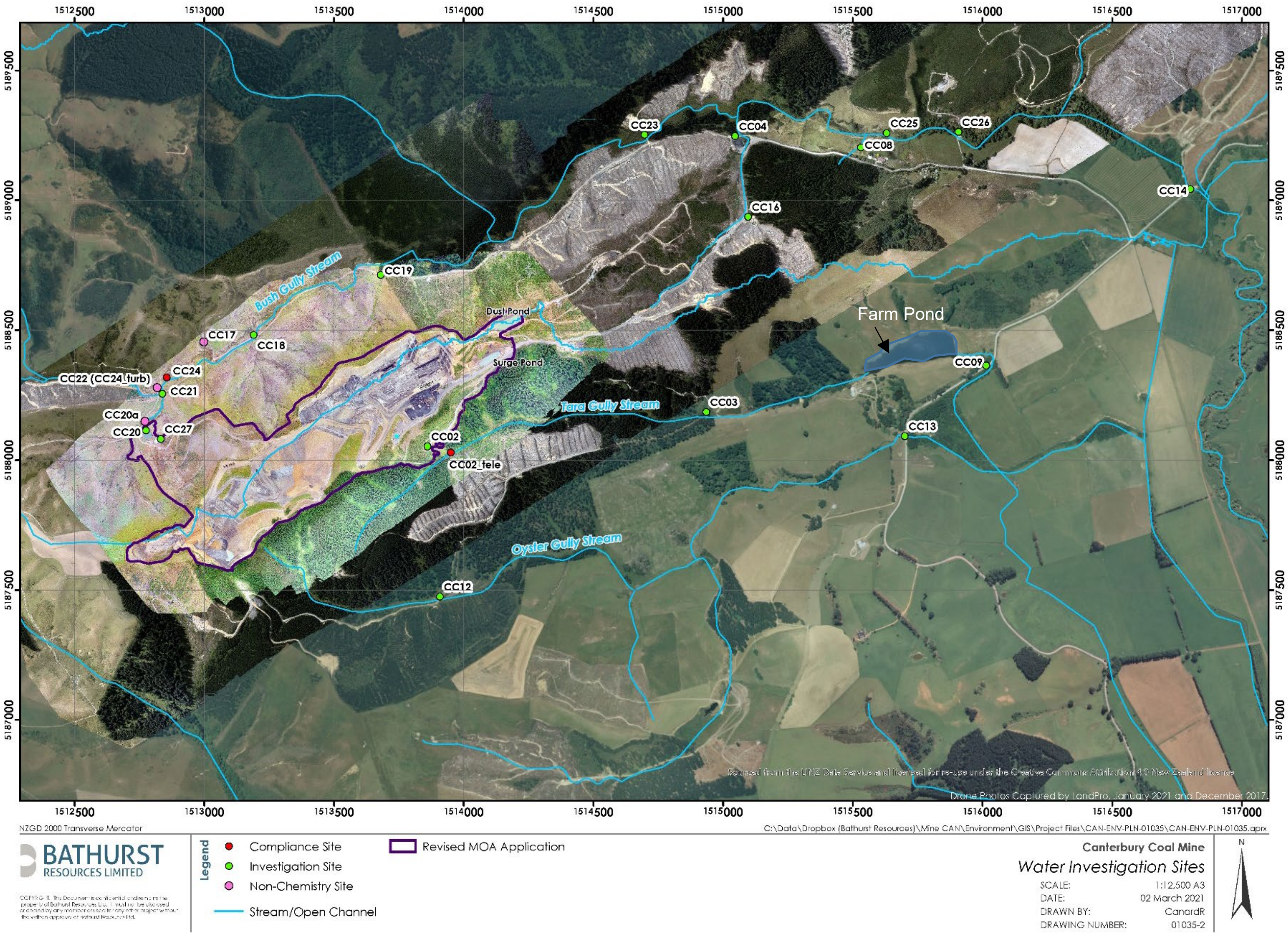

Figure 3. CCM water investigation sites.

SCOPE OF WORKS

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

- Derive / specify flow rate terms for key water sources at different flow conditions;
- Specify water quality and contaminant load terms for key water sources at different flow conditions;
- Provide expectations on duration of passive treatment requirements; and
- Provide comment on CCR / ash derived leachate post closure.

WATER MANAGEMENT SCENARIOS

A number of modelling scenarios have been developed for the CC02 underdrain and N02 Pit Pond. Low flow conditions are the focus of this memorandum as this is when compliance limits are more likely to be exceeded.

These scenarios relate to different combinations of CC02, Tara MSR, clean water, and N02 Pit Pond discharge scenarios. The scenarios incorporating 'clean water' assume BCL utilise the 20 units (i.e., 20 m^3/d) of water currently available through the Malvern Hills Water Scheme (drinking water supply) as an effectively contaminant free clean water source for dilution during prolonged dry periods during the active closure period. The model scenarios are summarised in Table 1 and described below providing a range of model scenarios:

1. **Low flow (CC02 untreated, undiluted)**
    - equivalent to CC02 underdrain discharge at 10th percentile flow (0.076 L/s) determined over the 2019/20 period.
    - coincidentally approximately equivalent to meeting the 0.08 L/s MALF7d flow rate (Chater, 2020) for the CCM disturbed footprint in Tara Gully.
    - this scenario assumes no treatment through Tara MSR and no diluting flow from N02 Pit Pond or clean water sources.
2. **Low flow (CC02 untreated, clean water diluted @ 0.11 L/s)**
    - equivalent to CC02 underdrain discharge at 10th percentile flow (0.076 L/s) determined over the 2019/20 period, diluted by a 0.11 L/s clean water flow rate.
    - this scenario assumes no treatment through Tara MSR and the CC02 flow is diluted by a clean water source (0.11 L/s), as required for combined discharge to meet the CRC 150741 B concentration limit of 1.5 mg/L.
3. **Low flow (CC02 untreated, N02 Pit Pond diluted @ 0.78 L/s)**
    - equivalent to CC02 underdrain discharge at 10th percentile flow (0.076 L/s) determined over the 2019/20 period, diluted by a 0.78 L/s N02 Pit Pond water flow rate.

- this scenario assumes no treatment through Tara MSR and the CC02 flow is diluted by a N02 Pit Pond water as required for combined discharge to meet the hardness modified CRC150741 Zn concentration limit.

4. **Low flow (CC02 treated, undiluted)**
    - equivalent to CC02 underdrain discharge at 10th percentile flow (0.076 L/s) determined over the 2019/20 period.
    - this scenario assumes CC02 discharge is treated by the Tara MSR (for Fe and Zn removal) but there is no diluting flow from N02 Pit Pond or clean water sources.
5. **Low flow (CC02 treated, clean water diluted @ 0.11 L/s)**
    - equivalent to CC02 underdrain discharge at 10th percentile flow (0.076 L/s) determined over the 2019/20 period, diluted by a 0.11 L/s clean water flow rate.
    - this scenario assumes CC02 discharge is treated by the Tara MSR (for Fe and Zn removal) and the MSR discharge is diluted by a clean water source (0.11 L/s) as required for combined discharge to meet the CRC150741 B concentration limit of 1.5 mg/L.
6. **Low flow (CC02 treated, N02 Pit Pond diluted @ 0.18 L/s)**
    - equivalent to CC02 underdrain discharge at 10th percentile flow (0.076 L/s) determined over the 2019/20 period, diluted by a 0.18 L/s N02 Pit Pond flow rate.
    - this scenario assumes CC02 discharge is treated by the Tara MSR (for Fe and Zn removal) and the MSR discharge is diluted by N02 Pit Pond water (0.18 L/s) as required for combined discharge to meet the CRC150741 B concentration limit of 1.5 mg/L.
7. **MSR design flow (CC02 treated, N02 Pit Pond diluted @ 0.48 L/s)**
    - equivalent to the nominal Tara MSR design discharge rate (0.2 L/s) diluted by a 0.48 L/s N02 flow rate.
    - this scenario assumes CC02 discharge is treated by the Tara MSR (for Fe and Zn removal) and the MSR discharge is diluted by N02 Pit Pond water as required for combined discharge to meet the CRC150741 B concentration limit of 1.5 mg/L.
    - this scenario does not consider possible additional flows contributed by surface runoff from the Green ELF / Boxcut drainages.
8. **High flow (CC02 treated, N02 Pit Pond diluted @ 10 L/s)**
    - equivalent to Tara MSR design discharge rate (0.2 L/s) diluted by high N02 Pit Pond discharge rates including spillway flows (nominally 10 L/s).
    - this scenario does not consider possible additional flows contributed by surface runoff from the Green ELF / Boxcut drainages.

