MACRAES GOLD MINE

Macraes Phase Four Project

Coronation Mine Proposed Expansion – Effects on Surface Waters

March 2024

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Coronation Mine Proposed Expansion – Effects on Surface Waters

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Cover photo:	Lower Trimbells Creek tributary, looking upstream. (photo: G. Ryder)

CONTENTS

1 INTRODUCTION

1.1 Background

Oceana Gold (NZ) Limited (OceanaGold) owns and operates the Macraes Gold Project in the Macraes Flat area of East Otago, 50 km north of Dunedin and about 20 km inland of the township of Palmerston (Figure 1). Mining has been operating since the 1980s and now consists of a number of open pit and underground mines, waste rock stacks, tailings storage facilities, water storage ponds, haul roads and a processing plant.

OceanaGold is proposing an expansion of open pit mining operations and developing a new tailings storage facility in the Frasers Open Pit, to extend the life of mine (LOM) from 2024 to 2030. This is a key part of Stage 3 of the “Macraes Phase 4 Project” (“MP4”).

Stage 3 includes:

- Extension of three open pits, namely Innes Mills, Coronation Pit and Golden Bar Pit, and their associated backfills and waste rock stacks (“WRS”);
- Development of a Tailings Storage Facility in Frasers Open Pit (“FTSF”);
- Realignment of Golden Bar Road; and
- Ancillary features such as topsoil stockpiles, low-grade ore stockpiles, silt ponds, areas for pit infrastructure and access roading.

Various water-related technical studies have been undertaken to assess the potential effects of the various aspects of Stage 3, including potential loss of surface watercourses, modelling of mine-influenced groundwater and waste rock stack seepages to surface waters, and potential loss of surface water flow due to mine activities. Effects on surface water ecology and water quality of the Back Road Waste Rock Stack (BRWRS), the raising of the Top Tipperary Tailings Storage Facility (TTTSF) by two metres to 570 m RL, an extension of the Golden Point Underground mine (GPUG) and a proposed extension to the Golden Bar Pit and associated WRS have already been addressed in separate reports (Ryder 2022a, Ryder 2022b, Ryder 2023, Ryder 2024) and the cumulative effects have been assessed as part of this report.

The effects of extending the Coronation mine on the aquatic ecology in the Mare Burn catchment is the subject of this report. The effects of MP4 open pit extensions are the subject of a further report that assesses the cumulative effects of discharges from the Coronation and

Golden Point Pits and associated WRSs on the nearby Deepdell Creek, and Frasers and Golden Bar Pits and WRSs on the North Branch Waikouaiti River.

1.2 Coronation Pit extension – brief description

The existing Coronation Stage 5 pit (CO5) is located approximately 5 km north of the Macraes Gold Processing Plant, 7 km northwest of Macraes village and to the immediate north of Taieri Ridge, within the Taieri River catchment (Figure 1). The area is located within OceanaGold owned land and within Mining Permit 41064. The Coronation project includes:

- Creating a new Coronation Stage 6 pit by expanding approximately 250 m to the south-east over rank pasture and harvested pine forest; and
- Backfilling the existing Coronation North pit with the waste rock produced from CO6.

No new disturbance is created by the waste rock disposal.

Ore will be transported directly to the processing plant with mine trucks using the existing haul road.

The CO5 pit is currently being used as a water storage reservoir. This will need to be emptied prior to the progression of CO6 stripping. This water is intended to be pumped back to the Processing Plant and/or Deepdell North Pit.

It is not intended to backfill CO6 and eventually it will form a pit lake merged with the CO5 void. Waste rock generated from CO6 will be used to infill the Coronation North pit void, quickly followed by capping and vegetation as part of the rehabilitation process.

The locations of these components are shown in Figure 2.

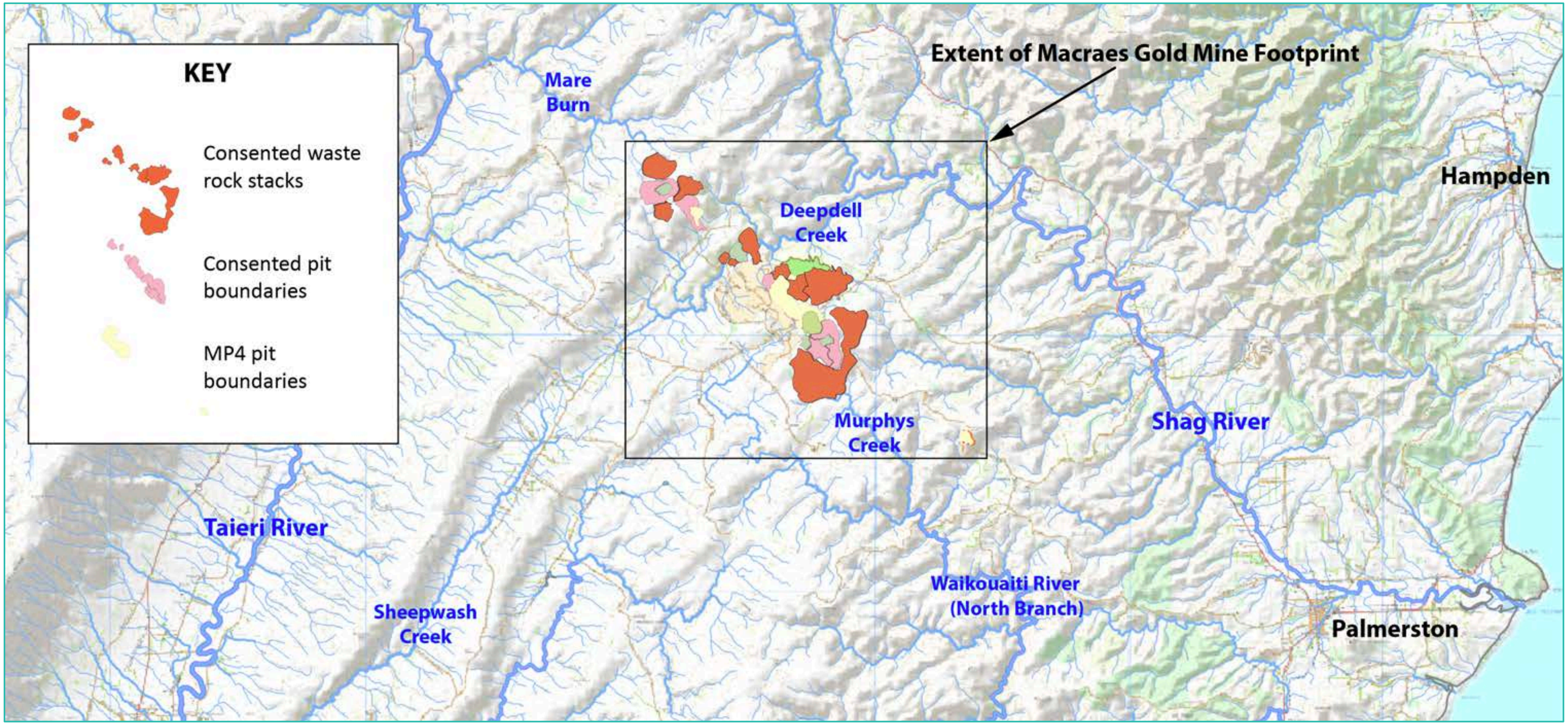

Figure 1. Map showing general location of the Macraes Gold Mine and extent of existing mining operations.

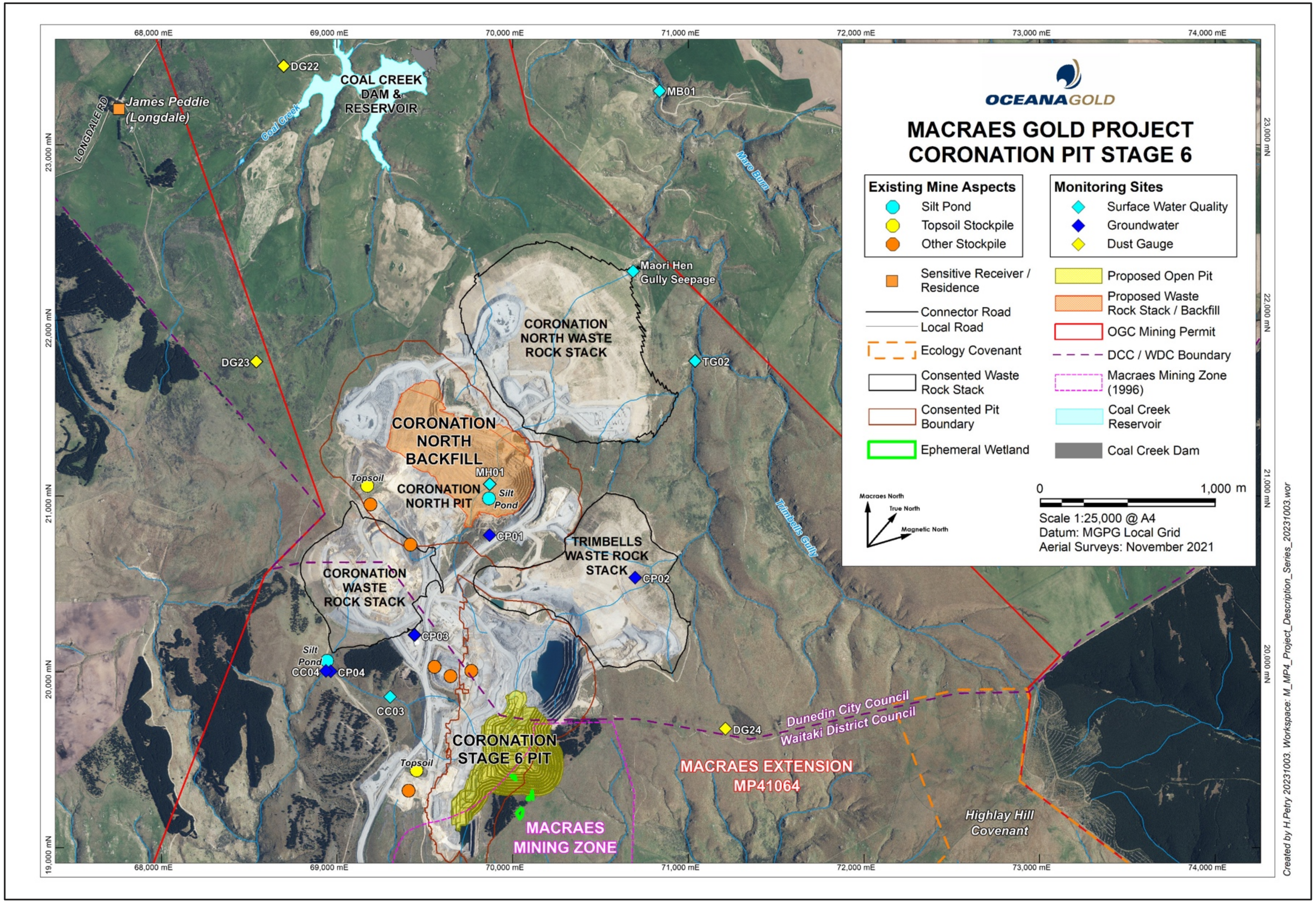

Figure 2. Aerial close-up map showing the Coronation mining area and proposed open pit (CO6) and proposed Coronation North pit backfilling.

1.3 Assessment methods

This report reviews existing surface water ecology and water quality of the Mare Burn catchment and considers the potential effects on Mare Burn surface waters as a result of the construction and operation of CO6 and the new backfill area in the Coronation North Pit.

Regular biological monitoring of the Mare Burn catchment at three surface water monitoring sites (Figure 3, plates 1 and 2) has taken place since 2017 as a requirement of resource consent conditions, including annual summer surveys of fish populations and quarterly surveys of benthic communities (algae, macrophytes and macroinvertebrates).

Plate 1. TG01 monitoring site (Trimbells Gully), spring 2021.

Plate 2. Mare Burn monitoring sites (left: MB01, right: MB02, spring 2021.

