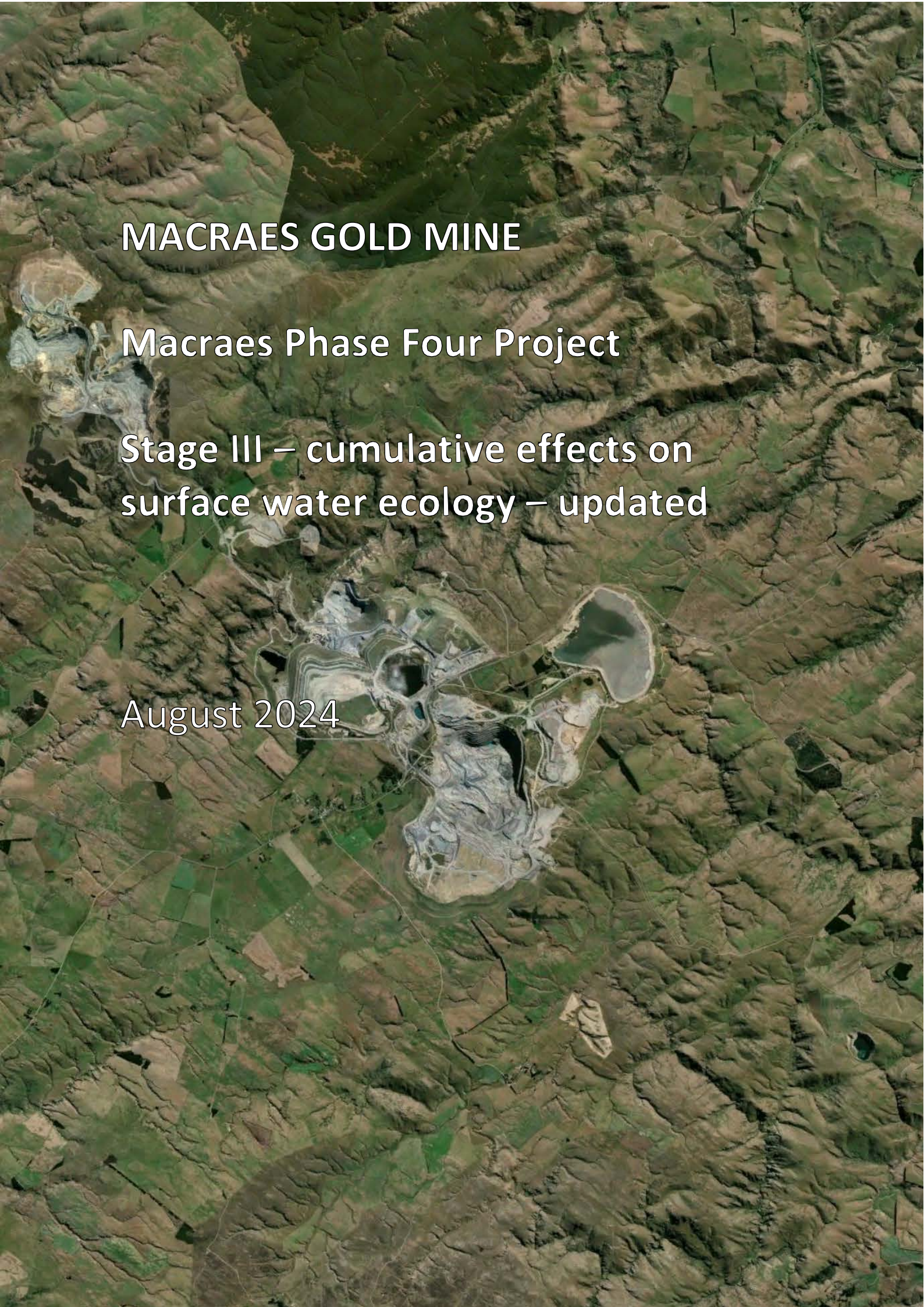

MACRAES GOLD MINE

Macraes Phase Four Project

Stage III – cumulative effects on surface water ecology – updated

August 2024

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August 2024

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Version:	5 September 2024 – Final

CONTENTS

1 INTRODUCTION

1.1 Background

Oceana Gold (New Zealand) 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). The mine 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, a processing plant and various ancillary buildings, such as workshops and office facilities.