Table 1: Tara catchment discharge flow rates

Model No.	Scenario	CC02 underdrain (untreated)	Tara MSR (treated)	Clean water dilution	N02 Pit Pond	Combined Tara discharge
		(L/s)	(L/s)	(L/s)	(L/s)	(L/s)
1	Low flow (CC02 untreated, undiluted)	0.076	-	-	-	0.076
2	Low flow (CC02 untreated, C/W diluted @ 0.11 L/s)	0.076	-	0.11	-	0.18
3	Low flow (CC02 untreated, N02 Pit Pond diluted @ 0.78 L/s)	0.076	-	-	0.78	0.86
4	Low flow (CC02 treated, undiluted)	-	0.076	-	-	0.076
5	Low flow (CC02 treated, C/W diluted @ 0.11 L/s)	-	0.076	0.11	-	0.18
6	Low flow (CC02 treated, N02 Pit Pond diluted @ 0.18 L/s)	-	0.076	-	0.18	0.26
7	MSR design flow (CC02 treated, N02 Pit Pond diluted @ 0.48 L/s)	-	0.2	-	0.48	0.68
8	High flow (CC02 treated, N02 Pit Pond diluted @ 10 L/s)	-	0.2	-	10	10.2

N02 PIT POND WATER BALANCE

A probabilistic water balance model has not been undertaken for the CCM post closure. However, a sensitivity analysis on N02 Pit Pond live storage volume (and therefore decantable storage volume) has been undertaken. This analysis uses a deterministic assessment of N02 Pit Pond surface water inflows, outflows, and changes to live storage volumes calculated on a daily timestep.

Modelled water outflows are representative of flow discharge through a decant pipe (or pipes) installed 0.5 m below the spillway crest. The final decant configuration is yet to be finalised, however BRL indicate that it is likely that a series of ~40 mm diameter fixed decants pipes will be installed through the spillway wall 0.5 m below the spillway crest. This will allow for spillway pipes to be opened and closed to provide some flow regulation capacity.

Modelled water inflows are based on a simple runoff calculation using the rational method:

$$Q = CiA$$

Where, Q = runoff flow rate / volume

C = runoff coefficient

i = rainfall intensity

A = Catchment surface area

The purpose of this sensitivity analysis is to determine the utilisation of the live storage zone. This includes assessing the likelihood of the rainfall frequency and live storage capacity being sufficient to maintain decant discharge rates at the ~0.48 L/s (Equivalent to Scenario 7 in Table 1) required for dilution of the design Tara (treated) MSR discharge B load. The sensitivity analysis tests the following assumptions:

- At full capacity the 3,743 m^3 live storage volume is sufficient to provide approximately 90 days of diluting flows at a rate of 0.48 L/s.
- Runoff volumes are calculated using the Whitecliffs Station daily rainfall record (ECan Station 315910), which includes measurements back to the year 1988. A comparison (Figure 4) of the Whitecliffs rainfall record against the on-site CCM weather station record (available from February 2018) showed a good correlation. Thus, the Whitecliffs rainfall record is assumed to be representative of rainfall depths and seasonal variability at CCM.

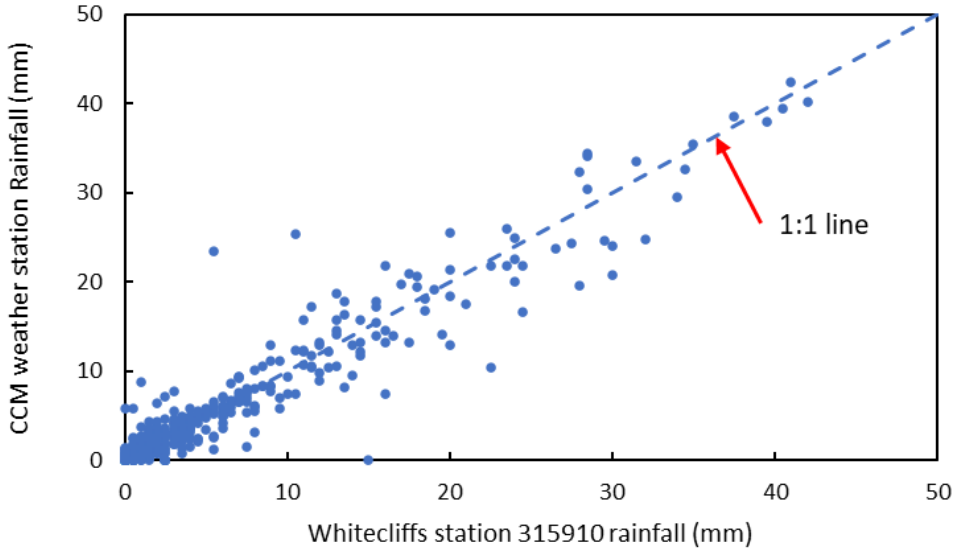

Figure 4. Comparison of CCM and Whitecliffs rainfall data on a given day

- Runoff volume calculations need to consider relatively frequent rain events to include regular live storage volume replenishment. To achieve this, the rainfall record has been processed to include a minimum daily rainfall threshold of 5 mm for runoff to be generated. The validity of this assumption was tested by plotting the change in CC04 stage height against daily rainfall depth (using the CCM weather station rainfall data). Figure 5 shows that daily rainfall depths of 5 mm and greater consistently result in an increased stage height at CC04, indicating generation of runoff flows. Thus, the assumption that daily rain events of 5 mm and greater trigger runoff is considered reasonable. Other stage height logger sites at CCM were not considered suitable for validation purposes due to either external manipulation of drainage flows (e.g. CC02 through water storage and release from Surge Sump and Dust Pond, CC20 due to decant structures) or the relative position of the monitoring site within the catchment (e.g. CC23 and CC26 are located relatively low in the Bush Gully catchment with greater potential for moderation of runoff flow volume (and therefore buffering of stage height fluctuation)).

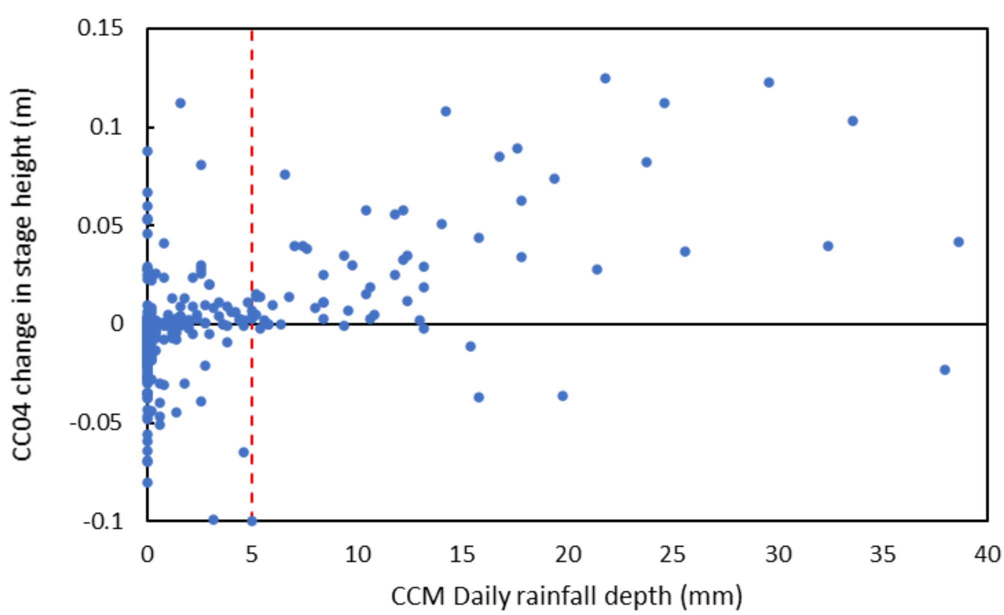

Figure 5. CC04 change in stage height versus daily rainfall depth

- A relatively low runoff coefficient of 0.2 was adopted for calculations (lower than the 0.3 unadjusted coefficient published in AS/NZ3500.3-2003 for a pasture surface and used by BCL for rehabilitated ELF runoff calculations). A low runoff coefficient was used to reflect inclusion of relatively low rainfall events (e.g., 5 mm daily rainfall) in the runoff volume calculation. These assumptions mean that if a 5 mm rainfall event occurs 20% of the total rainfall volume falling within the N02 Pit Pond drainage would report to the pond as runoff.

Using these assumptions, the daily runoff volume reporting to N02 Pit Pond was calculated using the ~30-year Whitecliffs rainfall database. The use of an actual rainfall dataset incorporates the inherent variability in rainfall intensity, seasonal variation, and longer-term effect of ‘dry’ years. The calculated runoff volume was used to adjust the N02 Pit Pond live storage volume on a daily timestep considering the following constraints:

- At time zero the N02 Pit Pond was at full capacity;
- Maximum live storage volume of 3,743 m^3 (and no additional live storage accumulation if this value was exceeded);
- A constant daily decant discharge rate of 41.4 m^3/d (equivalent to the required dilution discharge rate of 0.48 L/s); and
- Minimum live storage volume of 0 m^3 (and no additional live storage drawdown if this value was exceeded.