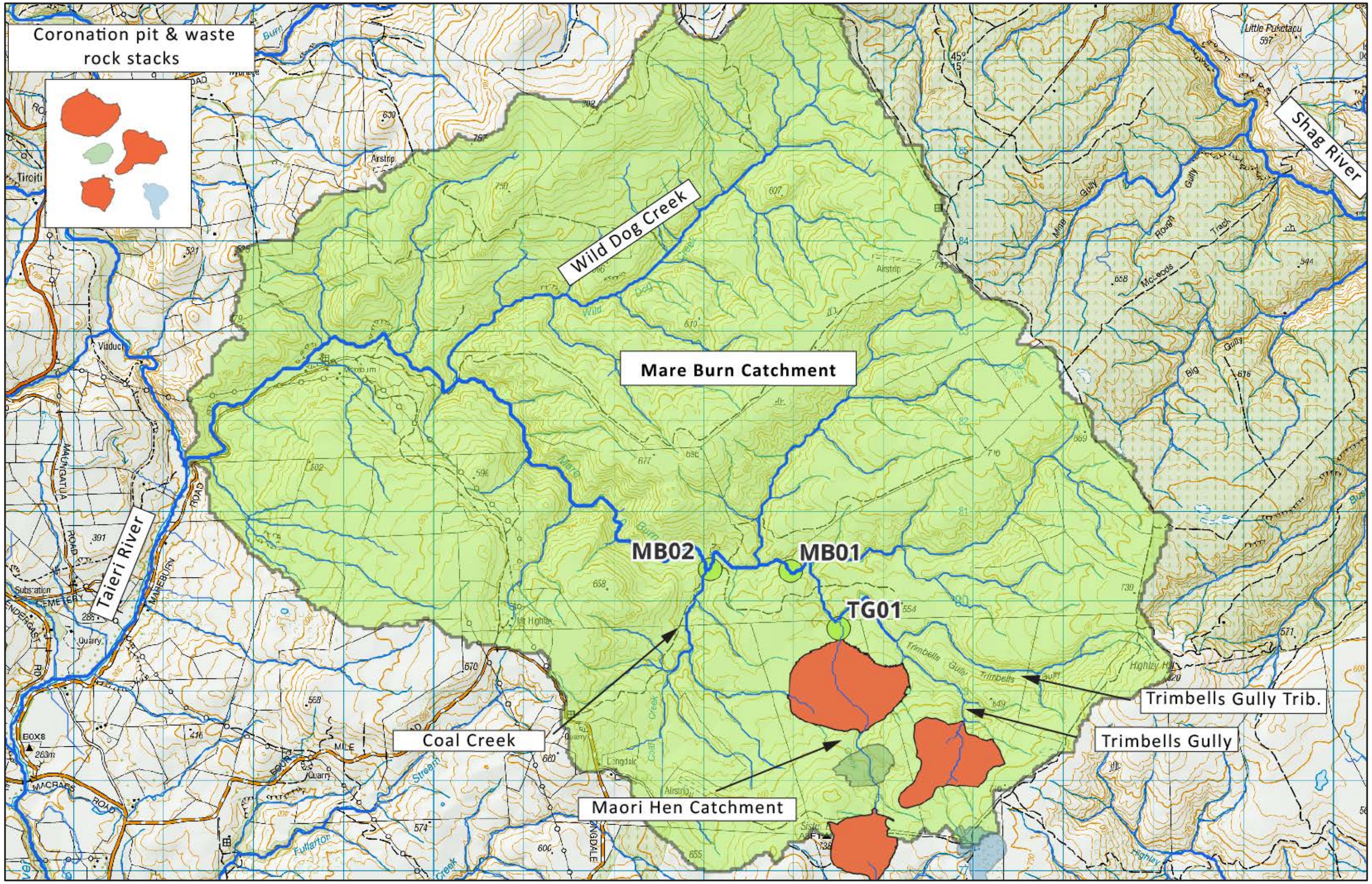

Figure 3. *Map showing general location of the Macraes Gold Mine and extent of existing mining operations.*

2 EXISTING VALUES

2.1 General character

The existing consented Coronation Mine area is located partly in the headwaters of Camp Creek, a major tributary of Deepdell Creek (which is situated adjacent to other Macraes Gold Project mining operations), but primarily in the headwaters of Maori Hen Creek and a major tributary of Trimbells Gully, known as Trimbells Gully Tributary (or Trimbells Gully Trib. – Figure 3). Both Māori Hen Creek and Trimbells Gully are tributaries of the Mare Burn, which flows into the Taieri River approximately 12 km downstream of the confluence of Māori Hen Creek and Trimbells Gully (Figure 1). The Mare Burn catchment is approximately 6,550 ha in area, or about 1.15 % of the Taieri River catchment.

The headwaters of Māori Hen Creek are situated in the vicinity of the Sister Peaks at an altitude of approximately 680m asl (above sea level). The headwaters of Trimbells Gully Tributary are in the vicinity of Highlay Hill, at elevations up to approximately 820 m asl. Both catchments drain in a north-westerly direction and join several other named and unnamed tributaries flowing into the Mare Burn (Figures 1 and 3).

The boundary of the Coronation Mine area envelopes almost the entire catchment of Maori Hen Creek, a tributary of Trimbells Gully. Prior to the commencement of modern mining (ca. 1990s), the upper reaches of Maori Hen Creek were comprised of a tussock and pasture filled basin. Stream ecosystem values were low. This section of the catchment has now been mined. Further downstream, the creek flows through a gully dominated by tussocks and pasture grasses, grazed by cattle and sheep. Instream habitat through the gully is comprised of shallow riffles, runs and small drops and pools. Bed substrate is dominated by gravels and cobbles, with some areas of boulders and bedrock. There is evidence of stock damage to the channel, particularly in the lower reaches.

The headwaters of Trimbells Gully Tributary is now largely occupied by the Coronation Mine area (Figures 2 and 3). Further downstream, the Trimbells Gully Tributary channel is well defined and incised in places. Several bedrock sections create small waterfalls and steep drops. Small pools (up to 35-45cm deep) form downstream of bedrock sections, however overall, water depth is shallow.

2.2 Water quality

There are surface water quality monitoring and compliance points on the Mare Burn (compliance points are MB01 and MB02 and there is also ecological monitoring at these sites along with TG01 on Trimbells Gully; see Figure 3), established by the consenting of the Coronation and Coronation North projects. A summary of the water quality compliance criteria associated with MB01 and MB02 is presented in Table 1[1]. These criteria are applied as a reference for assessing existing water quality, together with other frequently used criteria and guidelines (see further below).

Table 1. OceanaGold compliance limits for the Mare Burn. All units m^3/sec (mg/L) except for pH.

Compliance Parameter	Mare Burn @ MB01	Mare Burn @ MB02
pH (pH units)	6.0 - 9.5	6.5 - 9.5
Arsenic[2]	0.15	0.15
Cyanide (WAD)	0.1	0.1
Copper[1]	0.009	0.009
Iron	1.0	1.0
Lead[1]	0.0025	0.0025
Zinc[1]	0.12	0.12
Sulphate	1,000	1,000
Nitrate-N	-	2.4
Ammoniacal-N	-	0.24
Turbidity	-	30-50% change in clarity
Suspended solids	-	30-50% change in clarity

1 Metal limits hardness adjusted as per the equations below:

- Copper (g/m^3) = $(0.96\exp^{0.8545[\ln(\text{hardness})]} – 1.702) / 1000$
- Lead (g/m^3) = $(1.46203 – [\ln(\text{hardness})(0.145712)]^{\exp 1.273[\ln(\text{hardness})]} -4.705) / 1000$
- Zinc (g/m^3) = $(0.986\exp^{0.8473[\ln(\text{hardness})]} + 0.884) / 1000$

2 The limit for arsenic is equivalent to the criterion continuous concentration (CCC) for arsenic identified in USEPA (2020) for freshwater aquatic life. The CCC is an estimate of the maximum concentration of a material in water that aquatic communities can be indefinitely exposed to without causing adverse effects.

A summary of the water quality at these monitoring sites is presented in Table 2 and concentrations over time for sulphate, ammoniacal-N and nitrate-nitrite-N (predominantly nitrate) are graphically presented in Figures 4, 5 and 6. The data show that the surface waters are typically slightly alkaline and within the consent compliance range. Concentrations of dissolved metals and cyanide are all within consent compliance limits and often below laboratory detection limits.

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[1] There are no nitrate-nitrite-N or ammoniacal-N compliance limits for MB01.

Table 2. Water quality statistics for Mare Burn catchment surface water monitoring sites, Macraes Gold Project, 2014 – 2022.

Parameter	MB00			MB01			MB02			TG01			TG02		
	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min
pH (pH units)	8.0	7.5	6.4	8.4	7.7	6.5	8.2	7.7	6.5	8.0	7.4	6.5	8.3	7.7	6.8
TSS (g/m^3)[2]	10	3	3	19	3	3	10	3	3	300	10	3	10	3	3
Turbidity (NTU)	3.9	1.4	0.3	10.8	1.5	0.2	11.3	2.1	0.2	16.6	2.6	0.2	5.0	1.5	0.1
Nitrate-Nitrite-N (g/m^3)	2.900	0.007	0.002	17.200	0.700	0.002	13.600	0.325	0.002	23.000	0.017	0.002	18.300	1.385	0.002
Ammoniacal-N (g/m^3)	0.012	0.010	0.010	0.750	0.010	0.010	1.260	0.010	0.010	2.100	0.010	0.010	0.900	0.010	0.010
Conductivity (µS/cm)	380	69	49	419	138	60	349	143	77	573	67	46	531	192.5	77
Chloride (g/m^3)	13	5	3.1	13	5	2.9	11	6	4	16.3	5	1.6	14	5	4.8
Hardness-Total (g/m^3 as $CaCO_3$)	250	25.5	11.5	490	63	15	390	63	22	530	24	9.8	660	110	24
Sulphate (g/m^3)	183	5	1.5	350	24	1.3	270	23	4.8	370	5	0.5	560	53	9
Arsenic-Diss (g/m^3)	0.010	0.002	0.001	0.010	0.0011	0.001	0.010	0.002	0.001	0.003	0.001	0.001	0.010	0.001	0.001
Copper-Diss (g/m^3)	0.0050	0.0006	0.0005	0.0050	0.0006	0.0005	0.0050	0.0006	0.0005	0.0010	0.0005	0.0005	0.0050	0.0006	0.0005
Iron-Diss (g/m^3)	0.720	0.280	0.090	0.540	0.150	0.020	0.840	0.250	0.100	0.580	0.160	0.020	0.380	0.130	0.020
Lead-Diss (g/m^3)	0.0010	0.0001	0.0001	0.0018	0.0001	0.0001	0.0010	0.0001	0.0001	0.0001	0.0001	0.0001	0.0010	0.0001	0.0001
Zinc-Diss (g/m^3)	0.010	0.001	0.001	0.017	0.001	0.001	0.015	0.001	0.001	0.008	0.001	0.001	0.115	0.006	0.001
Cyanide (WAD) (g/m^3)	0.020	0.020	0.001	0.030	0.009	0.001	0.030	0.020	0.001	0.001	0.001	0.001	0.020	0.001	0.001

[2] g/m^3 is equivalent to mg/L.

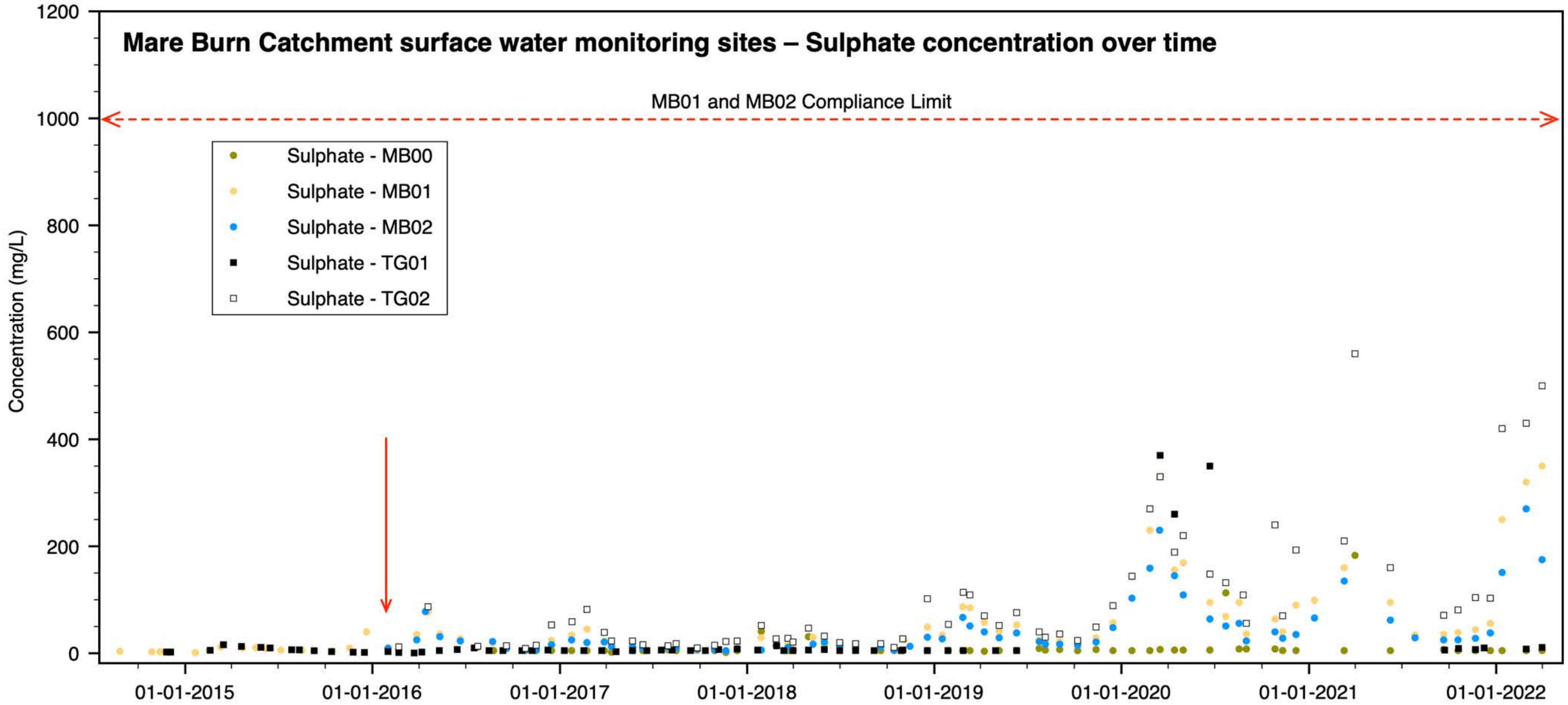

Figure 4. *Sulphate concentrations at Mare Burn catchment surface water monitoring sites, together with consent compliance limits. Vertical red arrow indicates approximate time mining commenced.*