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 forms part of Stage 3 "Macraes Phase 4 Project" ("MP4").

Stage 3 includes:

- Extension of the Innes Mills, Coronation and Golden Bar pits, and their associated backfills ("BF") and waste rock stacks ("WRS");
- Stage 2 of a Tailings Storage Facility in Frasers Open Pit ("FTSF");
- Realignment of Golden Bar Road;
- Rehandling of waste from Northern Gully Waste Rock Stack to infill Golden Point Pit; and
- Ancillary features such as topsoil stockpiles, low-grade ore stockpiles, silt ponds, areas for pit infrastructure and access roading.

Various technical studies have been undertaken to assess the potential effects of the various aspects of MP4 stages, including potential loss of surface watercourses, modelling of mine-influenced groundwater and waste rock stack seepages to surface waters. Effects of; raising of the Top Tipperary Tailings Storage Facility (TTTSF) by two metres to 570 m RL, an expansion and extension of the Golden Point Underground mine (GPUG Extension), the Coronation mine expansion, the expansion of the Golden Bar pit and associated waste rock stack, on surface water ecology and water quality, have already been addressed in separate reports (Ryder 2022a, Ryder 2022b, Ryder 2023a, Ryder 2023b, Ryder, 2024a, Ryder 2024b).

This report addresses the cumulative effects of the above proposed mine extensions on surface waters of the Deepdell Creek, Shag River (which receives inflows from Deepdell Creek, Cranky Jims Creek and Tipperary Creek) and the Waikouaiti River North Branch (NBWR) catchments. Effects of the Coronation mine extensions, that report to the Mare Burn catchment, are reported separately (Ryder 2024a).

1.2 Contaminant sources reflected in catchment water quality

To set the scene for the assessment of cumulative water quality effects on the receiving catchments that drain the Macraes Gold Project footprint, including MP4, the following contaminant surface water and groundwater inputs (GHD 2024) are presented below and these are reflected in Tables 3 through to 9 which summarise current and predicted long-term water quality. Current surface water quality data has been updated to included monitoring data collected up to May 2024 (i.e., 29 months of additional data), and predicted, long-term water quality reflects any amendments made to modelled long-term surface water quality presented in reports prepared by GHD (AEE appendices 11-13).

Deepdell Creek (monitoring sites DC07 and DC08)

MP4 developments result in additional flow and mass fluxes to Deepdell Creek via:

Surface flows:

- Overflow from the Coronation Pit Lake;
- Groundwater seepage from the combined Frasers-Innes Mill Pit (FRIM) through the *in situ* schist and waste rock embankment;
- Runoff from the Golden Point Pit waste rock infill surface; and
- Seepage from the Golden Point Pit waste rock infill.

Groundwater plumes:

- From Coronation and Golden Point Pits;
- From tailings storage facilities - MTI, SP11 and TTTSF (N.B. FTSF plume barely extends as far north as Deepdell Creek);
- From waste rock stacks – Coronation, Deepdell and Northern Gully.

A proposed expansion of the Golden Point Underground mine (GPUG) does not have any direct contact with Deepdell Creek or other nearby surface waters, however there is potential

for some loss of creek water to ground due to potential fracturing of the rocks above the mine workings.

Shag River (monitoring sites Shag River at Loop Road, Shag River at McCormicks)

Surface flows:

- Deepdell Creek flows (see above).

Groundwater plumes:

- The TTTSF groundwater plume to Cranky Jims and Tipperary creeks.