As a further sensitivity test, the effect of the other N02 Pit Pond dilution scenarios (from Table 1) on N02 Pit Pond live storage volume were analysed. Thus, in total three different N02 live storage scenarios were assessed to cover the following scenarios:

- Scenario 3 – Low flow (CC02 untreated, N02 Pit Pond diluted @ 0.78 L/s);
- Scenario 6 – Low flow (CC02 treated, N02 Pit Pond diluted @ 0.18 L/s); and
- Scenario 7 – MSR design flow (CC02 treated, N02 Pit Pond diluted @ 0.48 L/s).

The resulting estimated volume in the N02 Pit Pond live storage zone for these three scenarios using the Whitecliffs rainfall record is shown in Figure 6, assuming only >5 mm/day rainfall intensities generate runoff. The following data are presented:

- Modelled daily live storage volume (blue dots);
- Modelled days when the spillway would be flowing (calculated live storage capacity exceeds the available live storage capacity) are shown as green dots;
- Modelled days when the live storage capacity is exhausted are shown as orange dots and would represent days when decant discharge (and dilution of Tara MSR discharge) ceases; and
- Cumulative 90-day rainfall depth is also presented to show relationships between dry periods and live storage.

Figure 6 shows that the modelled live storage volume within the N02 Pit Pond fluctuates continuously. The magnitude of these fluctuations is dependent on the N02 Pit Pond decant rate, which defines how quickly the N02 Pit Pond water surface is drawn down. This storage fluctuation is due to the constant decant discharge combined with the seasonal rainfall patterns at CCM. The cumulative 90-day rainfall curve shows that extended periods of 0 m^3 live storage coincide with relatively low rainfall periods, particularly for scenarios 7 and 3.

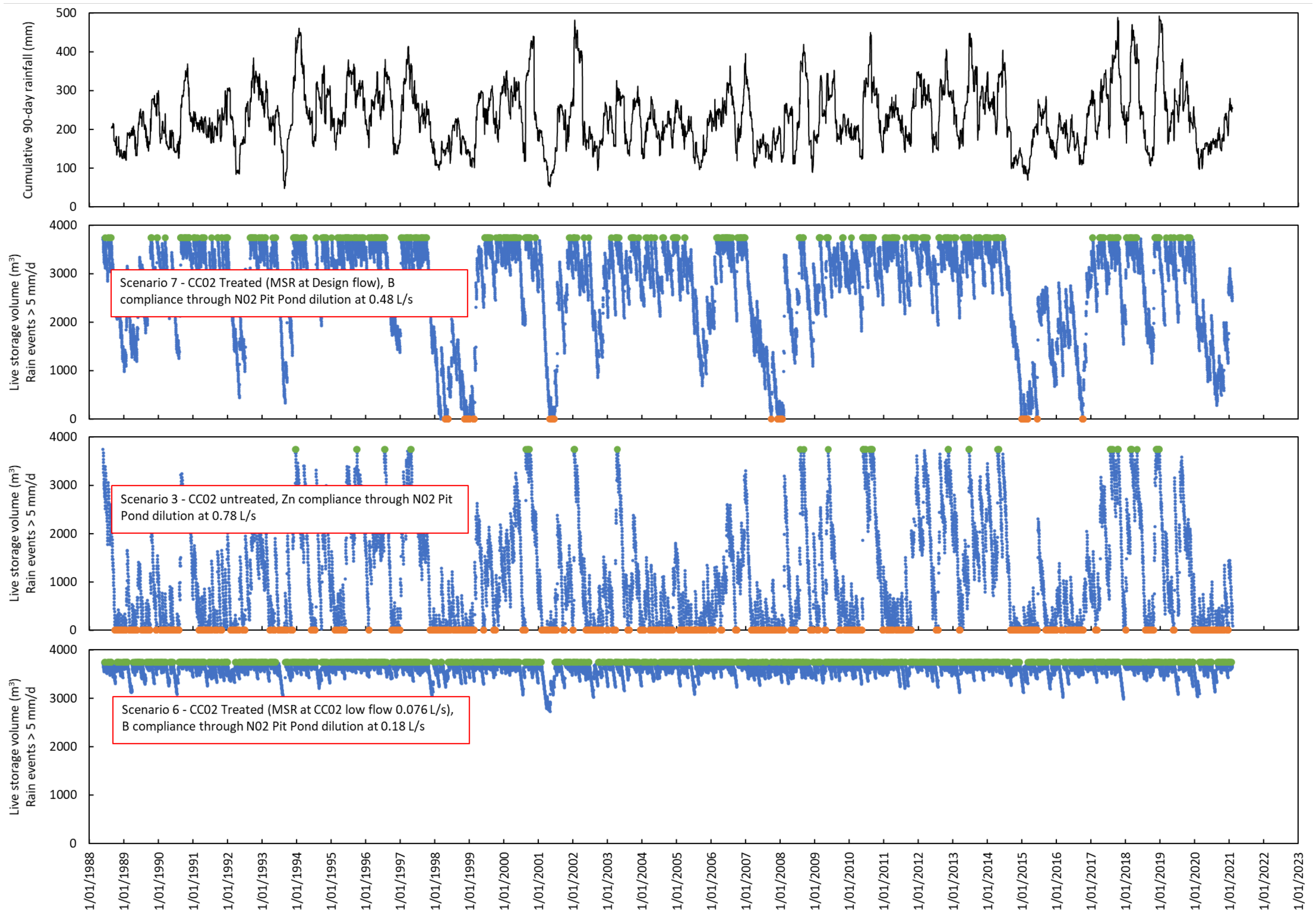

Figure 6. Modelled 90-day cumulative rainfall and daily live storage volume using the Whitecliffs rain record and including runoff from >5 mm/d rain intensities.

The proportion of modelled spilling and zero decant discharge days from Figure 6 are summarised in Table 2. These values were derived from calculated daily changes to storage using the available Whitecliffs rainfall record with a sample count of 11,926.

Table 2: Modelled N02 Pit Pond live storage empty and spilling frequency, only including runoff from >5 mm/d rain intensities.

Condition	Unit	Scenario 7	Scenario 6	Scenario 3
N02 Pit Pond decant rate	(L/s)	0.48	0.18	0.78
Live storage empty / Zero decant discharge	(no. days)	153	0	2,627
	(% of time)	1.3	0	22
Spilling	(no. days)	513	1,385	60
	(% of time)	4.3	11.6	0.5
Decant only discharge	(no. days)	11,260	10,541	9,239
	(% of time)	94.4	88.4	77.5

Table 2 suggests that under Scenario 7 the majority (>94%) of the time N02 Pit Pond discharge rates are likely to be equivalent to decant discharge rates (of 0.48 L/s), with zero decant discharge occurring only 1.3% of the time. The lesser decant rate modelled under Scenario 3 (0.18 L/s) shows zero decant discharge is unlikely to occur with a minimum live storage volume of ~2,700 m^3 calculated over the ~30-year rainfall record. Conversely, the higher decant rate modelled under Scenario 6 (0.78 L/s) shows regular zero decant periods (calculated at 22% of the time). This analysis shows that the N02 Pit Pond live storage volume is heavily dependent on decant rate.

The Scenario 7 decant rate of 0.48 L/s is considered a reasonable nominal maximum N02 Pit Pond diluting flow capacity, where the risk of zero decant days occurring is relatively low in the context of dilution requirements for the Tara MSR discharge to meet CRC170541 water quality criteria. However, the N02 Pit Pond discharge flow model is a simplistic model. It does not consider the potential:

- Volume loss from evaporation or seepage losses;
- Volume gains from seepage flowing into the N02 Pit Pond (which BCL have indicated have been gauged at up to 0.14 L/s during the N02 Pit Pond construction phase); or
- Significantly higher runoff yields during short duration and high intensity rain events or during winter when near saturated topsoil is likely to have a significantly higher runoff coefficient.

Further, the model does not consider changes in the CC02 underdrain discharge flow rate. The seasonality of CC02 underdrain flow rate after removal of the historic workings and seepage hydrogeological drainage is not yet clear in available monitoring data. It is likely that the MSR design discharge rate of 0.2 L/s is higher than the MSR discharge flow rate that would be occurring during a prolonged dry period (i.e., the CC02 underdrain 10th percentile flow is 0.076 L/s over the 2019/20 period). It is therefore reasonable to assume that a N02 Pit Pond discharge flow rate of <0.48 L/s could be sufficient at times for CCM discharges to meet CRC170541 compliance limits during low flow conditions. Performance monitoring is required to validate this assumption as the site moves into steady-state conditions. Decreasing the N02 Pit Pond decant flow rate would decrease the frequency of zero decant discharge, as alluded to under the Scenario 3 calculations in Table 2.