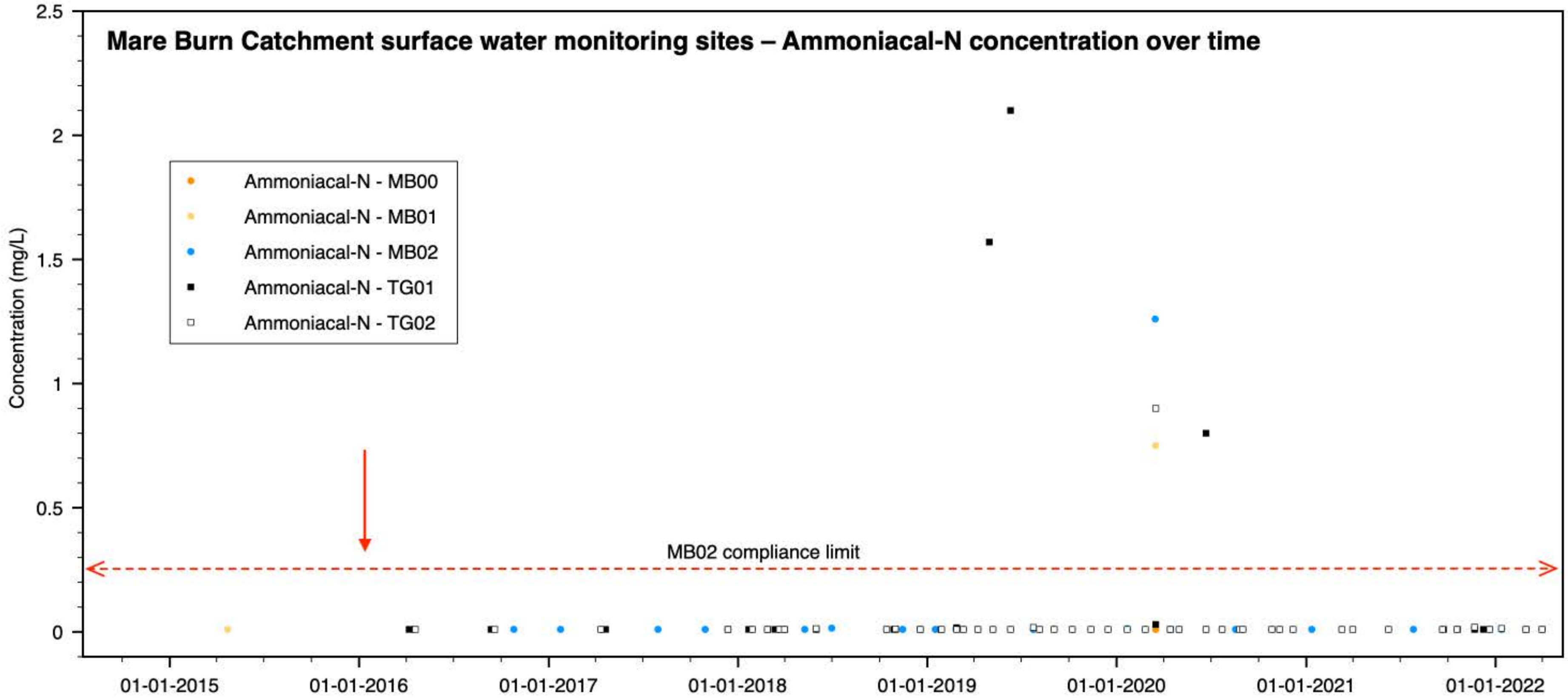

Figure 5. *Ammoniacal-N concentrations at Mare Burn catchment surface water monitoring sites, together with the consent compliance limit for MB02. Vertical red arrow indicates approximate time mining commenced.*

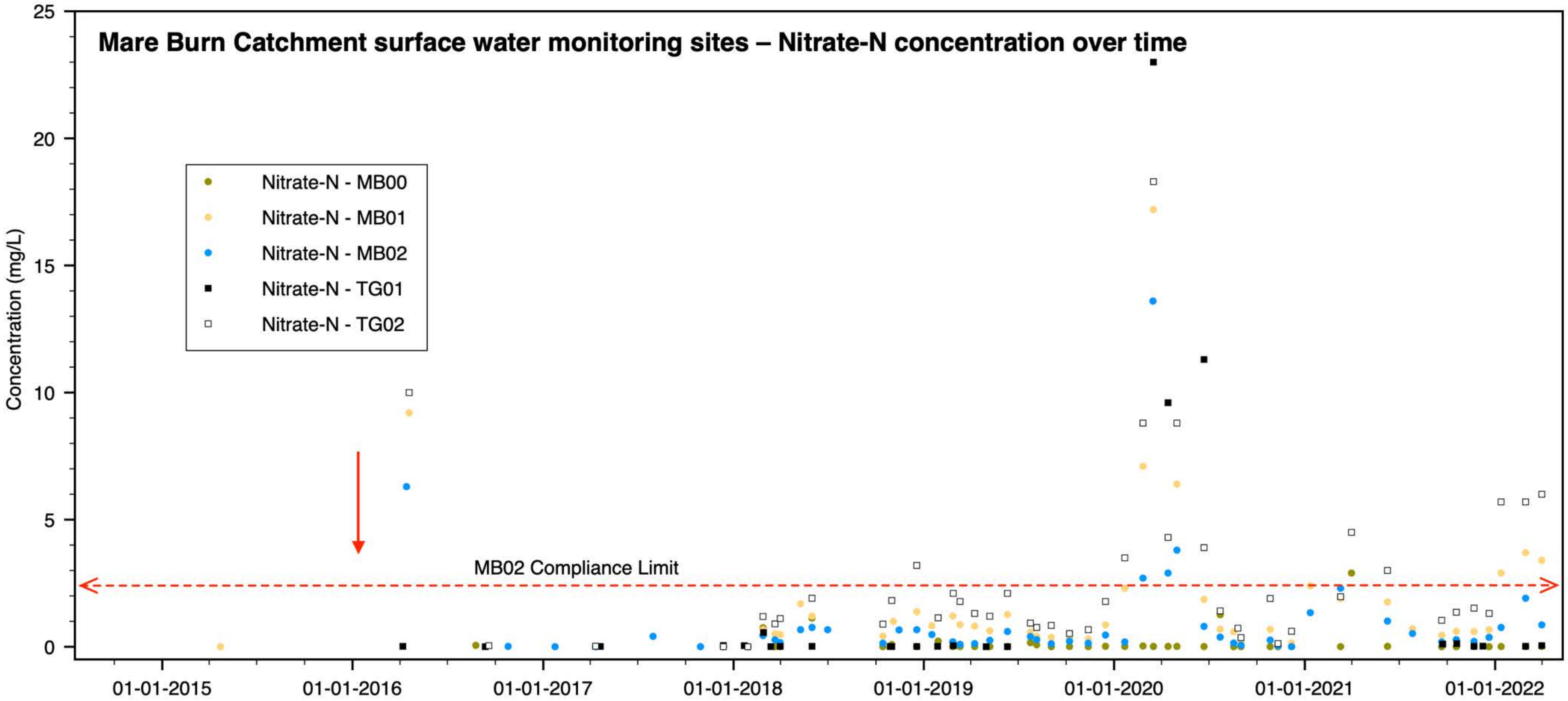

Figure 6. *Nitrate-N concentrations at Mare Burn catchment surface water monitoring sites, together with the consent compliance for MB02. Vertical red arrow indicates approximate time mining commenced.*

Sulphate concentrations have increased over time at sites TG01, MB01 and MB02 as a result of leaching and seepage from the waste rock stacks (Figure 4) but remain below respective compliance limits at MB01 and MB02.

Ammoniacal-N concentrations are generally very low apart from a couple of occasions between 2019 and 2020 (Figure 5). Nitrite-nitrate-N concentrations are more variable with some sites showing quite elevated levels in recent years (Figure 6). The maximum ammoniacal-N and nitrate-nitrite-N concentrations in Table 2 for sites MB01, MB02 and TG02, and TG01 for nitrate-nitrite-N, all occurred on the same monitoring occasion (16-17 March 2020) (see figures 4 and 5). Sulphate concentrations were also relatively elevated at these sites on this occasion, although still within respective compliance limits for MB01 and MB02 (Figure 6).

The ammoniacal-N and nitrate-N exceedances are all related to pit water discharges and not to normal day-to-day operations (Debbie Clarke, OceanaGold, pers. comm.)[3].

2.3 Stream ecology

2.3.1 Algae & macrophytes

Algae (periphyton) and macrophyte cover is assessed at Mare Burn catchment monitoring sites (TG01, MB01, MB02) seasonally each year. Mat algae cover usually dominates all three sites, but filamentous algae cover can be observed on occasions and its presence appears to be seasonally dependent.

Macrophytes can be abundant at MB01 in summer (69 % cover), but can drop away to less than 1 % at other times of the year. Macrophyte and periphyton cover vary seasonally and from year to year, and this is likely to be due to the seasonal influence of temperature and the frequency and duration of stable flows and flood flows.

2.3.2 Benthic Macroinvertebrates

Comparisons of the benthic invertebrate communities from the 2017 (when regular monitoring commenced, Ryder Environmental 2018), 2021 (Alden *et al*. 2022) and 2022 (Alden *et al*. 2023) surveys have been presented below, with a focus on mayfly densities and the

[3] There were several issues with pipe failures, drainage washouts and the like. March 2020 was particularly bad where there was a pipe blow out that was not detected and acted upon promptly (partly due to the Covid lockdown). Pit water can be high in nitrate and somewhat elevated in sulphate.

QMCI health index scores. Benthic macroinvertebrate data tables for 2021 and 2022 surveys are presented in appendices A and B.

Mayfly densities were lowest at TG01 throughout 2017 when compared to MB01 and MB02 (Figure 6). Densities were consistent throughout 2017 at TG01, but were variable at both of the Mare Burn sites. The highest mayfly densities were at MB02 in autumn (~2,500/m^2).

For 2021, the mean mayfly density was lowest at TG01 in autumn (50/m^2) and was lower than at the other two sites on all sampling occasions. Mayfly density decreased considerably in spring at MB01 and MB02 (Figure 7). However, mayfly densities were relatively high at MB01 and MB02 in three out of four seasons and were higher than those recorded in 2017 (Figure 7). For 2022, the highest mayfly densities were found at MB01 in summer and autumn (>3,000/m^2). As in 2021, the mayfly density decreased considerably in spring at MB01 and MB02. Mean mayfly density was consistently low at TG01 on all sampling occasions (0-270/m^2) (Figure 8).

In 2017, QMCI scores were similar at all three sites although highest at MB02 in autumn and winter (Figure 8). Scores were indicative of 'poor-fair' quality conditions at TG01, 'poor' to 'poor-fair' quality conditions at MB01, and 'poor' to 'fair-good' quality conditions at MB02, using the narrative terminology of Stark and Maxted (2007, Table 3).

In 2021, QMCI scores at TG01 indicated 'poor' quality conditions, while scores at MB01 and MB02 were higher and indicative of 'poor' to 'fair' and 'poor' to 'good' quality conditions, respectively. In 2022, QMCI scores at MB01 and TG01 indicated 'poor' to 'fair' quality conditions (Figure 8). QMCI scores at MB02 also indicated 'poor' to 'fair' quality conditions, except in winter when 'good' quality conditions were indicated (Figure 8).

Generally speaking, mayfly densities and QMCI scores at MB01 and MB02 are very similar for 2017 and 2021/2022 indicating no adverse effects as a result of mining. These health metrics for TG01 are more degraded in 2021 relative to 2017. There is no clear reason why this in the case, although TG01 is a smaller tributary and located further up the catchment, and subsequently is probably more likely subject to the effects of low flows in the warmer months of the year. Monitoring of Mare Burn surface waters is still in its infancy and as such long-term trends have yet to be determined.

Table 3. *Narrative descriptions of NPS-FW NOF bands for QMCI together with the interpretation of Stark and Maxted (2007) (Quality class B).*

NPS-FW NOF 2020	**A**	**B**	**C**	**D**
QMCI range	≥ 6.5	< 6.5 – ≥ 5.5	<5.5 – ≥ 4.5	< 4.5
NPS-FW 2020 band narrative descriptions	Macroinvertebrate community indicative of pristine condition with almost no organic pollution or nutrient enrichment.	Macroinvertebrate community indicative of mild organic pollution or nutrient enrichment.	Macroinvertebrate community indicative of moderate organic pollution. There is a mix of taxa sensitive and insensitive to organic pollution/nutrient enrichment.	Macroinvertebrate community indicative of severe organic pollution or nutrient enrichment. Communities are largely composed of taxa insensitive to (in)organic pollution/nutrient enrichment.
Stark and Maxted (2007)	**Excellent**	**Good**	**Fair**	**Poor**

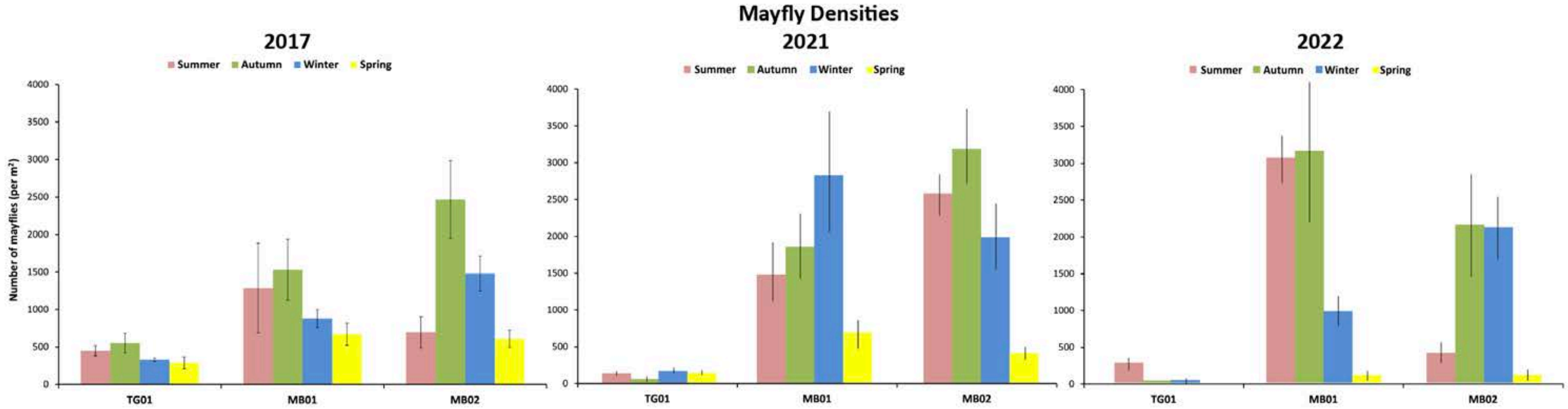

Figure 7. *Average mayfly densities for Trimbells Gully (TG01) and the Mare Burn (MB01 and MB02), Left: 2017, Middle: 2021, Right: 2022. Standard error bars are shown.*