Waikouaiti River North Branch (monitoring sites NBWRRF, MC02, NB02, NB03)

MP4 developments result in additional flow and mass fluxes to NBWR via:

Surface flows:

- Frasers TSF and the eventual FRIM Pit Lake – The TSF and Pit Lake are not expected to lose water to external water bodies, however, external seepages from Frasers Waste Rock Stacks, will be captured and released at high background flows after passive treatment from Murphys, Frasers West, and the proposed silt ponds/sumps near NBWRRTR;
- Golden Bar Pit overflow water via Golden Bar Creek;
- Golden Bar Waste Rock Stack via Clydesdale Silt Ponds (seepage released at high background flows after passive treatment) into Clydesdale Creek – Murphys Creek to NBWR.

Groundwater plumes:

- Frasers WRS and FRIM Pit Lake (incorporating any FTSF contaminants).

1.3 Surface water quality compliance sites

To assess the cumulative effects of the proposed mine expansion on surface water quality and stream ecology, the relevant surface water quality and aquatic ecology compliance sites are shown in Figure 2, and their consented water quality compliance limits are presented in Table 1.

In addition, to water quality monitoring, sites DC07, DC08, MC02 and NBWRRF are also subject to regular biological monitoring (quarterly for benthic ecology and annually for fish population assessments).

Table 1. *Summary of current existing consented water quality criteria at compliance monitoring sites. All units g/m^3 (mg/L) except pH.*

Parameter	Deepdell Creek		Shag River		Waikouaiti Catchment		
	DC07	DC08	Loop Road	McCormicks	MC02	NBWRRF	NB03
Resource consent		RM120.024.14	RM20.024.14	RM10.351.13, RM10.351.20 RM10.351.23	RM2002.491, RM2002.759, RM2002.763	RM20.167.04	RM10.351.08, RM10.351.11 RM10.351.12
Arsenic	0.02	0.15	0.010	0.01	0.15	0.15	0.01
Copper*	0.009	0.009	0.009	0.009	0.009	0.009	0.009
Iron	1	1	0.2	0.2	1	1	0.2
Lead*	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
Zinc*	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Sulphate	1000	1000	250	250	1000	1000	250
pH (range)		6.0-9.5	7.0-8.5	7.0-8.5	6.0-9.5	6.0-9.5	6.0-9.5
Nitrate-N		≤2.4 median; <3.5 95th %					2.4 median$^{\#}$
Ammoniacal-N		0.24$^{\#}$					0.24$^{\#}$

* Copper, lead and zinc standards shall be hardness related limits. Values given in the tables above assume a hardness of 100g/m^3 $CaCO_3$.

$^{\#}$ DC08 has no compliance for Ammoniacal-N, however the Mare Burn MB02 limit is implied to be applicable at DC08 as a term of reference.

$^{\#}$ NB03 has no compliance for Ammoniacal-N or Nitrate-N, however the Mare Burn MB02 limits are implied to be applicable at NB03 as a term of reference.