This assessment does identify that during prolonged dry periods it is possible the live storage capacity will be exhausted resulting in decant discharge ceasing. During such periods, an alternative dilution source (rather than N02 Pit Pond flows) would be required to continue the MSR discharge dilution required for combined discharge B concentrations to meet CRC170541 criteria. The following low flow management options could be part of an adaptive management approach:

- BCL could utilise the 20 units (i.e., 20 m^3/d) of water available through the Malvern Hills Water Scheme as a contaminant-free clean water source for dilution during the active closure phase only. This is the option presented in Table 1 (Model Scenarios 2 and 5);
- Use of a syphon to draw the N02 Pit Pond water level below the decant elevation could be used. The longest period of frequent zero decant flows in the > 5 mm/d rain event live storage calculation was approximately 100 days. This would equate to syphoning a further ~4,140 m^3 of water out of N02 Pit Pond and is likely to equate to drawdown of the water level by a further ~0.5 m; or
- Change the spillway / decant design by raising the head of N02 Pit Pond spillway to increase the live storage capacity.

WATER QUALITY AND CONTAMINANT LOAD

The expected water quality of the key water sources is shown in Table 3. The Tara MSR discharge water quality was derived in Memorandum 1 (MWM, 2021a) and is assumed to be constant under all modelled scenarios. The other water source contaminant concentrations were derived assuming:

- The 90th percentile CC02 underdrain discharge water quality from 2019/20 sample dataset is representative of low flow conditions;
- The 90th percentile CC20 contaminant concentration is assumed to be a reasonable analogue for 'normal' N02 Pit Pond discharge water quality, capturing the effects of seepage and surface water flows. This conservative assumption was made to represent the fact that the majority of the time (~94% under Scenario 7 modelled decant rates of 0.48 L/s) the N02 Pit Pond discharge flow rates will be limited to decant only flow. Thus, water quality in the N02 Pit Pond will theoretically tend towards 90th percentiles during dry periods but when the decant is still discharging at 0.48 L/s;
- The 10th percentile CC20 contaminant concentration is assumed representative of 'high flow' N02 Pit Pond discharge water quality (i.e., Model Scenario 8); and
- The clean water dilution source contaminant concentration is negligible.

Table 3: Tara catchment key discharge water source water quality

Parameter	Unit	CC02 underdrain (untreated)*	Tara MSR discharge**	N02 Pit Pond discharge***	
		Low flow	All flows	Decant flow	High flow
pH		6.1	7.3	7.1-7.7	
Calc acidity	(mg $CaCO_3$/L)	75	1.1	0.23	0.08
Sulfate	(mg/L)	1,277	1,130	328	195
Al	(mg/L)	0.008	0.005	0.025	0.005
B	(mg/L)	3.65	3.65	0.60	0.40
Ca	(mg/L)	254	302	86	47
Fe	(mg/L)	28	0.40	0.07	0.01
Mg	(mg/L)	124	116	36	21
Mn	(mg/L)	3.0	1.7	0.44	0.03
Ni	(mg/L)	0.10	0.015	0.011	0.004
Zn	(mg/L)	0.67	0.065	0.020	0.005
Hardness	(mg $CaCO_3$/L)	1,142	1,228	362	202

** 90th percentile CC02 water quality data over the 2019/20 period, ** derived in Memorandum 1 (MWM, 2021a), *** derived in Memorandum 1 (MWM, 2021b)*

These water quality data were combined with the flow rates presented in Table 1 to derive combined contaminant loads and water quality (Table 4) discharging the Tara catchment post closure for the eight different modelled scenarios. These calculations show that while the contaminant load increases significantly during higher N02 Pit Pond discharge periods (e.g., scenarios 7 and 8) the contaminant concentration decreases. This is attributed to relatively clean surface runoff flowing into the N02 Pit Pond and causing a modest contaminant dilution (e.g., ~3x dilution of B at high flow versus low flow conditions). While a greater dilution effect might be expected considering the flow rate variability (i.e., 'low' flows of ~0.08 to 0.86 L/s versus 'high' flows of ~10 L/s) the volume of water and contaminant load stored in the N02 Pit Pond is expected to buffer rapid changes in water quality during rain events.

Table 4 Tara catchment discharge concentration values shown in bold red are either at or above the CRC170541 water quality criteria, including after hardness modification of trigger values for Zn. This identifies the critical parameters for compliance for each modelled scenario. These values are also illustrated relative to CRC170541 water quality criteria in Figure 7.

Table 4: Combined Tara catchment discharge contaminant load and concentration

Parameter	Tara catchment discharge combined discharge load (kg/d)								Tara catchment discharge combined discharge water quality (mg/L)							
Scenario No.	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
pH									6.1	6.5	7.1	6.9	7.3	7.1	7.5	7.1
Calc acidity	0.49	0.007	0.49	0.007	0.51	0.011	0.028	0.08	75	31	1.1	1.1	0.45	0.48	0.48	0.10
Sulfate	8.4	7.4	8.4	7.4	31	13	33	188	1277	526	19	1130	466	564	564	213
Al	0.0001	0.00003	0.0001	0.00003	0.0018	0.0004	0.0011	0.0046	0.0080	0.0033	0.0001	0.0050	0.0021	0.019	0.019	0.0052
B	0.024	0.024	0.024	0.024	0.065	0.033	0.088	0.41	3.7	1.5	0.053	3.7	1.5	1.5	1.5	0.46
Ca	1.7	1.9	1.7	1.9	7.5	3.3	8.7	46	252	104	3.7	296	122	148	148	52
Fe	0.18	0.003	0.18	0.003	0.19	0.0038	0.010	0.015	28	12	0.41	0.40	0.17	0.17	0.17	0.02
Mg	0.81	0.76	0.81	0.76	3.3	1.3	3.5	20	124	51	1.8	116	48	60	60	22
Mn	0.020	0.011	0.020	0.011	0.049	0.018	0.048	0.054	3.0	1.2	0.044	1.7	0.71	0.81	0.81	0.062
Ni	0.0007	0.0001	0.0007	0.0001	0.0014	0.0003	0.0007	0.0035	0.101	0.042	0.0015	0.015	0.0063	0.012	0.012	0.0040
Zn	0.0044	0.0004	0.0044	0.0004	0.0057	0.0007	0.0019	0.0054	0.67	0.28	0.010	0.065	0.027	0.033	0.033	0.0062
Hardness	7.5	8.0	7.5	8.0	32	14	36	196	1142	471	38	1214	500	613	613	222

NB: Values shown in red are above the CRC170541 water quality trigger limits, including after hardness modification of trigger values for Zn.

The forecast Tara catchment discharge water quality from Table 4 was compared against CRC170541 compliance limits for a contaminant suite that included B, Fe, Mn, and Zn in Figure 7, which are considered the contaminants of concern for this site.

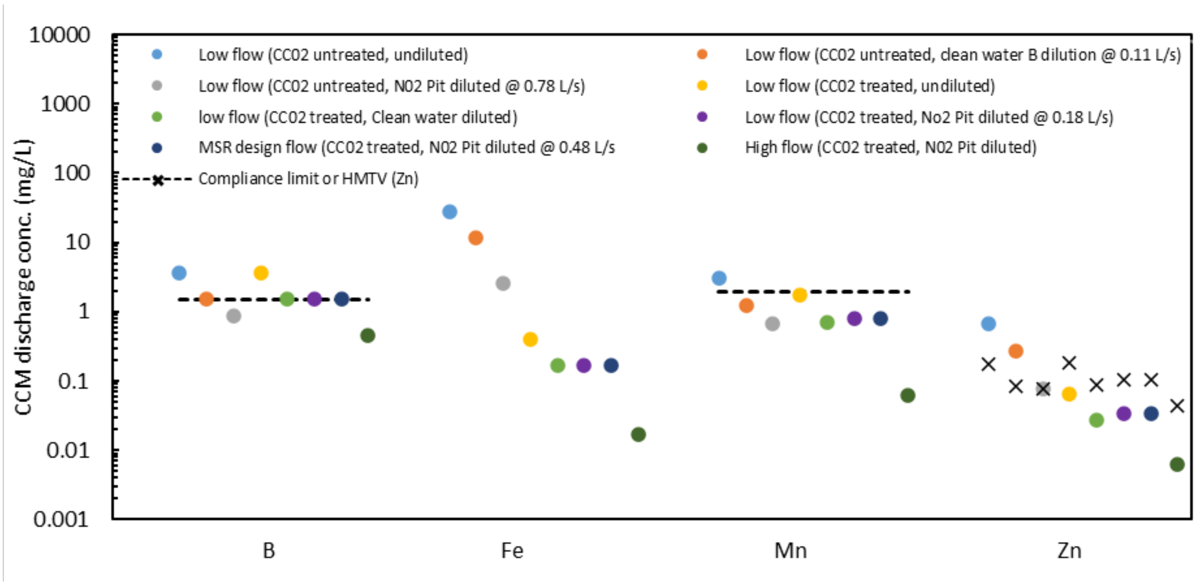

Figure 7. Combined Tara MSR and N02 Pit Pond contaminant concentration versus CRC170541 limits