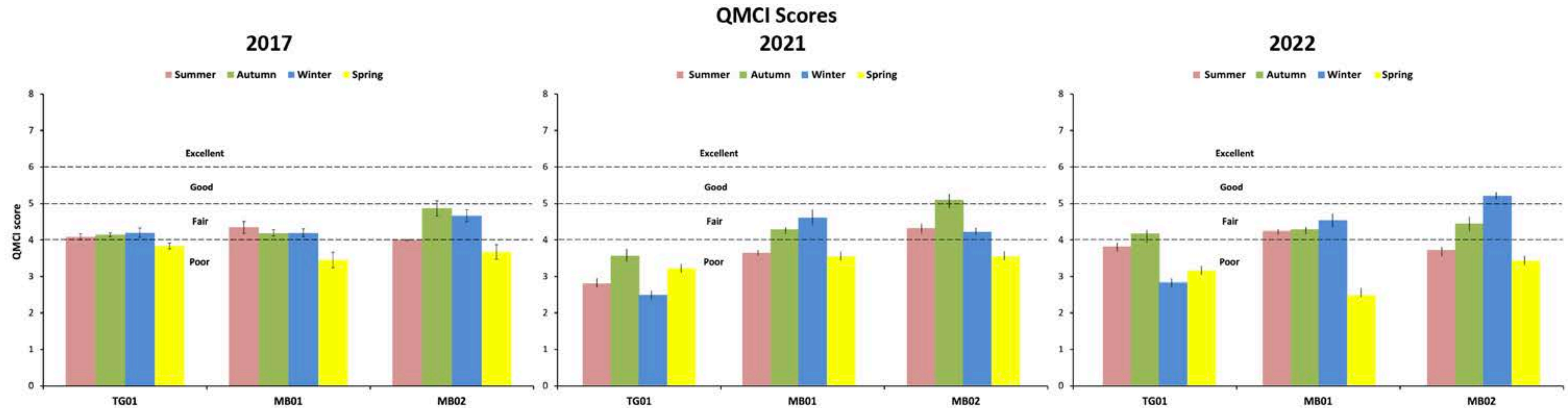

Figure 8. *Average QMCI scores for Trimbells Gully (TG01) and the Mare Burn (MB01 and MB02) , Left: 2017, Middle: 2021, Right: 2022. Standard error bars are shown.*

2.3.3 Fish

The Taieri flathead galaxiid (*Galaxias depressiceps*) (Plate 3) is by far the dominant fish species in the Mare Burn catchment, having been found in a number of tributaries surveyed. Brown trout have previously been recorded in the catchment, but only in the lower reach near the confluence with the Taieri River. There is at least one known fish barrier on the lower Mare Burn – a farm dam. This dam probably restricts trout from gaining access further up the catchment, which is positive for the catchment's galaxiid population.

Ryder Environmental freshwater ecologists sighted an adult eel (tuna) in Trimbells Gully (at monitoring site TG01) in 2016, but there are no other records for tuna in this catchment.

Plate 3. Flathead galaxias caught at Trimbells Gully tributary - lower in November 2012.

Annual quantitative electric fishing surveys have been undertaken at three monitoring sites (MB01, MB02, TG01) in late summer/early autumn since 2017. Flathead galaxias are commonly found at all three sites along with freshwater crayfish (kōura).

For the late summer 2021 survey, 41 galaxiids were caught at MB01, ranging between 40-90 mm long (Figure 9), 92 galaxiids were caught at MB02, ranging between 42-98 mm long, and 81 galaxiids were caught at TG01, ranging between 39-90 mm long. At all sites, most galaxiids were between 40-50 mm long. The 2021 summer population estimate was highest at MB02, followed by TG01 and then MB01.

For the late summer 2022 survey, 149 galaxiids were caught at MB02 ranging in length between 38-100 mm, 71 were caught at MB01 (length range 30-82 mm), and 32 were caught at TG01 (length range 34-66 mm) (Figure 9).

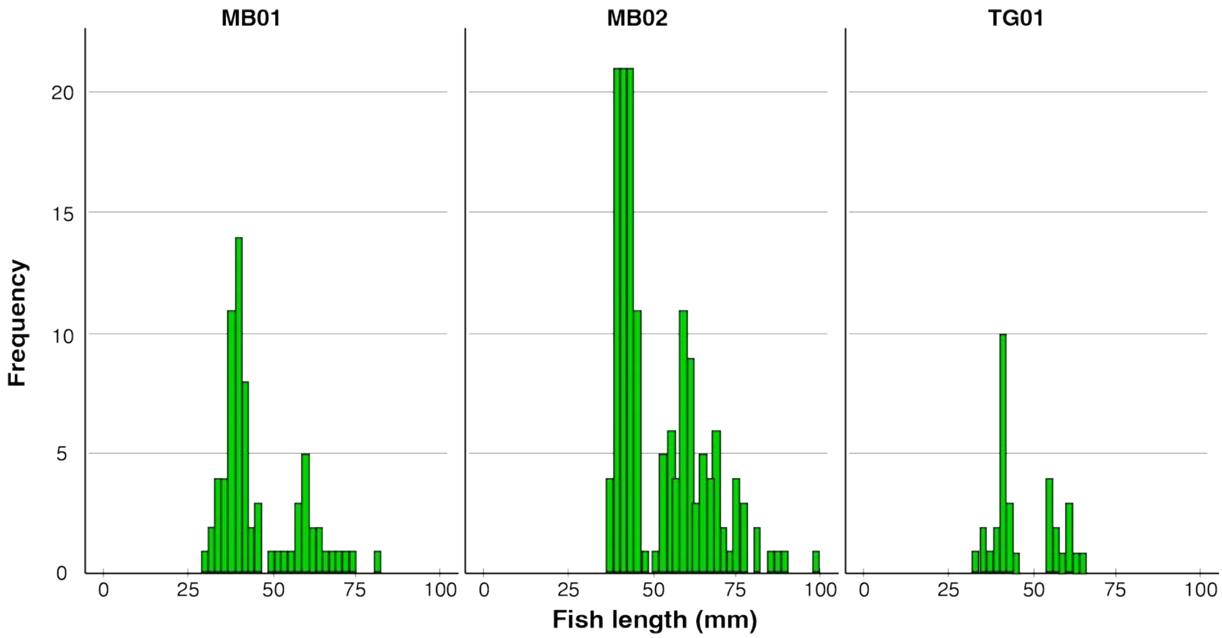

Figure 9. Length-frequency distributions of flathead galaxiids, Mare Burn catchment, summer 2022.

MB02 had the highest population estimate for 2022, followed closely by MB01 and then TG01 (Figure 10). While MB01 and MB02 both recorded the highest number of galaxiid counts and population estimates since monitoring started, the estimated density at TG01 was lower than in the previous two surveys (Figure 10).

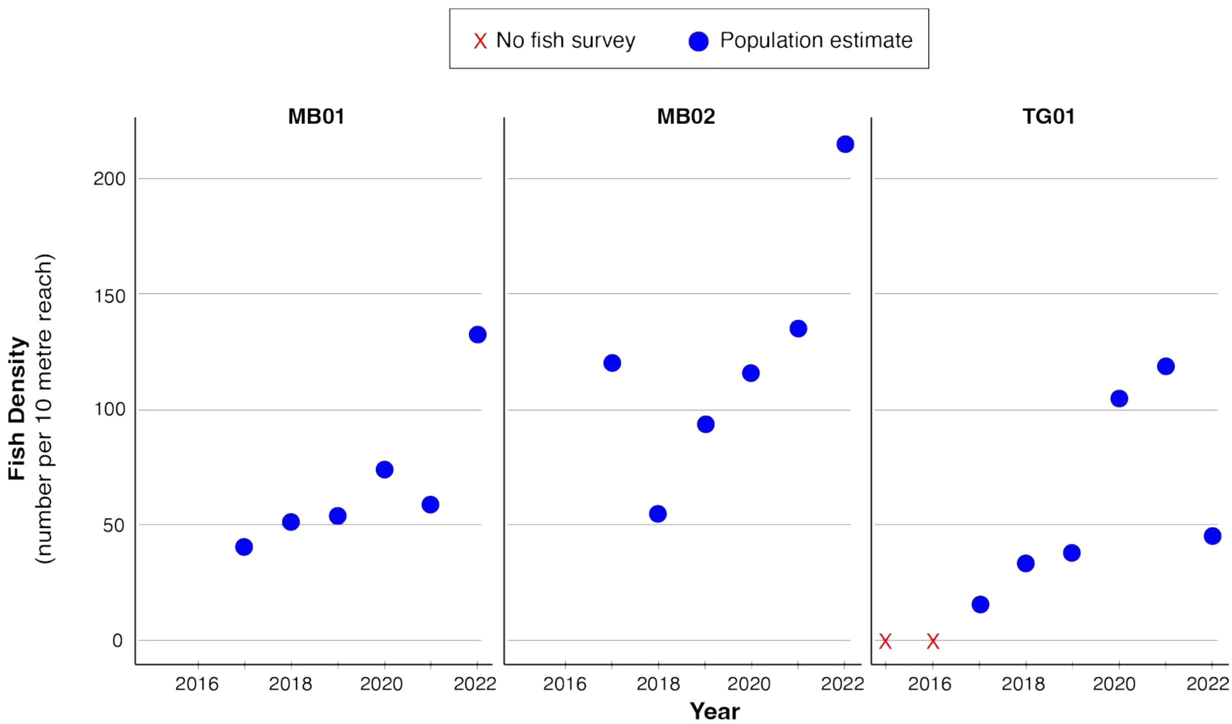

Figure 10. Galaxiid population estimates (blue circles) for Mare Burn catchment sites from 2015 to 2022. 'X' denotes periods when no electric fishing occurred. Note that 2018 data is calculated from fishing undertaken in winter 2018.

3 SUMMARY OF NATURAL VALUES

Schedule 1A (natural values) of the ORC Regional Plan: Water identifies significant aquatic values of the Mare Burn catchment. Listed values are the provision of areas for salmonid spawning and development, and the presence of riparian vegetation of significance to aquatic habitats. Assessments over the past 10 years or so have not identified the presence of any suitable salmonid spawning habitat, nor have any salmonids been caught in Mare Burn tributaries within the areas surveyed within, downstream and adjacent to the Coronation mine footprint. It is likely that this type of habitat is located much further downstream in the catchment towards the Taieri River. As previously noted, barriers to upstream passage are also likely to restrict the presence of salmonids in the upper Mare Burn catchment.

The presence of 'riparian vegetation of significance to aquatic habitats' is not elaborated on further in the plan, but presumably this is referring to the presence of overhanging tussocks.

Non-migratory galaxiids

The flathead galaxias is common and a widely distributed native fish species throughout the Macrae's district, and is common in the Mare Burn and Mare Burn tributaries. As noted in the previous reports (Ryder 2023b), monitoring over several decades has indicated that the population is significant and reasonably resilient to algae blooms, physical disturbance (e.g., large floods and stock damage), droughts and changing water quality, including the effects of mining on water quality.

The flathead galaxiid population present in the Shag River (which Deepdell Creek discharges into), Waikouaiti River, and Taieri River catchments are all being managed as *Galaxias depressiceps* K Taieri flathead galaxias. The Taieri flathead galaxias has been classified by the Department of Conservation as 'Threatened – Nationally Vulnerable', with criteria C (3) (moderate population, with population trend that is declining, total area of occupancy ≤ 100 ha (1 km^2), predicted decline 10–50%) and the qualifiers 'Conservation Dependent' and 'Data Poor' (Dunn *et al.* 2018). The geographic range of this species has decreased substantially in the last 150 years, since the introduction of invasive fish species (e.g., brown trout) and its distribution is now highly fragmented (Department of Conservation 2004, Jones 2014).

Other fish species

One eel has been observed in the upper catchment, but electric fishing and trapping surveys over several years have failed to capture or observe tuna. While longfin tuna is classified by the Department of Conservation as 'At Risk – Declining' (Dunn *et al*. 2018), the creek does not appear to be an important habitat for this species. This is probably beneficial for the local galaxiid and kōura populations.

Kōura

Freshwater crayfish or kōura (*Paranephrops zealandicus*) are common at Mare Burn catchment monitoring sites. Their relatively high abundance in some creeks is surprising given that habitat appears limited by a lack of flow and wetted habitat at times, particularly during late summer and into autumn, observations that also apply in the nearby Deepdell Creek catchment. Freshwater crayfish have been classified as ‘At Risk – Declining’ with the qualifier ‘Partial Decline’ (Grainger *et al.* 2018).

Benthic macroinvertebrates

The benthic macroinvertebrate fauna of the Mare Burn is not noted for its ecological significance. No taxa have been identified as having high conservation value and most monitoring sites are dominated by taxa that are tolerant of relatively poor water quality and poor habitat quality conditions.

4 ASSESSMENT OF EFFECTS & RECOMMENDED MITIGATION

4.1 Hydrology

The expansion areas do not encroach on any tributaries within the Mare Burn catchment, as such there will be no changes to the surface catchment geomorphology of the Mare Burn and its tributaries as a result of the proposed pit expansion and backfill.

Water balance modelling undertaken by GHD (2024) predicts that dewatering rates from the proposed Coronation Stage 6 pit expansion could range from 2.0 L/s (at the beginning of the excavation) to 0.8 L/s (towards the end)[4]. GHD report that a small reduction (~1 L/sec) is expected in the groundwater contributions to the Mare Burn Creek flows due to pit dewatering, representing approximately 4.5% of the estimated total groundwater contribution. This potential flow reduction can be considered minor with respect to surface flows in the Mare Burn and unlikely to influence the ecology of local creeks through physical changes to the watercourses.