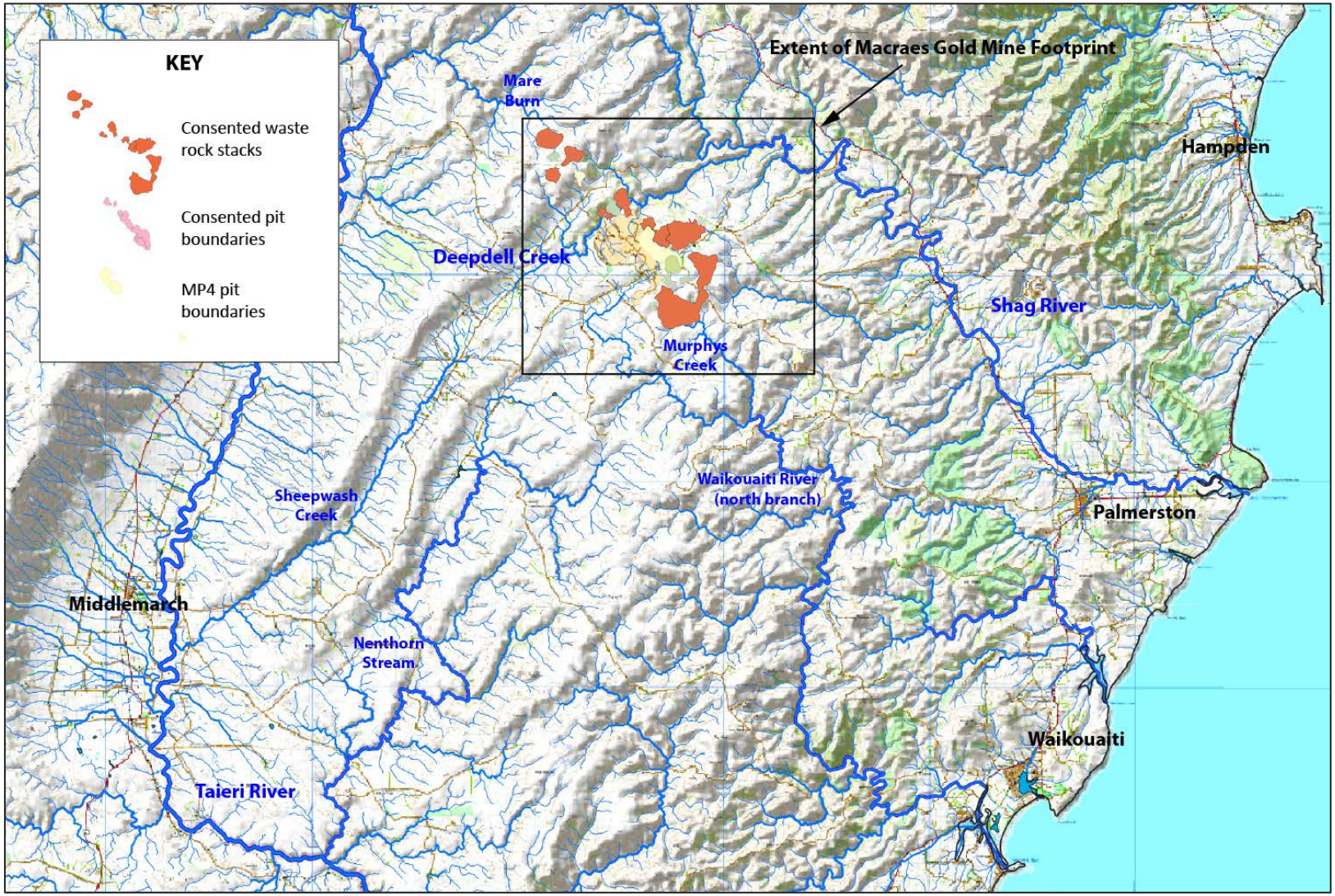

Figure 1. *Map showing general location of the Macraes Gold Project and extent of existing mining operations. Golden Bar pit is located in the bottom right hand corner of the box indicating the extent Macraes Gold Mine footprint.*