This comparison shows that based on recent CC02 underdrain monitoring data, Tara MSR design assumptions, and forecast N02 Pit Pond water quality the following is required for combined CCM discharge to meet CRC170541 trigger limits:

- Tara MSR treatment is required for Zn removal as dilution alone to achieve B compliance limits is insufficient (assuming the Scenario 3 modelled N02 Pit Pond decant rate of 0.78 L/s is unsustainable from a live storage perspective, or from an effects perspective). Further, while the combined discharge Fe concentration would meet CRC170541 water quality criteria (due to circum-neutral discharge pH), Fe precipitate removal is also considered beneficial; and
- Clean water (active mine closure phase) / N02 Pit Pond water dilution is required for dilution of MSR discharge waters to meet CRC170541 B criteria.

Discharge of water that meets CRC 170541 limits is expected during normal and high flow conditions. Table 2 indicates, that based on historical rainfall records exhaustion of the N02 Pit Pond live storage (and cessation of diluting flows) is likely to be relatively rare. Figure 6 indicates there is likely to be multiple years between live storage exhaustion and no decant flow.

During the active mine closure phase, the requirements for access to further clean water for B dilution (when N02 Pit Pond decants are not flowing) is expected to be rare (1.3% of the time using the 'daily rainfall > 5 mm' threshold), however other adaptive management options will also be considered / developed during this time. After mine closure it is anticipated that adaptive management options could include:

- Develop the concept of a syphon to draw the N02 Pit Pond water level below the decant elevation;

- Consider changing the spillway / decant design by raising the head of N02 Pit Pond to increase the live storage capacity, although this option may only be available in the early phases of project closure activities when equipment is available; and
- Other options not yet identified.

ESTIMATED PASSIVE TREATMENT DURATION

This section discusses the expected duration for passive treatment of CC02 underdrain using empirical data and observed trends.

Forecasting the longevity of CC02 underdrain treatment using the CC02 data record is complicated by recent changes in Tara Gully water management. For instance, early CC02 monitoring data (up to ~ mid 2017) are influenced by surface water runoff and discharge from the historic North / Shearers dump, which had a significant acidity and contaminant load.

The CC02 data record from August 2017 onwards is generally representative of CC02 underdrain discharge only. However, this does include some datapoints where the CC02 underdrain discharge outlet was flooded. On these dates the CC02 sample was collected from the surface of Tara Pond 1 and is influenced by Green ELF surface flows.

Recent (mid-2020) excavation of the N02 Pit into the area of historic workings and the adjacent hill behind workings that fed into the CC02 underdrain (see MWM Memorandum 1 (MWM, 2021a): Figure 7) has resulted in further changes, with CC02 flow rate decreasing and some contaminant concentration changes. These flow rate changes are expected to be permanent as the underground workings have been removed, which acted as a conduit collecting flows from the adjacent section of hillside. However, as N02 Pit Pond construction is ongoing there are not yet sufficient data to identify any further contaminant load (flow, quality) decay trends in the recently modified drainage.

Water quality data at three sites (CC02, CC03, and CC09) along the Tara Gully Stream show a decreasing trend in sulfate concentration at downstream sites CC03 and CC09 (Figure 10) over time. This long-term concentration decay will be a product of proactive AMD management activities at CCM (such as the removal of Shearers Dump). Short-term variability in concentration is attributed to variable natural dilution in the Tara Gully Stream catchment.

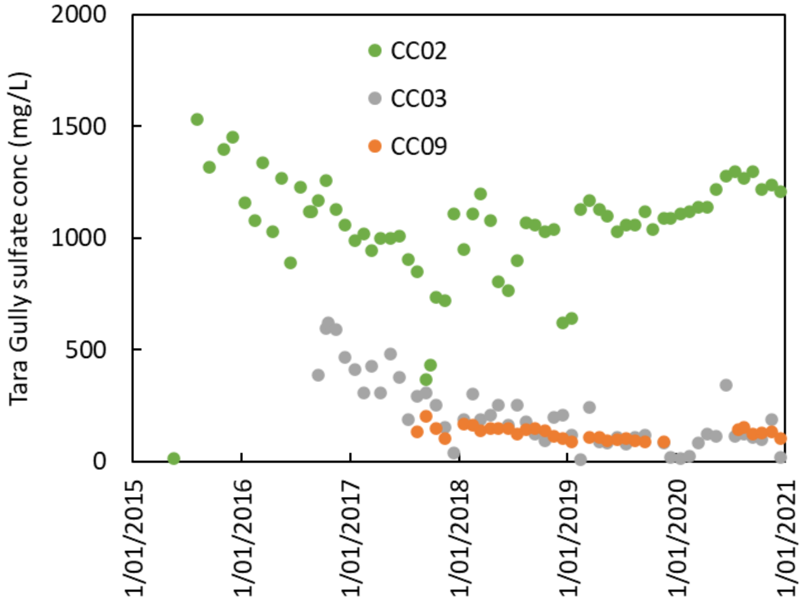

Figure 8. Tara Gully sulfate concentration trends

At this stage the CC02 underdrain empirical data cannot simply be extrapolated to determine the treatment longevity due to recent changes in the catchment affecting the dataset. However, the data in Figure 10 show indirectly that contaminant loads discharged from CCM have decreased over time. CC03 and CC09 are located sufficiently down catchment (e.g., CC03 below the Tara Wetland and CC09 below the ~80,000 m^3 Farm Pond) that the day-to-day variances in CCM discharge will have minimal effects on contaminant concentrations and loads. The downstream contaminant concentration decline is therefore expected to represent a decrease in contaminant load mobilised from AMD sources at CCM (including the CC02 underdrain). It should be noted that sites CC03 and CC09 have not been accurately flow gauged so a decreasing contaminant load trend at these sites has not been quantified.

The Zn load decrease at CC02 is shown in Figure 11 (data re-presented from Figure 6) as an indicator of the contaminant load decay resulting from AMD management at the site.

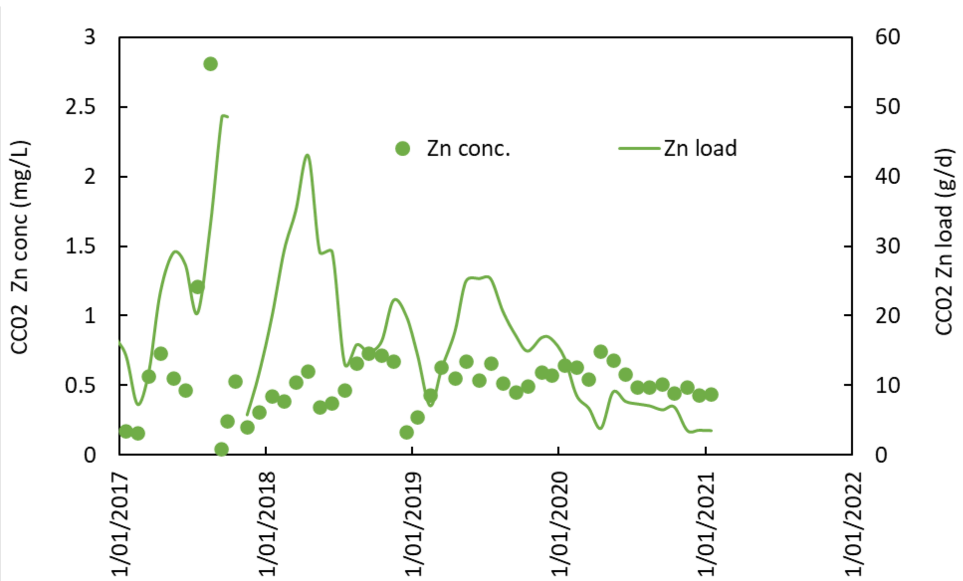

Figure 9. CC02 Zn concentration and 3-sample rolling average Zn load

Figure 11 shows that while CC02 Zn concentration has remained relatively stable (at ~0.5 mg/L) the Zn load has decreased from up to ~50 g/d in 2017 to <10 g/d through 2020. It should be noted that this contaminant load decay does not necessarily represent depletion of the CC02 seepage contaminant source as the data includes periods where other seepages and surface flows were included in the CC02 sample (e.g., Shearers Dump up to late 2017, removal of historic workings through 2020, etc.). As such, a representative Zn load decay trendline has not been fitted to the dataset to extrapolate out future Zn load decrease and hence treatment longevity.