The Coronation pit lake will eventually fill and overflow after a period of approximately 200 years post closure (GHD 2024), however this overflow will flow towards the Deepdell Creek catchment (via the Highlay Creek sub-catchment). Up to the elevation of its overflow level controlled by a spillway at 660 m RL, pit lake water will seep through the Trimbells WRS to the north (i.e., to the Mare Burn catchment) via the waste soils above the in situ schist elevation (at 640 m RL) after a post closure period of approximately 90 years (Figure 11). The volume of water discharging through this seepage flow path is predicted to increase as the lake level rises until the pit lake overflow level (660m RL) is reached (GHD 2024). The GHD water balance model estimates the groundwater loss through the Trimbells WRS pathway rising from 0 L/sec to a maximum rate of 0.61 L/sec (GHD 2024). Again, as for small reductions in flow associated with pit dewatering, this potential small increase in flow can be considered minor with respect to surface flows in the Mare Burn and unlikely to influence the ecology of local creeks.

[4] Mining and associated dewatering of the proposed new pit CO6 has been simulated in the water balance model from 2024 – 2026 as per the Macraes mining schedule (GHD 2024).

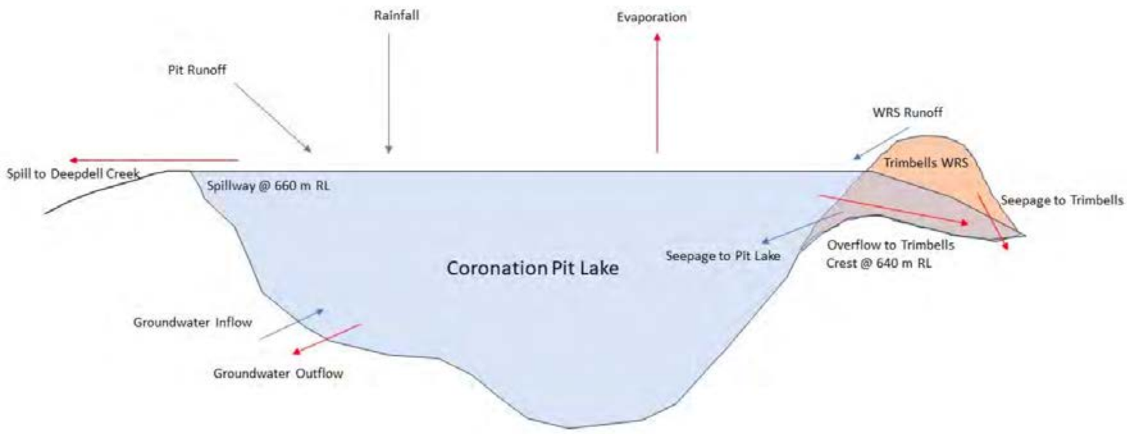

Figure 11. Coronation pit lake water balance – long term conceptual summary. (source: GHD 2024)

4.2 Water quality

The GHD (GHD 2024) water balance and contaminant mass transport models were developed to assess surface water quality during mining and after mine closure at the existing compliance points MB01 and MB02, and at the discharge point into Trimbells Gully. The modelling incorporated contributions from existing mine elements within the catchment, including the Coronation North Pit, Coronation, Coronation North and Trimbells Gully Waste Rock Stacks. Recent (2020-2022) and model predictions of long-term (2050-2260) water quality data for MB01 and MB02 have been assessed against Australian and New Zealand default guideline values for fresh water quality (ANZG 2018) for metals and cyanide, NPS-FW (2020) attribute states for ammoniacal-N and nitrate-N, and British Columbia Ministry of Environment guidelines (2013) for sulphate. These are summarised in Table 4 and discussed below.

Ammoniacal-N and Nitrate-Nitrite-N

Despite the historic and very occasional spikes in ammoniacal-N and nitrate-nitrite-N concentrations described in Section 2.2 (due to accidental discharges), both current and predicted long-term concentrations sit within NOF[5] bands A or B of their respective NPS-FW attribute states and within current compliance limits (figures 12 and 13, tables 5 and 6). Long-term concentrations of both ammoniacal-N and nitrate-nitrite-N are predicted to decrease relative to current levels.

Sulphate

In general, sulphate is predicted to increase in the modelled closure and long-term scenarios relative to the mining and closure period. The increase in sulphate is associated with a relative greater increase in sulphate concentration and mass from seepage water (from the existing

[5] The Government has set out a 'National Objectives Framework' (NOF) directing how regional councils should set objectives, policies and rules about fresh water in their regional plans.

Trimbells waste rock stack and pit lake) over time (GHD 2024).

While sulphate is the only contaminant that is predicted to increase over and above current concentrations, predicted future 95th percentile concentrations in the Mare Burn at MB01 and MB02 are well below the current consent compliance limit (Table 1) and would largely meet the British Columbia guideline of 309 mg/L for soft/hard to hard water (76-180 mg/L[6]) (Table 4). Increases in water hardness reduce the toxicity of sulphate. There is also evidence to suggest that concentrations higher than this would not adversely affect the local flathead galaxias population or the benthic invertebrate community in general, as discussed further below in section 4.5.

Cyanide

Modelling reported in GHD (2024) suggests that cyanide is unlikely to exceed its consented concentrations at either MB01 or MB02 throughout both the duration of the operational period and post closure period. Assessing cyanide(WAD) is problematical in that the current laboratory detection level used by Hill Laboratories is higher than the ANZG default guideline value of 0.007 mg/L (for protection of 95% of species). While laboratory testing results have frequently indicated that cyanide concentrations are lower than the lab's detection limit, changes to the lab testing procedure are necessary in order to determine the actual concentration more accurately.

Metals

Modelling of arsenic, cyanide, copper, iron, lead and zinc concentrations indicates that they are unlikely to exceed their current consented compliance limits at either MB01 or MB02 throughout both the duration of the operational period and post closure period (GHD 2024). Further, current and predicted long-term metal concentrations meet their respective ANZG default guideline values for protection of 95% of species (Table 4), even without adjusting for hardness. Increases in water hardness reduce the toxicity of some metals. Updated guidance on guideline-value derivation by Batley *et al.* (2018[7]) and Warne et al. (2018[8]) advised that hardness adjustments should still be incorporated for hardness-sensitive metals (cadmium, chromium, lead, nickel, zinc). Increases in water hardness reduce the toxicity of some metals.

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[6] Average hardness at the Mare Burn monitoring sites is currently in excess of 100 mg/L.

[7] Batley, GE, van Dam, RA, Warne, MStJ, Chapman, JC, Fox, DR, Hickey CW & Stauber, JL, 2018, Technical Rationale for Changes to the Method for Deriving Australian and New Zealand Water Quality Guideline Values for Toxicants, CSIRO Land and Water Report, Lucas Heights.

[8] Warne, MStJ, Batley GE, van Dam RA, Chapman JC, Fox DR, Hickey CW & Stauber JL 2018, Revised Method for Deriving Australian and New Zealand Water Quality Guideline Values for Toxicants, Australian Government Department of Agriculture and Water Resources, Canberra.

Table 4. Current and predicted long-term water quality statistics for Mare Burn catchment surface water monitoring sites MB01 and MB02 compared against Mare Burn surface water compliance limits and current applicable water quality guidelines (ANZG 2018, NPS-FW B band attribute states and alternative published guidelines for sulphate and iron).

** Recommended for application for slightly to moderately disturbed ecosystems (for protection of 95% of species). ** Adjusted for hardness using algorithms. † MB02 only. †† Water quality data from Tables 5.8 and 5.9 of GHD Coronation report (2024).*

Parameter (all units mg/L)	**Mare Burn compliance limits for MB01 and MB02**	**DGV guidelines†** (ANZG 2018) (Mare Burn's REC is Cool Dry Hill)	**Alternative guideline**	**Attribute state** NPS-FW (2020) (B band - 95% species protection level)	**MB01††** Current [2020-2022] median & (95th percentile)	**MB01††** Long-term [2050-2260]	**MB02††** Current [2020-2022] median (95th percentile)	**MB02††** Long-term [2050-2260]
Ammoniacal-N	0.24†			>0.03 and ≤0.24 annual median >0.05 and ≤0.40 annual 95th percentile	0.019 (0.110)	0.012 (0.019)	0.034 (0.061)	0.011 (0.015)
Nitrate-N	2.4†			>1.0 and ≤2.4 annual median >1.5 and ≤3.5 annual 95th percentile	0.4 (1.8)	0.5 (2.1)	0.3 (0.8)	0.4 (1.2)
Sulphate	1,000	(No guideline specified)	309 mg/L for moderately soft/hard to hard water (76-180 mg/L $CaCO_3$) However, for water with hardness >250mg/L $CaCO_3$ sulphate toxicity should be assessed on a site-specific basis. Ministry of Environment, British Columbia (2013)	N/A	80 (439)	129 (591)	52 (179)	89 (310)
Dissolved Arsenic	0.15	For As(III) 0.024* For As(V) 0.013*		N/A	0.003 (0.004)	0.009 (0.030)	0.003 (0.003)	0.005 (0.016)
Dissolved Copper	0.009**	0.0014*		N/A	0.001 (0.001) for both		0.001 (0.001) for both	
Cyanide (WAD)	0.1	0.007*		N/A	Not assessed		Not assessed	
Iron (total)	1.0	(Insufficient data to derive a reliable trigger value)	ANZG (2018) suggest the current Canadian guideline level of 0.3 mg/L could be used as an interim indicative working level but	N/A	0.184 (0.234)	0.175 (0.231)	0.184 (0.218)	0.186 (0.216)

Parameter (all units mg/L)	**Mare Burn compliance limits for MB01 and MB02**	**DGV guidelines†** (ANZG 2018) (Mare Burn's REC is Cool Dry Hill)	**Alternative guideline**	**Attribute state** NPS-FW (2020) (B band - 95% species protection level)	**MB01††** **Current Long-term** [2020-2022] [2050-2260] median & (95th percentile)	**MB02††** **Current Long-term** [2020-2022] [2050-2260] median (95th percentile)
			further data are required to establish a figure appropriate for New Zealand waters.			
Dissolved Lead	0.0025**	0.0034*		N/A	0.0002 (0.0002) for both	0.0002 (0.0002) for both
Dissolved Zinc	0.12**	0.008*		N/A	0.002 (0.006) for both	0.002 (0.003) 0.002 (0.004)

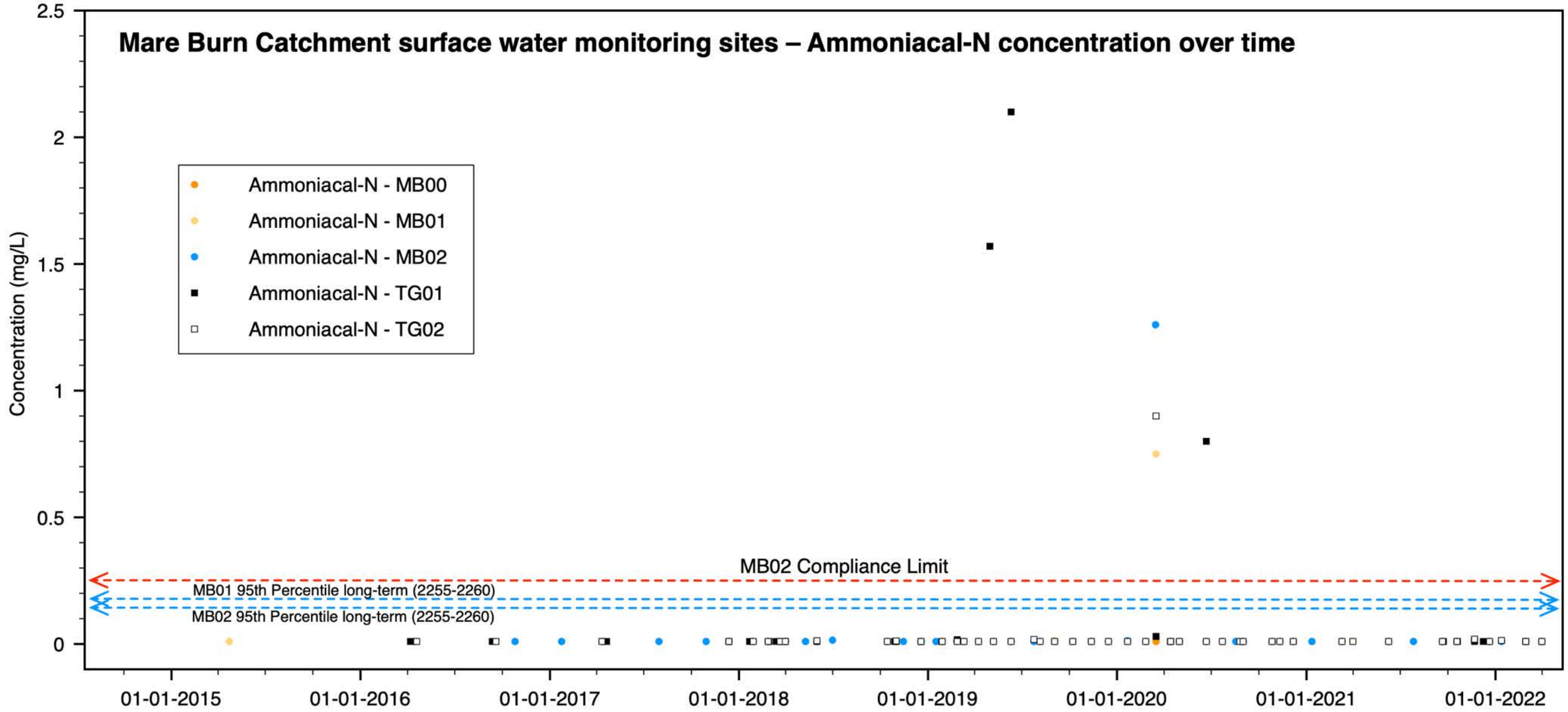

Figure 12. Ammoniacal-N concentrations at Mare Burn catchment surface water monitoring sites. The existing consent compliance limit for MB02 is shown along with modelled long-term 95th percentile concentrations for MB01 and MB02. Note there is no ammoniacal-N compliance limit for MB01.