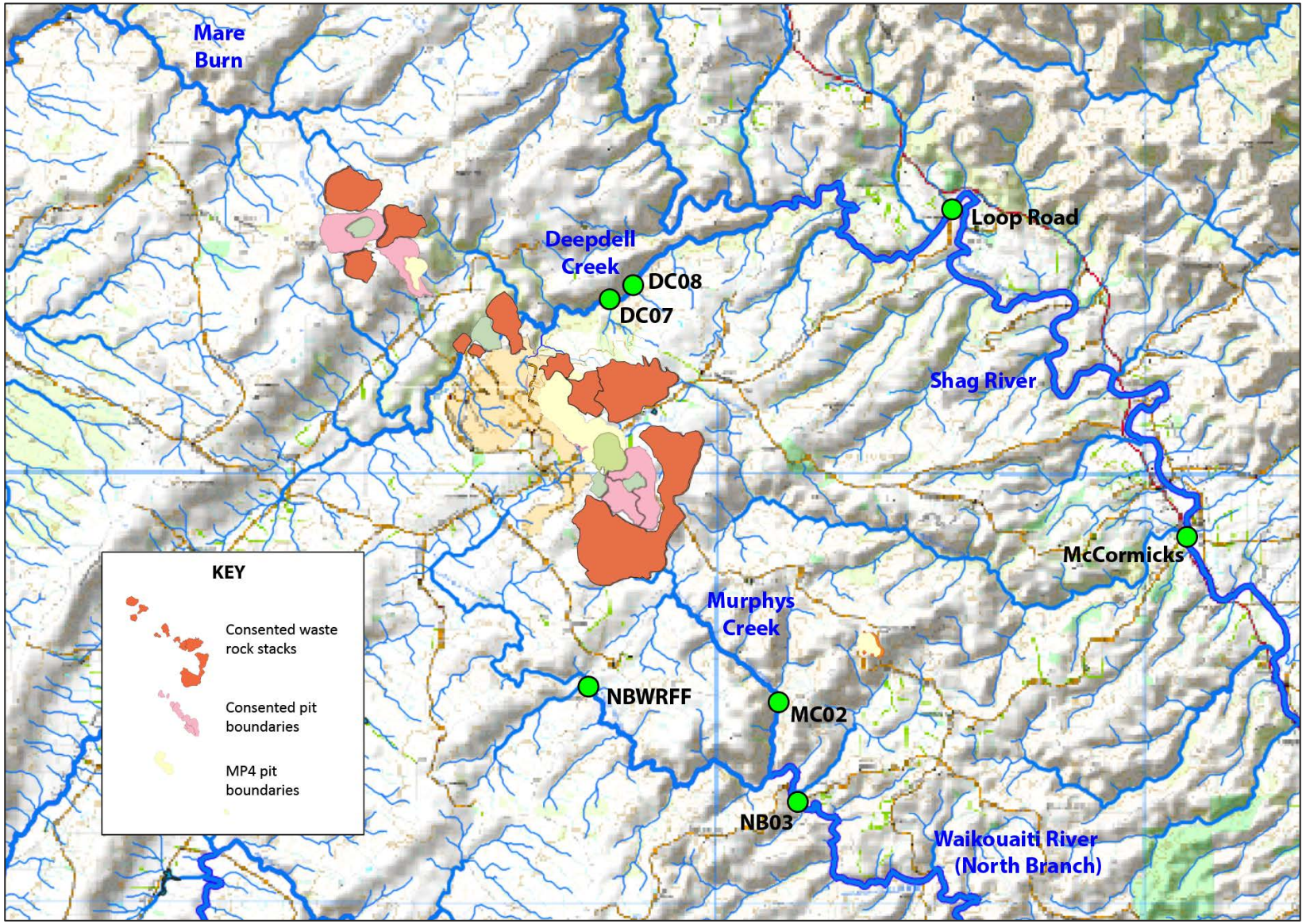

Figure 2. *Map showing approximate locations of surface water monitoring sites discussed in this report.*

2 CATCHMENT DESCRIPTIONS & CURRENT ECOLOGY AND WATER QUALITY CONDITIONS

Catchment descriptions have been described in previous reports noted above in section 1.1, however brief descriptions are presented below.

2.1.1 Deepdell Creek

Physical

Deepdell Creek (Figure 1) has a median flow of approximately 30 L/sec and a 7-day mean annual low flow (MALF) of 4 L/sec at the DC04 gauging site. In summer, the flow in Deepdell Creek can drop significantly, however, even under these low flow events, the creek is punctuated with deep, very slow flowing sections. Small riffle and run sections are also present. In riffle and run sections the substrate is dominated by cobbles with gravels and occasional boulders. Softer sediment is present in the slow moving glides and pools. These habitats support significant macrophyte cover, particularly in the warmer months and following periods of stable flow. Algae growth can be significant also.