Figure 12 shows the measured CC02 Zn load decreased significantly after mining of the underground workings and adjacent hillside that commenced in 2020.

The modelled 'low flow' CC02 Zn load (Figure 12) is estimated using 90th percentile CC02 Zn concentration (0.67 mg/L) and 10th percentile CC02 discharge flow rate of 0.076 L/s, equating to a Zn load of 4.4 g/d (Model Scenario 1). The model has been used to estimate the degree of CC02 Zn load decay required for CRC170541 trigger limits to be met due to N02 Pit Pond dilution alone (i.e., without requiring Tara MSR treatment). The required CC02 Zn load decay was estimated for two N02 Pit Pond flow scenarios, which equate to:

- N02 Pit Pond flow of 0.48 L/s – as required to dilute the 'MSR design' B load discharged from the Tara MSR treating a CC02 flow of 0.2 L/s; and
- N02 Pit Pond flow of 0.18 L/s – as required to dilute the 'low flow' B load discharged from the Tara MSR treating a CC02 flow of 0.076 L/s (10th percentile CC02 flow rate gauged between 2019/20).

This analysis assumed the N02 Pit Pond water had a Zn concentration of 0.020 mg/L and hardness of 362 mg $CaCO_3$/L (equivalent to the 90th percentile of the measured CC20 Zn and hardness concentration through the year 2020). The 90th percentile CC02 hardness of 1,142 mg/L was also used in calculations. The resulting estimate of the Zn load decrease required for downstream Zn concentrations to meet CRC170541 criteria (summarised in Figure 12) showed that:

- A 38% CC02 Zn load decrease (from current 'low flow' modelled levels of 4.4 g/d to 2.7 g/d) would be required provided a constant 0.48 L/s diluting flow from N02 Pit Pond; and
- A 75% CC02 Zn load decrease (from current 'low flow' modelled levels of 4.4 g/d to 1.1 g/d) would be required provided a constant 0.18 L/s diluting flow from N02 Pit Pond.

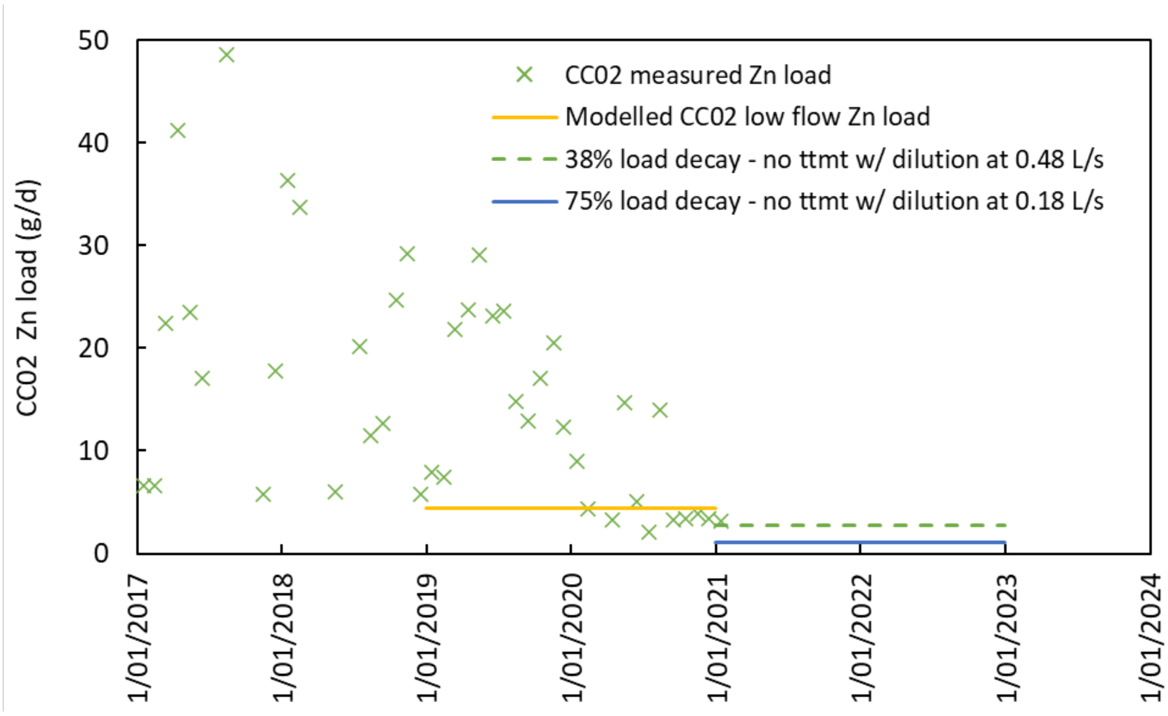

Figure 10. CC02 Zn load and N02 Pit Pond dilution

Runoff volume estimates (MWM, 2021b) show that exhaustion of the live storage volume at a decant rate of 0.48 L/s would be rare (~1.3 % of time), under relatively conservative model assumptions. Thus, assuming a constant diluting flow of 0.48 L/s is available, a 38% decrease in CC02 Zn load (from the 'Modelled CC02 low flow Zn load' in Figure 12) would be required before combined CCM discharges would be expected to meet CRC170451 water quality criteria without treatment.

A 38% decrease in CC02 contaminant load is expected to occur over a period of years to decades. This contaminant load reduction is expected to occur as:

- Mining and backfilling of the N02 Pit Pond is completed with a potential reduction in CC02 flow rate as the phreatic surface is drawn down and stabilises at the new landform profile;
- Net percolation decreases as the Green ELF / N02 Pit area is rehabilitated and revegetated (e.g., due to decreased surface permeabilities, increased transpiration, etc.); and
- The long-term contaminant source (e.g. stored oxidation products) decreases.

Performance monitoring data collected over the remaining life of mine phase and into the post closure phase will provide a more representative basis for forecasting the required treatment duration. Performance monitoring will determine any contaminant load reduction due to site rehabilitation activities. The reduction in contaminant loads achieved through rehabilitation at other mine sites in New Zealand include:

- 65% reduction in acidity loads from Mt Fred Quarry, Stockton in the first year after rehabilitation (McLachlan et al., 2018); and
- Conservative 40% reduction in acidity loads at Stockton Mine after cover installation – used in a cost:benefit of different cover systems (Olds et al., 2014).

However, CC02 underdrain contaminant concentrations are likely to remain comparable to current concentrations over the medium term reflecting BCLs best practicable AMD management strategy that:

- Minimises the generation of contaminants; but
- Results in small amounts of residual seepages produced by the ELFs that have relatively high contaminant concentrations but low contaminant loads.

These elevated residual seepage contaminant concentrations make achieving compliance against concentration limits at the discharge point difficult without treatment or dilution, despite very low contaminant loads. However, the beneficial effect of these AMD management strategies on concentrations downstream (e.g., sulfate in Figure 10) is significant (sulfate being a key indicator of sulfide oxidation / AMD within the catchment).

As discussed, Zn is the critical parameter for removal through the Tara MSR to maintain compliance with CRC 170541 trigger limits at CC02-tele and will therefore define the passive treatment duration. Iron is also moderately elevated in CC02 underdrain concentrations. Both Zn and Fe are sulfide associated contaminants and are therefore expected to decrease over time as sulfide oxidation processes in the Green ELF decrease (due to AMD management and rehabilitation activities).

The quantity of any residual Fe loads on the Tara wetland after removal of the MSR are expected to be minor. There are many known seeps near the CCM site and in Bush Gully Stream catchment that emanate small amounts of orange Fe-rich precipitates. This includes some seepages where no historic workings exist (Pers. Comm. Eden Sinclair) suggesting natural processes associated with mineralogy of the sediments of Monro, Conway, and Broken River Coal Measures formations may be causing this.

CRC170541

The Tara Gully treated AMD discharge consent (CRC170541) expires in 2032. Performance monitoring data over the initial ~12-18 months post closure will provide data for estimating the required treatment duration.

There are a number of events or scenarios that could justify ceasing passive treatment by 2032, including:

- A 38% decrease in CC02 underdrain Zn load occurring by 2032 (as a result of landform rehabilitation and revegetation) with the diluting 0.48 L/s flow from N02 Pit Pond achieving compliance;
- The N02 Pit Pond water quality improving from the modelled inputs such that the N02 Pit Pond is a more effective dilutant;
- Higher than modelled runoff yields in the N02 Pit Pond drainage allowing a sustainable increase to diluting flows; and
- Surface runoff volumes from the Green ELF providing effective flushing of contaminant loads accumulating in Tara Pond 1 (assuming CC02 underdrain were re-directed to Tara Pond 1) such that when combined with N02 Pit Pond discharges CRC170541 criteria were achieved in combined discharges.