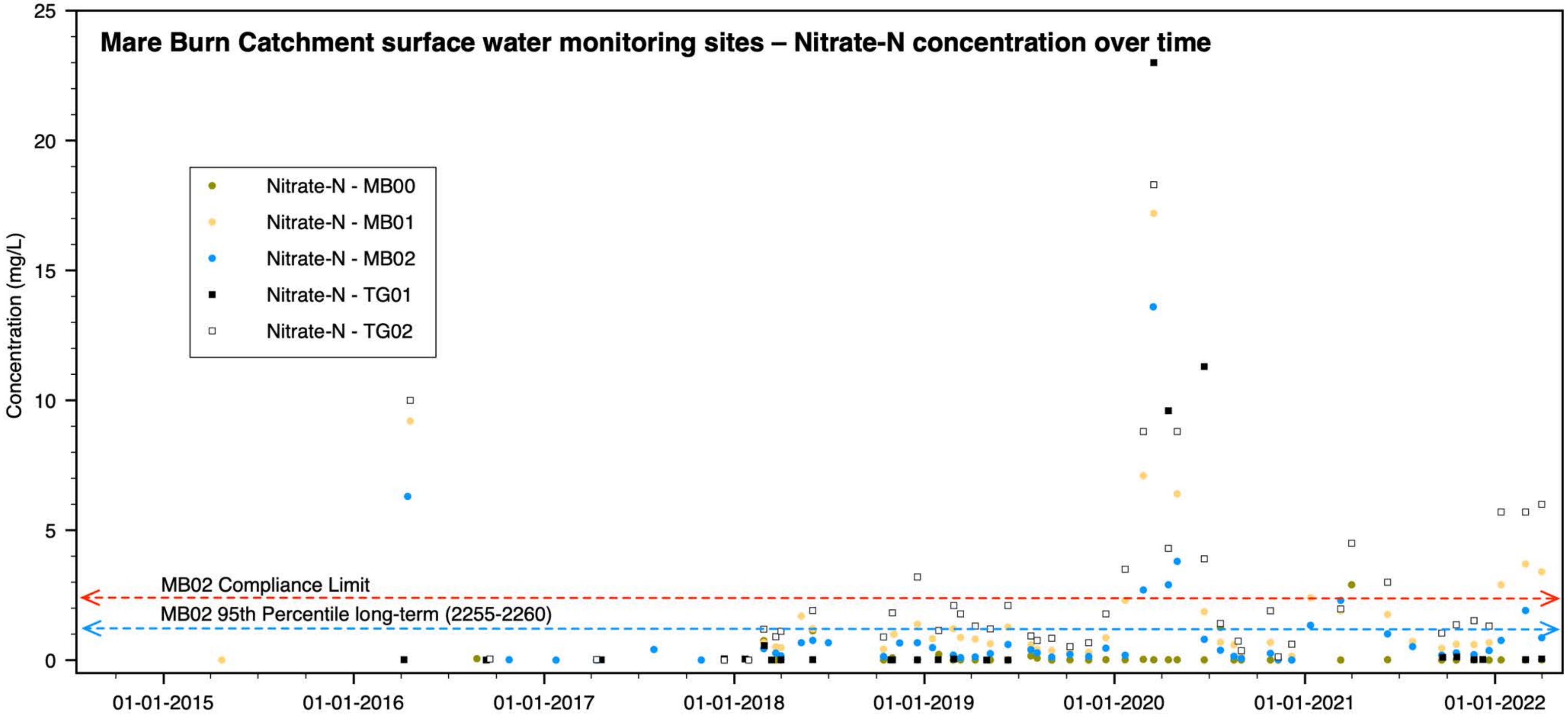

Figure 13. *Nitrite-Nitrate-N concentrations at Mare Burn catchment surface water monitoring sites. Existing consent compliance limit is shown for MB02 along with modelled long-term 95th percentile concentrations. Note there is no nitrate-N compliance limit for MB01.*

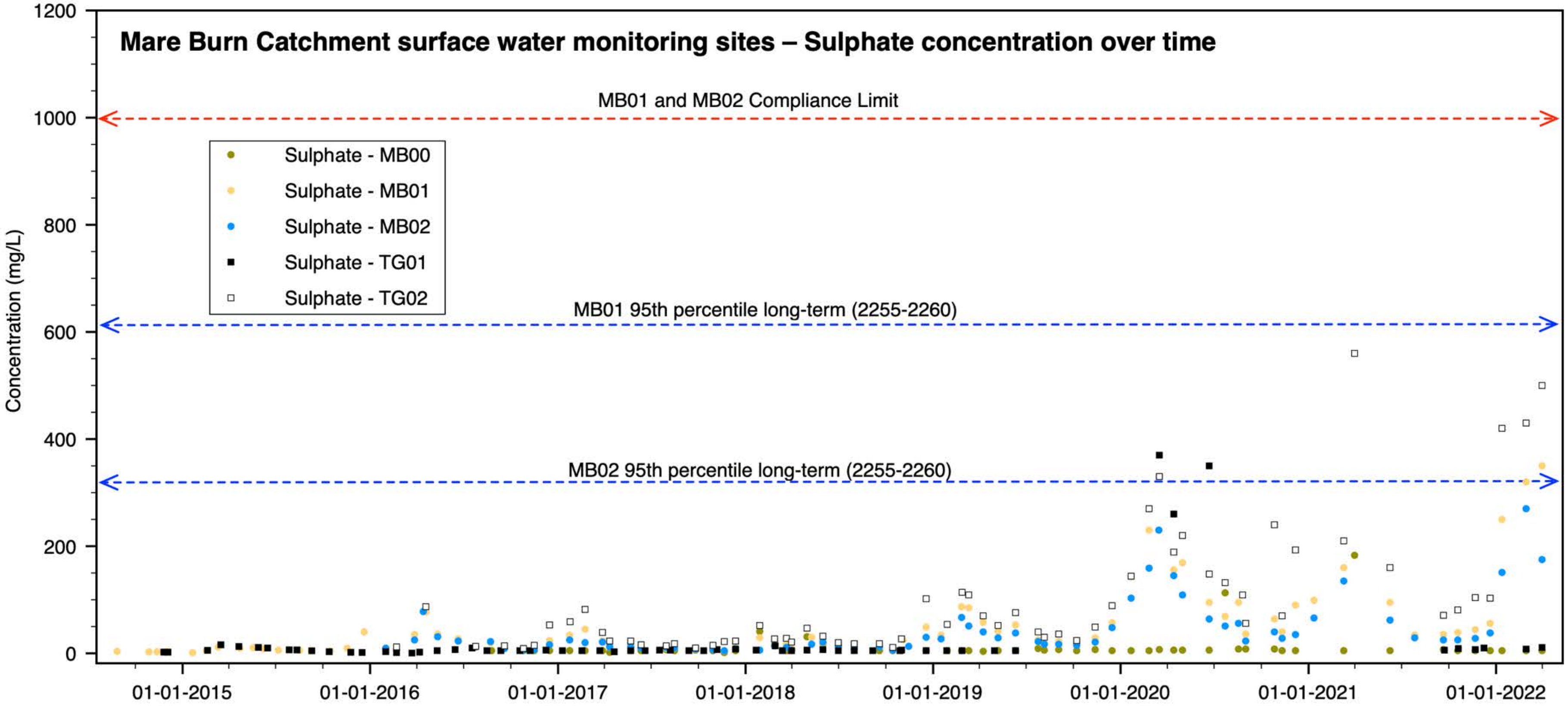

Figure 14. Sulphate concentrations at Mare Burn catchment surface water monitoring sites. Existing consent compliance limits are shown for MB01 and MB02 along with modelled long-term 95th percentile concentrations.

Table 5. Ammonia (toxicity) attribute states from the NPS-FW 2020.

Value (and component)	Ecosystem Health (water quality)	
Freshwater Body Type	Rivers	
Attribute Unit	NH_4**-N** mg/L (milligrams nitrate-nitrogen per litre)	
Attribute band and description	**Numeric Attribute State**	
	Annual Median	Annual 95th Percentile
A 99% species protection level: No observed effect on any species tested.	≤0.03	≤0.05
B 95% species protection level: Starts impacting occasionally on the 5% most sensitive species.	>0.03 and ≤0.24	>0.05 and ≤0.4
National Bottom Line	**0.24**	**0.40**
C 80% species protection level: Starts impacting regularly on the 20% most sensitive species (reduced survival of most sensitive species).	>0.24 and ≤1.30	>0.40 and ≤2.20
D Starts approaching acute impact level (that is, risk of death) for sensitive species.	>1.3	>2.20

Numeric attribute state is based on pH 8 and temperature of 20°C. Compliance with the numeric attribute states should be undertaken after pH adjustment.

Table 6. Nitrate (toxicity) attribute states from the NPS-FW 2020.

Value (and component)	Ecosystem Health (water quality)	
Freshwater Body Type	Rivers	
Attribute Unit	NO_3**-N** mg/L (milligrams nitrate-nitrogen per litre)	
Attribute band and description	**Numeric Attribute State**	
	Annual Median	Annual 95th Percentile
A High conservation value system. Unlikely to be effects even on sensitive species.	≤1.0	≤1.5
B Some growth effect on up to 5% of species.	>1.0 and ≤2.4	>1.5 and ≤3.5
National Bottom Line	**2.4**	**3.5**
C Growth effects on up to 20% of species (mainly sensitive species such as fish). No acute effects.	>2.4 and ≤6.9	>3.5 and ≤9.8
D Impacts on growth of multiple species, and starts approaching acute impact level (i.e. risk of death) for sensitive species at higher concentrations (>20 mg/L).	>6.9	>9.8

Note: This attribute measures the toxic effects of nitrate, not the trophic state. Where other attributes measure trophic state, for example periphyton, freshwater objectives, limits and/or methods for those attributes will be more stringent.

4.3 Algae and plants

There is nothing unique about the aquatic plant and periphyton communities of the Mare Burn or Trimbells Gully. Historically, since European colonisation, this has been a farming catchment with no protection of watercourses from stock access, resulting in nutrient inputs into surface waters and associated proliferations of plants and periphyton under favourable conditions. The proposed Coronation expansion will not exacerbate this situation.

4.4 Benthic invertebrates

The benthic invertebrate communities of the Mare Burn have not altered materially since mining has commenced in the catchment. Indicators of ecosystem health (mayfly densities and QMCI scores), while fluctuating from year to year and season to season, have not shown any clear trends over time. The invertebrate community at TG01 shows some sign of degradation in 2021 and 2022 relative to 2017, however data for 2019 and 2020 indicate the community was as at least as healthy then as it was in 2017, and it is too early to establish whether any long-term trend is developing. There is no evidence to suggest that future mine-induced water quality will significantly alter the composition of the benthic invertebrate community at Mare Burn monitoring sites.

4.5 Fish

Galaxiid population densities at MB01 and MB02 between 2017 and 2022 appear to be trending up and there is no clear reason why this is occurring. Predicted changes in water quality over the short to very long-term appear to remain largely within existing compliance limits for the Mare Burn, apart from some occasional exceedances of the sulphate compliance limit for MB01. However, there is no evidence to suggest that fish populations will be adversely affected as a result of the proposed Coronation expansion.

Sulphate concentrations in Trumbull Gully silt pond are predicted to increase, as is expected from modelling work, however they will be diluted by water contributions from the Trimbell's catchment flow further upstream and progressively downstream, so actual sulphate concentrations in Trimbells Gully will be much lower than those in the silt pond. Toxicity testing conducted using Taieri flathead galaxias (eggs and larvae), local waste rock stack seepage water and Mare Burn water, showed no effects at a sulphate concentration equivalent to the existing compliance limit for MB02 of 1,000 g/m^3 (Ryder 2019). The toxicity testing work also indicated that current and predicted nitrate concentrations are not a threat to the local galaxiid population.

5 SUMMARY & CONCLUSION

The proposed expansion of the Coronation Mine at Macraes involves a minor pit extension (CO6), and backfilling of the current Coronation North Pit. There is no incursion of tributaries that feed the Mare Burn or any changes to their physical features. Pit CO5 will need to be dewatered at an early stage in the mine schedule to allow CO6 to be fully mined and it is planned for this water to be pumped to the Processing Plant and/or Deepdell North Pit. A minor reduction in groundwater contribution to the Mare Burn catchment due to dewatering, and a minor increase in flow when the pit lake eventually reaches its overflow level after a post closure period of approximately 90 years, are anticipated. These minor changes in flow over time are unlikely to influence the ecology of local creeks because there are no physical changes to the watercourses and less than minor changes to water quality.

Modelling has been undertaken to predict changes in water quality in the Mare Burn catchment. Arsenic, cyanide, copper, iron, lead and zinc concentrations are predicted not to exceed their current consented compliance concentrations at Mare Burn monitoring sites MB01 or MB02 throughout both the duration of the operational period and post closure period (GHD 2024). Current and predicted long-term metal concentrations also meet ANZG (2018) default guidelines values for protection of 95% of species.

In general, it is predicted that there is low probability of consent compliance limits being exceeded at MB02 for sulphate, ammoniacal-N and nitrate-N concentrations. The closure and long term scenarios show a low (<1%) probability of exceeding compliance limits for sulphate and consequently less than minor effects on surface water ecology. Current and predicted long-term ammoniacal-N and nitrate-N concentrations lie within NPS-FW NOF bands A or B.

Regular monitoring of stream ecosystem components at downstream monitoring sites since 2017 have not detected any significant adverse changes in ecosystem health, while the local Taieri flathead galaxiid population, if anything, appears to be increasing. This species has been shown to be resilient to elevated nitrate and sulphate concentrations and is not expected to be adversely affected by the anticipated increases in concentration over time. However, it is too early to establish whether any long-term trends in local stream ecosystems are developing and continued monitoring of fish and benthic invertebrate communities is recommended.

Existing water quality compliance limits for the Mare Burn appear to be met both now and in the long-term future. Currently, there is no evidence to indicate that they are posing a threat to the local aquatic ecological community.