Existing water quality

Lower Deepdell Creek typically has a pH above 7 (often between 7 and >8) and relatively high conductivity (since the start of 2020, an average of 538 µS/cm at DC07 and an average of 638 µS/cm at DC08). The pH has remained stable over time. At DC08, pH has remained within the range specified by the Consent compliance limits (6.0 to 9.5). Dissolved inorganic nitrogen concentrations are moderate to low (nitrate-nitrite-N, averages of 0.32 mg/L at DC07 and 0.075 mg/L at DC08 since the start of 2020). At DC07 and DC08, recent (since the start of 2020) ammoniacal and nitrate nitrogen concentrations are typically within the NPS-FW 2020 Attribute band A (for toxicity). Regular monitoring of dissolved reactive phosphorus at DC08 indicates low concentrations (average of <0.0033 mg/L since the start of 2022 when regular monitoring commenced) that should not promote nuisance algae and plant growths.

Sulphate concentrations are significantly higher in Deepdell Creek at monitoring sites downstream of the mine's influence, however they are generally well below the surface water compliance limit of 1,000 g/m^3 at DC08 (median of 183 mg/L since the start of 2020), except on one occasion (1,310 mg/L, 22 February 2024). This elevated level was due a very dry spell when the flow at the Deepdell Creek flow recorder registered 0.002 L/sec (Figure 3), meaning that surface flow was made up entirely of catchment seepage water. Sulphate concentrations at DC07 are generally similar to DC08 (median of 180 mg/L since the start of 2020 and a maximum concentration of 660 mg/L).