Performance monitoring data that will be collected over the ~12-18 months post closure should provide a representative dataset for defining the required treatment duration.

LONG TERM CCR LEACHATE EFFECTS

There are two key potential geochemical contaminant sources at CCM, which have been the focus of previous discussions:

- Rock / waste rock; and
- Coal Combustion Residuals (CCR)

Some rock / waste rock can be potentially acid forming (PAF), which can generate low pH water that can be elevated in contaminants of concern such as Al, Fe, Mn, Ni, and Zn. Such materials can also generate elevated boron in drainage waters. These materials are managed in a strategic manner as per Section 6 of the CCM EMP (BRL, 2018).

CCR are alkaline in nature with ANC values of ~50 kg H_2SO_4/t and paste pH of ~9.0 reported in a recent (October 2020) analysis of three samples, which has benefits for the management of AMD. However, the coal combustion process also results in concentration of naturally occurring coal contaminants in coal ash. This is reflected in the elevated Al, B, Fe elemental abundance data reported in Table 6.

Table 5. CCR total recoverable contaminant content compared to Class B landfill screening criteria.

Parameter	Unit	Class B criteria	Total recoverable elemental abundance				
Sample date			26/5/2016	26/5/2016	26/5/2016	26/5/2016	30/8/2016
Sample name			Canty DHB blended	Synlait bottom ash	Synlait fly ash	Clandeboye blended	Clandeboye blended
Total Al	(mg/kg)	80	40,000	47,000	34,000	61,000	54,000
Total B	(mg/kg)	40	1,680	1,210	2,100	670	510
Total Ca	(mg/kg)	n/a	47,000	45,000	41,000	59,000	60,000
Total Fe	(mg/kg)	n/a	35,000	26,000	37,000	21,000	17,200
Total Mg	(mg/kg)	n/a	4,200	3,400	4,500	3,700	2,800
Total Hg	(mg/kg)	0.4	< 0.10	< 0.10	0.46	0.13	0.12
Total Ni	(mg/kg)	20	45	36	60	21	15
Total Zn	(mg/kg)	20	28	44	630	20	31
Sulfate	(mg/kg)	n/a	1,930	750	12,200	6,700	6,000

CCR are blended with waste rock at a minimum ratio of 1:4 for disposal to meet Class B landfill waste acceptance criteria, as per Section 10 of the CCM EMP (BRL, 2018) and the consent requirements set out in CRC170540. This has the benefit of placing acid producing and acid neutralising materials together to minimise sulfide oxidation and acidity generation while reducing the composite material contaminant content.

A summary of blended CCR and waste rock sample results compared against Class B landfill concentration in leachate criteria analysis (i.e., TCLP testing results) are shown in Table 7. Further results of TCLP testing are included in Appendix I. These data show that the blended CCR and waste rock material achieves the Class B landfill concentration in leachate criteria. BCL note that these blended CCR and waste rock samples are representative field samples collected from active engineered landforms during construction and the overall mixing process results in significantly greater CCR : waste rock blending than the 1:4 minimum requirement.

Table 6. Blended CCR and waste rock sample results of Class B landfill concentration in leachate criteria assessment

Parameter	Unit	Class B criteria	TCLP extract contaminant concentration				
Sample date			April 2018	April 2018	June 2019	June 2020	June 2020
Sample name			NELF001	NELF002	Canterbury Coal	Frews 001	Frews 002
Total Al	(mg/L)	4.0	0.074	0.24	0.35	0.3	0.191
Total B	(mg/L)	2.0	0.42	0.15	0.22	0.36	0.26
Total Fe	(mg/L)	n/a	< 0.42	< 0.42	0.65	0.97	< 0.42
Total Mn	(mg/L)	n/a	0.46	0.84	0.75	0.84	0.46
Total Hg	(mg/L)	0.02	<0.0021	<0.0021	<0.0021	<0.0021	<0.0021
Total Ni	(mg/L)	1.0	0.026	0.128	0.177	0.127	0.101
Total Zn	(mg/L)	1.0	0.09	0.51	0.24	0.2	0.27
Post extraction pH			NA	NA	4.9	5	4.9

NELF001 and NELF002 samples are blended CCR/waste rock materials from the Northern ELF; NA = not available.

The relative risk of CCR constituents to the CCM operation meeting discharge water quality criteria is described in the following series of bullet points:

- The presence of elevated Al and Fe in CCR is considered a negligible risk to the CCM operation meeting discharge water quality criteria. TCLP data indicates Al and Fe are low, even after the acid digest;
- The presence of elevated Ni and Zn in CCR is considered a relatively low risk to the CCM operation meeting discharge water quality criteria. The total recoverable Ni and Zn content of CCR does exceed the mg/kg Class B criteria (by a factor of up to 30x for Zn in the fly ash component (However, the TCLP extract results (of blended CCR / waste rock samples collected from the engineered landforms) show Ni and Zn mobilisation from blended CCR/rock is relatively low and meets the Class B TCLP criteria. Furthermore, BCL have viable options for managing elevated Ni and Zn concentrations (e.g., MSR treatment and NaOH dosing) if triggered as part of its adaptive management approach for the site; and
- The presence of elevated B in CCR is considered a moderate risk to the CCM operation meeting discharge water quality criteria. Boron is significantly elevated above the mg/kg Class B criteria (by a factor of up to 52x in the fly ash component). TCLP results of field samples show that the current disposal method of blending with waste rock is sufficient to

meet the Class B criteria. Post closure, BCL have viable options for managing elevated B concentrations in water discharges from site (e.g., N02 Pit Pond dilution) if triggered as part of its adaptive management approach for the site. However, as B is not removed by either of the treatment strategies (MSR treatment or NaOH dosing) it is considered the critical CCR related contaminant of concern from a water quality compliance perspective. Due to its geochemically conservative nature B is also considered a good indicator of any CCR effects on water quality at CCM, but these effects must be considered in parallel with elevated B identified in in-situ coal measures, waste rock, and historic underground workings environments too.

Boron source and water quality observations

The CCR and waste rock are distributed throughout the Tara and North ELF Domains. Laboratory trials were undertaken in 2016 to improve understanding of B mobilisation rates from CCR and waste rock under rainwater and acidic leaching conditions. The trials consisted of a modified synthetic precipitation leaching procedure (SPLP) test where a series of unblended 20 g CCR and waste rock samples (weighed on an as received basis) were reacted with 1 L of rainwater and AMD extraction solutions for 18 hours on a bottle roller to quantify B mobilisation. This was considered a fairer assessment methodology for the potential to mobilise B compared to a TCLP test. Data analysis quantified the following B mobilisation rates:

- Average mobilisation of B from the five CCR samples tested with the AMD extractant was 324 mg/kg (greater than the rainwater B mobilisation of 156 mg/kg); and
- Average mobilisation of B from the 16 waste rock samples tested with the rainwater extractant was 9.2 mg/kg (greater than the acid soluble B mobilisation of 8.9 mg/kg).

It should be noted that the leachate pH of the AMD extracted CCR samples remained acidic (pH 2.8 to 4.0) after the 18-hour mixing period (i.e., the acid neutralising capacity of the ash sample was not sufficient to neutralise the 'acidic' nature of the extraction solution).

Total cumulative material movements by mine domain to December 2019 (as provided by BCL) are presented in Table 8.

Table 7. CCR and waste rock volumes by mine domain to December 2019. (Source: BCL)

Domain	CCR		Waste Rock	
	CCR mass (t)*	Acid soluble B reserve (kg)**	Rock mass (t)	Water soluble B reserve (kg)***
Tara Domain	93,000	30,200	14,800,000	136,000
North ELF Domain	14,000	4,500	2,900,000	26,700
Total	**107,000**	**34,700**	**17,700,000**	**162,700**

** As received moisture content, ** Acid soluble CCR boron content of 324 mg B / kg CCR (as received moisture content) derived from laboratory trials, *** Water soluble (greater than acid soluble) waste rock boron content of 9.2 mg B / kg rock derived from laboratory trials.*

Table 8 shows that from a bulk materials perspective CCR is a small proportion of the backfill volume/mass. CCR is not disposed in a designated single cell area on site so a more holistic assessment of the bulk backfill material is required to understand any potential CCR risks or effects on the receiving environment.

It is likely that any effects of CCR disposal on water quality in the Tara Catchment is already being shown in monitoring data. Longitudinal survey water quality data for Tara Gully (CC02-tele, CC03, and CC09 - Figure 10) show that boron concentrations decrease downstream of the controlled mine water discharge points.