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APPENDIX A: MARE BURN MACROINVERTEBRATE DATA FOR 2021

SUMMER 2021		TG01					MB01					MB02				
TAXON	**MCI score**	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
ACARINA	5	1														
ARACHNIDA																
Dolomedes	5															
CNIDARIA																
Hydra	3	2	3	4		2		1				3	3			
COLEOPTERA																
Elmidae	6						1					2		4	4	3
Hydraenidae	8															
Hydrophilidae	5															
Scirtidae	8				1											
COLLEMBOLA	6	1	2		1							1			1	6
CRUSTACEA																
Cladocera	5															
Copepoda	5															
Isopoda	5															
Ostracoda	3	96	42	101	2	71	73	160	19	28	11	23	17	1	4	15
Paracalliope	5	81	51	40	67	66	81	160	11	30	2					
Paraleptamphopus	5					1						1				
Paranephrops	5															
DIPTERA																
Aphrophila	5	13	3	4	4	2				1	2		1	1	1	1
Austrosimulium	3		2		5	1	5	4		2				1		1
Chironomidae	2	43	209	80	25	14	185	45	64	152	42	115	49	89	15	35
Empididae	3															
Ephydridae	4															
Eriopterini	9															
Hexatomini	5						1									
Limonia	6			1												
Mischoderus	4															
Muscidae	3											1		1		
Paradixa	4															
Paralimnophila	6		2													
Psychodidae	1															
Stratiomyidae	5															
EPHEMEROPTERA																
Deleatidium	8	6	8	3	3	4	109	26	36	88	32	119	95	75	88	130
Neozephlebia	7															
HEMIPTERA																
Mesoveliidae	-															
Microvelia	5															
Saldidae	5															
MECOPTERA																
Nannochorista	7															
MEGALOPTERA																
Archichauliodes	7						1		1		1					
MOLLUSCA																
Gyraulus	3		1			3	238	149	15	11	21	16	15	53	19	17
Physa / Physella	3											21	11	11	10	7
Potamopyrgus	4	660	228	394	88	98	760	467	295	147	825	397	423	333	159	437
Sphaeriidae	3	4	1	8		5					38	11	2			24
NEMATODA	3						1	2			1	1				
NEMATOMORPHA	3															
NEMERTEA	3															
ODONATA																
Xanthocnemis	5							3	1	1						
OLIGOCHAETA	1	276	275	125	340	74	221	44	16	59	3	49	45	42	7	39
PLATYHELMINTHES	3	2	2	6	1		4	3			1	2	12	5		1
PLECOPTERA																
Austroperla	9															
Stenoperla	10															
Zelandobius	5	1	3	7	2	3	2	5	1	11	4					1
Zelandoperla	10								1							
TRICHOPTERA																
Hudsonema alienum	6		8	8	4	1	7	2	1							
Hudsonema amabile	6	17	6	14	2	2	37	20	10	13	4	10	29	4	4	42
Hydrobiosidae early instar	5		1													
Hydrobiosis umbripennis group	5								1					1		
Hydropsyche - Aoteapsyche group	4	1					62	2	16	25	60	16	25	88	22	36
Oeconesus	9															
Olinga	9										1					
Oxyethira	2	75	217	126	57	94	230	150	31	181	41	11	9	1		
Paroxyethira	2															
Plectrocnemia	8												2			
Polyplectropus	8		1			1	12	7			11		6			
Psilochorema	8	2	6		1	2	12	5	2	6	3	5	4	3		3
Pycnocentria	7															
Pycnocentrodes	5				1	1			2			9	22	3	2	30
Triplectides	5															
Number of invertebrates (per sample)		1281	1071	921	604	445	2042	1255	523	755	1103	813	770	716	336	828
Number of taxa		17	21	15	17	19	20	19	18	15	19	20	18	18	13	18
QMCI score		3.2	2.5	3.1	2.2	3.1	3.5	3.6	3.9	3.4	4.0	4.1	4.3	3.9	4.9	4.5

AUTUMN 2021		TG01					MB01					MB02				
TAXON	**MCI score**	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
ACARINA	5							1								
COLEOPTERA																
Antiporus	5															
Elmidae	6						1									
Hydraenidae	8															
Scirtidae	8															
COLLEMBOLA	6															
CRUSTACEA																
Cladocera	5															
Ostracoda	3	6	3	7	4	6	7	63	29	12	27		47	3	11	3
Paracalliope	5	7	22	5	26	35	70	78	7	8	1					
Paraleptamphopus	5				1											
Paranephrops	5															
DIPTERA																
Aphrophila	5	2	1	1	1	2						7				2
Austrosimulium	3						25	6	33	39	15	36	7	21	4	20
Chironomidae	2	17	27	3	25	6	51	56	96	66	50	61	26	23	19	16
Empididae	3															
Ephydridae	4															
Hexatomini	5			1												
Mischoderus	4								1							
Molophilus	5															
Muscidae	3						2								1	
Paradixa	4															
Paralimnophila	6															
Stratiomyidae	5															
EPHEMEROPTERA																
Deleatidium	8	1	2		6	1	26	39	104	86	111	150	71	160	78	168
HIRUDINEA	3															
MECOPTERA																
Nannochorista	7															
MEGALOPTERA																
Archichauliodes	7															
MOLLUSCA																
Gyraulus	3	2			2	1	8	17	34	4	9	29	12	9	4	17
Physa / Physella	3											1	5		1	
Potamopyrgus	4	139	31	299	88	188	252	448	1564	78	257	388	423	57	13	67
Sphaeriidae	3			3	1							2	2		1	4
NEMATODA	3															
NEMERTEA	3															
ODONATA																
Xanthocnemis	5														1	
OLIGOCHAETA	1	15	43	9	27	40	4	23	30	30	6	12	9	4	11	4
PLATYHELMINTHES	3	1			2	2	5	2	9	2						
PLECOPTERA																
Austroperla	9															
Stenoperla	10															
Zelandobius	5	2	3		11	3		4	6	4						
Zelandoperla	10											3		2		
TRICHOPTERA																
Hudsonema alienum	6	1			3											
Hudsonema amabile	6			1	2		44	25	50	10	3	2	3		5	17
Hydrobiosidae early instar	5						2		1							
Hydrobiosis umbripennis group	5									2		5	1	2		2
Hydropsyche - Aoteapsyche group	4						26	1	28	10	9	101	9	61	2	144
Oeconesidae	9				1											
Olinga	9											1			1	
Oxyethira	2								7	5	1				2	
Paroxyethira	2															1
Polyplectropus	8												3		1	
Psilochorema	8					1	3		5			1	3	3	1	3
Pycnocentria	7															
Pycnocentrodes	5						1	1	2			13	7	5	3	6
Tiphobiosis	6															
Triplectides	5															
Number of invertebrates (per sample)		193	132	329	200	285	527	764	2006	356	489	812	628	350	159	474
Number of taxa		11	8	9	15	11	16	14	17	14	11	16	15	12	18	15
QMCI score		3.6	2.8	3.9	3.7	3.7	4.2	4.0	4.1	4.3	4.6	4.5	4.3	5.7	5.5	5.3

WINTER 2021		TG01					MB01					MB02				
TAXON	MCI score	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
ACARINA	5									1						
ARACHNIDA																
Dolomedes	5															
COLEOPTERA																
Antiporus	5															
Elmidae	6						1				1	2	1	3	5	
Hydraenidae	8									1						
Scirtidae	8															
COLLEMBOLA	6				1	1										
CRUSTACEA																
Copepoda	5															
Ostracoda	3	1		1		2		4	10	2	1	1	14		1	
Paracalliope	5	14	13	46		14	11	6	11	1	1					
Paraleptamphopus	5															
DIPTERA																
Aphrophila	5	8	2	2		11	1				1	1	6	1		11
Austrosimulium	3	1	2	2	1	1	63	65	59	88	77	60	56	24	91	101
Ceratopogonidae	3															
Chironomidae	2	87	52	62	13	84						38	18	72	34	79
Empididae	3															
Eriopterini	9															
Hexatomini	5														1	
Mischoderus	4														2	
Molophilus	5															
Muscidae	3					1	1					1		1		
Neolimnia	3											1				
Paralimnophila	6											1				
Sciomyzidae	3															
Stratiomyidae	5															
EPHEMEROPTERA																
Deleatidium	8	5	12	6	5	3	31	63	223	94	147	137	101	44	46	64
HEMIPTERA																
Microvelia	5															
MEGALOPTERA																
Archichauliodes	7								1	1	1					1
MOLLUSCA																
Gyraulus	3					1	2	8	14	3	2	2	1		1	10
Physa / Physella	3															1
Potamopyrgus	4	139	20	14	6	173	125	1870	505	116	419	540	301	84	38	295
Sphaeriidae	3		1			3		1				9	2	1		
NEMATODA	3		1			1			1					1		
NEMERTEA	3															
ODONATA																
Anisoptera	5															
Xanthocnemis	5															
OLIGOCHAETA	1	176	39	116	59	308	24	17	16	13	12	14	9	22	4	
PLATYHELMINTHES	3															
PLECOPTERA																
Austroperla	9															
Stenoperla	10															
Zelandobius	5		3	10	2	10		4			1	1				
Zelandoperla	10	1												1		1
TRICHOPTERA																
Costachorema	7															
Hudsonema alienum	6			1		1										
Hudsonema amabile	6						4	56	16	2	2	7		2		4
Hydrobiosidae early instar	5					1										
Hydrobiosis umbripennis group	5					1	4	1		2	4	4	2		7	5
Hydropsyche - Aoteapsyche group	4						40	3	4	5	18	50	30	85	52	142
Oeconesidae	9															
Oeconesus	9			1												
Olinga	9															
Oxyethira	2	1	2	7		10										
Paroxyethira	2															
Polyplectropus	8					1										
Psilochorema	8	1	1		1		6	5	2	4	5	4	4	2	2	1
Pycnocentria	7							1								
Pycnocentrodes	5							2			1	14	9	1	3	7
Number of invertebrates (per sample)		434	148	268	88	627	313	2106	862	333	693	887	554	344	287	722
Number of taxa		11	12	12	8	19	13	15	12	14	16	19	14	15	14	14
QMCI score		2.5	2.9	2.5	2.0	2.3	4.1	4.1	4.9	4.8	4.7	4.5	4.5	3.9	4.1	4.0

SPRING 2021		TG01					MB01					MB02				
TAXON	**MCI score**	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
ACARINA	5															
CNIDARIA																
Hydra	3		1								1					
COLEOPTERA																
Antiporus	5															
Elmidae	6														3	5
Hydraenidae	8												1			
Lancetes	5															
Liodessus	5															
Rhantus	5															
Scirtidae	8	1	2	1												
COLLEMBOLA	6															
CRUSTACEA																
Ostracoda	3	1		1	5		2	7	5	19			3			
Paracalliope	5	46	50	185	149	88	6	27	8	7	4		1			
Paraleptamphopus	5			5												
DIPTERA																
Aphrophila	5	10	3	5	11	8	3	1	2	2	2	3	5	3	4	2
Austrosimulium	3	4	1							1	2			27	6	16
Calopsectra	4															
Ceratopogonidae	3															
Chironomidae	2	268	200	168	233	98	146	219	163	152	225	168		37	80	45
Empididae	3												135			
Ephydridae	4					1										
Hexatomini	5			1												
Muscidae	3			4	2							2				
Paradixa	4															
Paralimnophila	6															
Sciomyzidae	3															
Stratiomyidae	5		1													
EPHEMEROPTERA																
Deleatidium	8	7	3	8	3	5	29	47	6	33	21	15	27	17	10	12
HEMIPTERA																
Microvelia	5															
MEGALOPTERA																
Archichauliodes	7						2	1	1	1	4					
MOLLUSCA																
Gyraulus	3				1	1	7	4	7	14	2		2			
Physa / Physella	3											2	2			
Potamopyrgus	4	195	100	78	148	51	615	565	543	696	765	216	176	15	124	132
Sphaeriidae	3	3				1				2		2			2	
NEMATODA	3									3	1					1
NEMERTEA	3															
ODONATA																
Xanthocnemis	5															
OLIGOCHAETA	1	20	137	43	58	19	9	14	17	9	40	23			12	12
PLATYHELMINTHES	3	2	1	1				4	1		1	2	1			
PLECOPTERA																
Acroperla	5															
Austroperla	9															
Megaleptoperla	9															
Stenoperla	10															
Taraperla	7		1													
Zelandobius	5							1		1						
TRICHOPTERA																
Hudsonema alienum	6															
Hudsonema amabile	6		2	2			5	4	7	3	2					2
Hydrobiosidae early instar	5	2						1		1						
Hydrobiosis clavigera group	5															
Hydrobiosis umbripennis group	5		4	2		1	7	1	1		7	6	1	3	2	4
Hydropsyche - Aoteapsyche group	4						11		6	1	9	4	9	9	5	12
Oeconesus	9															
Olinga	9										1					
Oxyethira	2	3	4	20	10	5	9	28	15	36	25		1			1
Paroxyethira	2															
Paroxyethira	2															
Polyplectropus	8															
Psilochorema	8	6	2	1	1	3	8	5	2	14	7	5	2	1	1	5
Pycnocentria	7															
Pycnocentrodes	5											1	1			
Number of invertebrates (per sample)		568	512	525	621	281	859	929	784	995	1119	449	367	112	249	249
Number of taxa		14	16	16	11	12	14	16	15	18	18	13	15	8	11	13
QMCI score		3.1	2.6	3.5	3.2	3.5	3.8	3.7	3.5	3.8	3.6	3.3	4.0	3.8	3.4	3.8