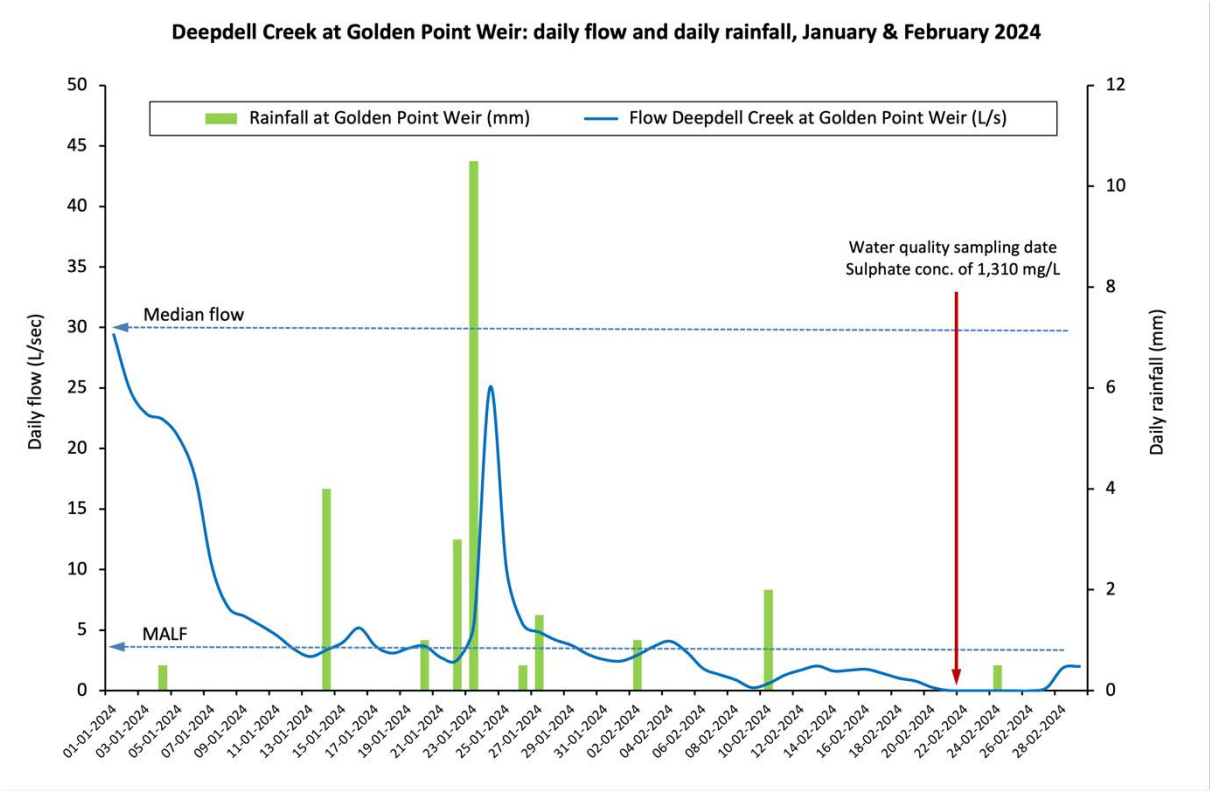

Figure 3. Deepdell Creek daily flows and rainfall in January and February 2024.

Except for iron and arsenic at DC07, element concentrations have largely remained below laboratory detection limits in Deepdell Creek, and the concentrations measured at DC08 have consistently remained below consent compliance limits. The iron concentrations should be treated with caution as they likely result from elevated background concentrations.

Weak acid dissociable (WAD) cyanide concentrations have been below the laboratory detection limit at all sites on all sampling occasions.

Aquatic biota

The most recent reported monitoring of benthic macroinvertebrates at Deepdell Creek monitoring sites (2023) indicated community composition at Deepdell sites was largely composed of molluscs (snails) and trichopterans (caddisflies), with dipterans (true-flies) contributing to community abundance in winter and spring, and ephemeropterans (mayflies) contributing to abundance at control sites in some seasons. Crustaceans and plecopterans (stoneflies) were also present across all sites at low densities throughout the year.

Taxa belonging to caddisflies, mayflies (Ephemeroptera) and stoneflies (Plecoptera) are referred to as EPT taxa and, collectively, are indicative of good water quality and habitat conditions in streams and rivers. The proportion of EPT abundance varied among Deepdell Creek sites in all seasons in 2023, generally declining between sites DC00 and DC03, then

generally increasing between sites DC05 and DC08 (Figure 4). In general, EPT taxa represent a relatively minor proportion of the total invertebrate community at Deepdell Creek monitoring sites, except at DC00, DC02 and DC08.

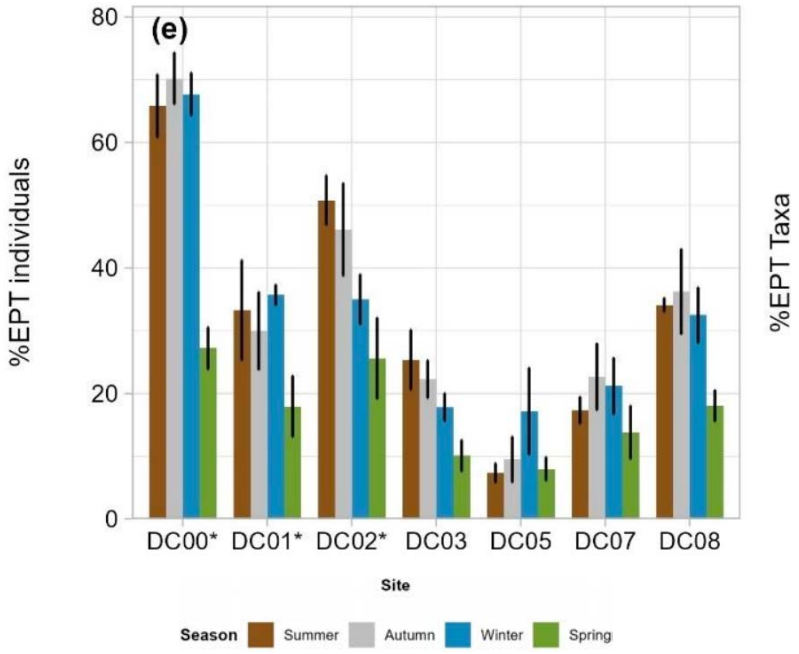

Figure 4. Mean (± standard error) seasonal %EPT individuals at Deepdell Creek sites, 2023.