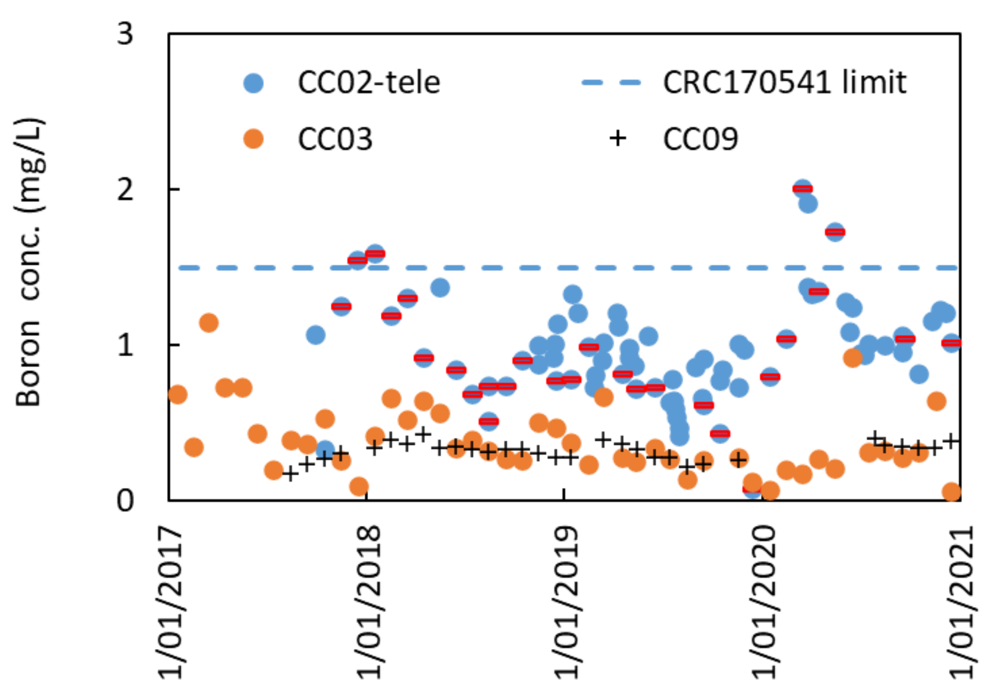

Figure 11. Longitudinal survey of B concentration through Tara Gully Stream. 'No-discharge' at CC02-tele data shown by (–).

These data show that:

- Boron concentrations decrease as discharge water moves through the receiving catchment, likely due to dilution; and
- There are no significant unexpected increases in boron concentrations at downstream water quality investigation sites, suggesting there are no unknown or uncontrolled B discharges from site.

No adverse changes to the currently observed water quality trends due to changes in CCR and leachate interactions are anticipated through the post closure period. The North ELF monitoring data at CC20 showed a stabilisation (within two years of construction) of contaminant concentration downstream of a waste rock and CCR co-disposed landform. Much of the CCR disposed in the Tara Catchment has been in-place for several years. Regular CCR deliveries to CCM will cease as coal mining activities finish around June 2021.

RECOMMENDATIONS

To advance the Tara catchment discharge water quality component of closure preparations, MWM recommend BCL:

- Develop the concept of a syphon to draw the N02 Pit Pond water level below the decant elevation; and
- Explore the possibility of changing the spillway / decant design by raising the head of N02 Pit Pond to increase the live storage capacity, though this may have ramifications for pond volume and may trigger dam consent,

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. 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 Tara Stream Discharge the following Adaptive Management is proposed.

1. Understand Risk
   a. The risks associated with AMD within the catchment and CC02 Underdrain are understood with data available on quality and flow.
   b. Data confirms that passive treatment is a viable option for the management of key AMD effects (e.g., Fe, Mn, Zn)
   c. With recent, and significant changes in the catchment affecting water quality and flow rates, and decreasing contaminant loads there is uncertainty on longer term trends although decreases in load and quality are expected; Variance in loads is likely to affect treatment duration and management costs.
2. Conduct Performance Monitoring
   a. Continue monitoring of flow and quality to understand trends including seasonal trends in water quality and flow rates;
   b. 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; and

   a. Review expected treatment duration.

3. Plan

   a. Develop an adaptive management plan for water management in Tara Stream catchment at the cessation of mine closure earthworks. This plan should include TARPS.

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APPENDIX I: FULL CCM BLENDED WASTE ROCK / CCR CLASS B TCLP LANDFILL ANALYSIS

Table 8. Blended CCR and waste rock sample results of Class B landfill concentration in leachate criteria assessment

Parameter	Unit	Class B criteria	TCLP extract contaminant concentration				
Sample date			April 2018	April 2018	June 2019	June 2020	June 2020
Sample name			NELF001	NELF002	Canterbury Coal	Frews 001	Frews 002
Total Aluminium	g/m^3	4	0.074	0.24	0.35	0.3	0.191
Total Antimony	g/m^3	0.06	< 0.0042	< 0.0042	< 0.0042	< 0.0042	< 0.0042
Total Arsenic	g/m^3	0.5	< 0.021	< 0.021	< 0.021	< 0.021	< 0.021
Total Barium	g/m^3	10	0.21	0.12	0.23	0.21	0.23
Total Beryllium	g/m^3	1	< 0.0021	< 0.0021	< 0.0021	< 0.0021	< 0.0021
Total Boron	g/m^3	2	0.42	0.15	0.22	0.36	0.26
Total Cadmium	g/m^3	0.1	< 0.0011	0.0013	0.0014	< 0.0011	0.0011
Total Calcium	g/m^3	n/a	41	17.8	34	46	30
Total Chromium	g/m^3	0.5	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011
Total Copper	g/m^3	0.5	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011
Total Iron	g/m^3	n/a	< 0.42	< 0.42	0.65	0.97	< 0.42
Total Lead	g/m^3	0.5	0.0036	0.0045	0.0044	0.0043	0.0046
Total Lithium	g/m^3	2	0.0118	0.0088	0.0091	0.0135	0.0121
Total Magnesium	g/m^3	n/a	13.6	6.5	9.8	13.5	9.9
Total Manganese	g/m^3	n/a	0.46	0.84	0.75	0.84	0.46
Total Mercury	g/m^3	0.02	< 0.0021	< 0.0021	< 0.0021	< 0.0021	< 0.0021
Total Molybdenum	g/m^3	1	< 0.0042	< 0.0042	< 0.0042	< 0.0042	< 0.0042
Total Nickel	g/m^3	1	0.026	0.128	0.177	0.127	0.101
Total Potassium	g/m^3	n/a	2.7	2	2.2	2.7	2.8
Total Selenium	g/m^3	0.11	< 0.021	< 0.021	< 0.021	< 0.021	< 0.021
Total Silver	g/m^3	0.5	< 0.0022	< 0.0022	< 0.0022	< 0.0022	< 0.0022
Total Tin	g/m^3	100	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011
Total Uranium	g/m^3	n/a	< 0.00042	< 0.00042	0.00048	0.00046	< 0.00042
Total Zinc	g/m^3	1	0.09	0.51	0.24	0.2	0.27
Post extraction pH			-	-	4.9	5	4.9

The TCLP extract concentration of the other containment groups reported by the laboratory listed below were below detection limits, unless noted:

- Haloethers in SVOC water samples – below detection limits for all samples;
- Nitrogen containing compounds in SVOC water samples – below detection limits for all samples;
- Organochlorine Pesticides in SVOC water samples – below detection limits for all samples;
- Polycyclic aromatic hydrocarbons in SVOC water samples – below detection limits for all samples;
- Phenols in SVOC water samples – below detection limits for all samples;
- Plasticisers in SVOC water samples – below detection limits for all samples;
- Other halogenated compounds in SVOC water samples – below detection limits for all samples;
- Other compounds in SVOC water samples – below detection limits for all samples;
- BTEX in VOC water – below detection limits for all samples, except for:
    - NELF002 sample Toluene, m&p-Xylene, and o-Xylene, which were ~4 orders of magnitude below the 10 g/m^3 Class B limit for Toluene and m&p-Xylene
- Halogenated aliphatics in VOC water – below detection limits for all samples;
- Halogenated aromatics in VOC water – below detection limits for all samples;
- Monoaromatic hydrocarbons in VOC water – below detection limits for all samples, except for:
    - NELF002 sample 1,2,4-Trimethylbenzene with a concentration of 0.0003 g/m^3 reported (which is equivalent to the detection limit).
- Ketones in VOC water – below detection limits for all samples;
- Trihalomethanes in VOC water – below detection limits for all samples; and
- Other VOC in water – below detection limits for all samples, except for:
    - NELF002 sample - carbon disulfide which was three orders of magnitude below the 0.3 g/m^3 Class B limit.