APPENDIX B: MARE BURN MACROINVERTEBRATE DATA FOR 2022

Summer 2022		MCI tolerance value	TG01					MB01					MB02				
ORDER	TAXON		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
ACARINA	ACARINA	5			1			1					2				
ARACHNIDA	*Dolomedes*	5															
CNIDARIA	*Hydra*	3			1	1											
COLEOPTERA	Elmidae	6											6		1	2	
	Hydraenidae	8															
	Rhantus	5															
	Scirtidae	8				1											
	Staphylinidae	5															
COLLEMBOLA	COLLEMBOLA	6		1													1
CRUSTACEA	Cladocera	5															
	Copepoda	5															
	Ostracoda	3	12	15	121	22	27	18	24	34	6	37	84	36	4		
	Paracalliope	5	75	25	228	60	195	7	3	11	11	1					
	Paraleptamphopus	5															
	Paranephrops	5															
DIPTERA	*Aphrophila*	5	4		1	3	5	1						2	4	2	1
	Austrosimulium	3	2	2	1		1								1		
	Chironomidae	2	40	20	43	34	19	256	153	126	101	47	38	32	63	184	84
	Dolichopodidae	3															
	Empididae	3										1					
	Ephydridae	4															
	Eriopterini	9															
	Hexatomini	5					2										
	Limonia	6															
	Mischoderus	4								1							
	Muscidae	3										1					1
	Paradixa	4															
	Paralimnophila	6															
	Sciomyzidae	3				1											
	Stratiomyidae	5														1	
	Zelandotipula	6															
EPHEMEROPTERA	*Austroclima*	9															
	Deleatidium	8	7	14	18	8	7	127	152	97	87	146	15	9	30	16	10
HEMIPTERA	*Microvelia*	5															
	Saldidae	5								1							
	Sigara	5															
LEPIDOPTERA	*Hygraula*	4															
MEGALOPTERA	*Archichauliodes*	7						1	1	1		7					
MOLLUSCA	*Gyraulus*	3	2	1	14	2	2	99	72	27	44	49	45	38	160	37	78
	Physa = Physella	3											68	43	55	20	23
	Potamopyrgus	4	325	78	578	218	414	701	1302	564	560	1689	893	443	354	120	225
	Sphaeriidae	3			1		5						34	9	2		
NEMATODA	NEMATODA	3					8			3		1					
NEMERTEA	NEMERTEA	3															
ODONATA	*Xanthocnemis*	5												1			
OLIGOCHAETA	OLIGOCHAETA	1	88	23	39	37	21	37	16	82	17	25	142	31	4	12	28
PLATYHELMINTHES	PLATYHELMINTHES	3		2				3	1	40	2						
	Temnohaswellia	3															
PLECOPTERA	*Austroperla*	9															
	Spaniocerca	8															
	Stenoperla	10															
	Taraperla	7															
	Zelandobius	5	2		1	2				1							
	Zelandoperla	10							1			2			1	2	5
TRICHOPTERA	*Hudsonema*	6	5	5	34	14	22	72	54	51	35	47	159	66	27	20	19
	Hydrobiosidae early instar	5															
	Hydrobiosis	5				1		5			3						5
	Hydropsyche - Aoteapsyche	4		1	2		1	326	89	64	229	133	66	31	208	189	256
	Neurochorema	6															
	Oeconesidae	9															
	Olinga	9								2					1		1
	Oxyethira	2	9	1	20	8	12	7	4	19	5		2	1	1		
	Paroxyethira	2															
	Polyplectropus	8									1						
	Psilochorema	8	4	2	2	1	1	6	8	10	14	5	2	1	2	9	3
	Pycnocentria	7							2	1		1					
	Pycnocentrodes	5						1	5	6	7	12	157	201	39	42	22
	Zelolessica	10															
Number of invertebrates (per sample)			575	190	1105	413	742	1668	1887	1141	1122	2204	1713	944	957	656	762
Number of taxa			13	14	17	16	16	17	16	20	15	17	15	15	18	14	16
QMCI score			3.6	3.8	4.0	3.8	4.1	4.0	4.2	3.9	4.2	4.2	3.9	4.1	3.9	3.6	3.7

Autumn 2022		MCI tolerance	TG01					MB01					MB02				
ORDER	TAXON	value	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
ACARINA	ACARINA	5		1													
CNIDARIA	*Hydra*	3	1	6		1											
COLEOPTERA	Elmidae	6						1					1	2			
	Hydraenidae	8															
	Rhantus	5															
	Scirtidae	8		1	1			1									
COLLEMBOLA	COLLEMBOLA	6		2				2									
CRUSTACEA	Ostracoda	3	2	11	6	19	12	9	271	5	37	104	5	31			1
	Paracalliope	5	89	142	152	113	187	13	11	11	3	12	1				
	Paraleptamphopus	5															
	Paranephrops	5															
DIPTERA	*Aphrophila*	5		4	1	1			1						5	3	5
	Austrosimulium	3		2				1							3	2	
	Chironomidae	2	8	54	14	5	19	74	21	6	53	10	10	4	9	7	33
	Empididae	3															
	Hexatomini	5															
	Limonia	6															
	Mischoderus	4											2				
	Muscidae	3						1					1				1
	Nothodixa	4															
	Paradixa	4															
	Paralimnophila	6											1				
	Psychodidae	1															
	Sciomyzidae	3															
	Stratiomyidae	5											1				
	Tipulidae	5															
EPHEMEROPTERA	*Austroclima*	9															
	Deleatidium	8					1	95	154	84	55	231	26	51	163	41	159
	Zephlebia	7															
HEMIPTERA	*Diaprepocoris*	5															
	Microvelia	5															
LEPIDOPTERA	*Hygraula*	4															
MECOPTERA	*Nannochorista*	7															
MEGALOPTERA	*Archichauliodes*	7	1	2			1		3	1					1		
MOLLUSCA	*Gyraulus*	3		2		4	2	6	12	2	10	28	6	8	5	33	37
	Lymnaeidae	3															
	Physa = Physella	3											8	2	1	8	10
	Potamopyrgus	4	410	311	61	131	515	302	3340	300	1860	897	701	120	268	107	455
	Sphaeriidae	3			1		1						63	33	1	1	
NEMATODA	NEMATODA	3															
NEMERTEA	NEMERTEA	3															
ODONATA	*Austrolestes*	6															
	Xanthocnemis	5															
OLIGOCHAETA	OLIGOCHAETA	1	51	62	23	57	13	512	402	7	83	17	76	84	2	25	8
PLATYHELMINTHES	PLATYHELMINTHES	3	3		2				1					1		1	
PLECOPTERA	*Austroperla*	9															
	Stenoperla	10															
	Taraperla	7															
	Zelandobius	5	2	2	5	2	7		1		7	2	1	1			1
	Zelandoperla	10	1	2				1							7	8	
TRICHOPTERA	*Hudsonema*	6	8	34	16	23	40	20	283	34	66	124	64	43	7	7	15
	Hydrobiosidae early instar	5									4	1	1			1	
	Hydrobiosis	5		1		2		9	3								2
	Hydropsyche - Aoteapsyche	4		2	3		2	267	128	91	46	37	34	40	150	201	241
	Neurochorema	6						1									
	Oeconesidae	9															
	Olinga	9								2	1						
	Oxyethira	2						2	13	3	6	1					
	Paroxyethira	2															
	Polyplectropus	8									1	1		2			
	Psilochorema	8	1	2	4	4	6	18	22	6	7	4	1	3		2	2
	Pycnocentria	7	1											8		23	
	Pycnocentrodes	5						2	3	1	8	14	92	55	14		20
Number of invertebrates (per sample)			578	643	289	362	806	1337	4669	553	2247	1483	1095	488	636	470	990
Number of taxa			13	19	13	12	13	20	17	14	16	15	20	17	14	16	15
QMCI score			3.9	3.9	4.4	3.9	4.3	3.1	3.9	4.7	4.0	4.7	4.0	4.1	5.1	4.4	4.6

Winter 2022 ORDER	TAXON	MCI tolerance value	TG01					MB01					MB02				
			1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
ACARINA	ACARINA	5										1					
CNIDARIA	*Hydra*	3															
COLEOPTERA	Elmidae	6												1		1	1
	Hydraenidae	8															
	Liodessus	5															
	Rhantus	5															
	Scirtidae	8			1												
COLLEMBOLA	COLLEMBOLA	6		1	1												
CRUSTACEA	Copepoda	5															
	Ostracoda	3			2	2	2				10	2		5	3		
	Paracalliope	5	2	26	62	26	30		1		1	2					
	Paraleptamphopus	5															
DIPTERA	*Aphrophila*	5	2	4		1							3	1			1
	Austrosimulium	3				1		7	5	3		1	20	2		7	2
	Ceratopogonidae	3															
	Chironomidae	2	4	13	4	8	59	49	41	16	52	40	22	2	2	24	12
	Empididae	3										1					
	Hexatomini	5		1													
	Limonia	6															
	Mischoderus	4									1						
	Muscidae	3															
	Paradixa	4															
	Paralimnophila	6		1													
	Stratiomyidae	5					1										
EPHEMEROPTERA	*Ameletopsis*	10															
	Deleatidium	8			2	2		11	39	63	26	39	73	100	72	37	127
HEMIPTERA	*Microvelia*	5															
	Sigara	5															
MEGALOPTERA	*Archichauliodes*	7	1									2					
MOLLUSCA	*Gyraulus*	3				1					6	5		8	12	6	8
	Physa = Physella	3											2	1	2		2
	Potamopyrgus	4	20	94	6	11	60	1	6	18	315	147	80	171	50	10	64
	Sphaeriidae	3					1				1		7	3			
NEMATODA	NEMATODA	3		1		1					2						
NEMERTEA	NEMERTEA	3															
ODONATA	*Xanthocnemis*	5															
OLIGOCHAETA	OLIGOCHAETA	1	137	149	117	9	15	2	5	6	2	1		1	12	9	4
PLATYHELMINTHES	PLATYHELMINTHES	3	3	1													
PLECOPTERA	*Austroperla*	9															
	Zelandobius	5			1		3					1					
	Zelandoperla	10						1	2				2			2	
TRICHOPTERA	*Hudsonema*	6	1	12		2	19	1	8	1	14	4	23	17	1		1
	Hydrobiosidae early instar	5															
	Hydrobiosis	5		1				2	2	1			4			2	1
	Hydropsyche - Aoteapsyche	4		1				31	36	30	52	57	37	18	7	54	73
	Oeconesidae	9															
	Olinga	9															
	Oxyethira	2															1
	Plectrocnemia	8															
	Polyplectropus	8															
	Psilochorema	8	1	2		2				1	2	1		1	1	1	2
	Pycnocentria	7								1							
	Pycnocentrodes	5							1	2	1	13	92	68	24	4	14
Number of invertebrates (per sample)			171	307	196	66	190	105	146	142	485	317	365	399	186	157	313
Number of taxa			9	14	9	12	9	9	11	11	14	16	12	15	11	12	15
QMCI score			1.6	2.7	2.6	4.0	3.5	3.5	4.6	5.5	4.0	4.3	5.0	5.2	5.4	4.5	5.6

Spring 2022		MCI tolerance value	TG01					MB01					MB02				
ORDER	**TAXON**		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
ACARINA	ACARINA	5	2														
CNIDARIA	*Hydra*	3	2	1			1			1							
COLEOPTERA	Elmidae	6											3	1	3	2	6
	Hydraenidae	8															
	Lancetes	5															
	Scirtidae	8															
COLLEMBOLA	COLLEMBOLA	6	1			1											
CRUSTACEA	Copepoda	5															
	Ostracoda	3	12	10	6	6	30			2	2	4	24	14	16	2	2
	Paracalliope	5	78	107	124	92	350	7		13	4	65	3				
	Paraleptamphopus	5															
	Paranephrops	5															
DIPTERA	*Aphrophila*	5				1	1						1		1		
	Austrosimulium	3	21	36	15	15	2	2	1				8	1		15	4
	Chironomidae	2	80	192	97	167	27	118	60	204	143	126	115	140	36	97	93
	Empididae	3															
	Hexatomini	5															
	Limonia	6															
	Mischoderus	4															
	Muscidae	3	1						1		1	4	1			1	2
	Paradixa	4															
	Paralimnophila	6															
	Stratiomyidae	5					2										
	Zelandotipula	6															
EPHEMEROPTERA	*Ameletopsis*	10															
	Austroclima	9															
	Deleatidium	8						7	3	3	1	1	4	3	5		2
	Neozephlebia	7															
	Zephlebia	7															
HEMIPTERA	*Microvelia*	5	1		1			2					1	1			
	Sigara	5															
MECOPTERA	*Nannochorista*	7															
MEGALOPTERA	*Archichauliodes*	7										1					
MOLLUSCA	*Gyraulus*	3	4		10	1	37		1	5	2	3	40	18	111	23	15
	Physa = Physella	3											10	9	7	8	3
	Potamopyrgus	4	420	82	125	62	144	26	15	17	48	145	200	138	147	136	75
	Sphaeriidae	3			1	2	11						13	5	1		2
NEMATODA	NEMATODA	3															
NEMATOMORPHA	NEMATOMORPHA	3												1			
NEMERTEA	NEMERTEA	3															
ODONATA	*Xanthocnemis*	5															
OLIGOCHAETA	OLIGOCHAETA	1	99	180	52	43	128	235	66	260	73	156	96	90	16	9	19
PLATYHELMINTHES	PLATYHELMINTHES	3											2				1
PLECOPTERA	*Stenoperla*	10															
	Zelandobius	5					1										
	Zelandoperla	10											1				1
TRICHOPTERA	*Hudsonema*	6	17	8	10	4	29	1			7	6	20	14	7	1	
	Hydrobiosidae early instar	5															
	Hydrobiosis	5	1		1		1	10	11	5	1	5	2			2	1
	Hydropsyche - Aoteapsyche	4	14	26	22	15	1	441	144	219	83	93	244	67	13	170	118
	Oeconesidae	9	1														
	Olinga	9									1				1		
	Oxyethira	2	16	21	35	165	58	15	28	58	109	87	7	12	3	1	5
	Paroxyethira	2															
	Polyplectropus	8															
	Psilochorema	8		6		3	1	3	2	2	2	1	3		1	2	1
	Pycnocentria	7											1				
	Pycnocentrodes	5			1								1				
	Tiphobiosis	6															
Number of invertebrates (per sample)			770	669	500	577	824	867	332	789	477	697	800	514	368	469	350
Number of taxa			17	11	14	14	17	12	11	12	14	14	23	15	15	14	17
QMCI score			3.5	2.7	3.4	2.8	3.7	2.9	3.0	2.4	2.5	2.8	3.3	2.9	3.4	3.5	3.3