Quantitative electric fishing surveys have been undertaken at Deepdell Creek monitoring sites in late summer for many years (over three decades). The Taieri Flathead galaxiid (*Galaxias depressiceps*) is by far the dominant fish species in Deepdell Creek, and site DC07, located downstream of the mine, typically supports a large population. 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 km2), predicted decline 10–50%) and the qualifiers 'Conservation Dependent' and 'Data Poor' (Dunn *et al.*2018).

For the 2020 survey, the highest population estimate was found at site DC02, followed by site DC01, then site DC08. Apart from DC07, all sites within or downstream of mining operations had higher population estimates compared to the 2019 survey. Population estimates in 2020 at all sites were within the respective estimate ranges of previous years. In addition to galaxiids, the 2020 fish survey found shortfin eels (*Anguilla australis*) at DC00 (body length 600 mm) and longfin eels (*Anguilla dieffenbachii*) were observed at DC03 (body length 700 mm) and DC07 (body length 260 mm). Longfin eels have been classified by the Department of Conservation as 'At Risk - Declining', while shortfin eels have been classified as 'Not Threatened' (Dunn *et al.* 2018). Unidentified eels were also observed but not caught at DC01 and DC03 in 2020.

For the 2021 survey, the highest population estimate of galaxiids was at impact site DC08, followed by control site DC01 and impact site DC07. Impact sites DC08, DC07 and DC03 had higher population estimates in 2021 relative to 2020, while population estimates at impact site DC05 were lower. Population estimates also decreased at control site DC02 in 2021 relative to 2020 (Ryder 2023c).

For the 2022 survey, 146 galaxiids were caught at DC07 (equating to a population density of approximately 200 fish per 10 m length of stream) and 90 at DC08. Two longfin eel and two small brown trout were also caught at DC08.

For the 2023 survey, the largest populations of galaxiids were at site DC02 (n=63), followed by DC08 (n=57), DC01 (n=53), DC07 (n=50), DC03 (48), DC00 (n=10), and DC05 (n=8). Body length ranged between 38 and 88 mm. High densities of small galaxiids (body length <50 mm) at all site suggests that populations are being sustained by successful spawning within the catchment. Kōura were also caught in fish surveys at sites DC00, DC01, DC02, DC03 and DC07.

Long-term linear trend analyses indicated that average galaxiid body length and galaxiid densities across Deepdell sites have not significantly varied over time, except for density at DC05, which appears going from 65 per 10 m of stream length in 2013 to 8 per 10 m stream reach in 2023 (Table 2). Habitat changes at this site, such as changes to the run-pool transition at the downstream end of the site with increased water depth and lower velocities, could be influencing DC05 fish densities.

Table 2. Permutational multivariate ANOVA results for long-term galaxiid population metrics at Deepdell Creek sites over time. Significant (i.e., p<0.05; denoted in bold) linear trends indicate a consistent change over time. 'n' denotes the sample size of mean annual measurements used in long-term tests (number of annual surveys).

Metric	DC00 (n=11)	DC01 (n=27)	DC02 (n=27)	DC03 (n=27)	DC05 (n=11)	DC07 (n=29)	DC08 (n=11)
Average galaxiid length (mm)	0.85	0.75	0.58	0.53	0.72	0.08	0.41
Galaxiid density (per 10 m of stream)	0.44	0.34	0.48	0.86	**0.02**	0.89	0.11

2.1.2 Shag River

The Shag River/Waihemo is a small river flowing from the slopes of Kakanui Peak and flowing in a south-easterly direction past the township of Palmerston before entering the Pacific Ocean just south of Shag Point/Matakaea. Most of the catchment consists of agriculture and

forestry with some short-rotation cropping in the lower catchment (ORC 2014[1]). The lower river has a median flow of 714 L/sec and a MALF of 160 L/sec.

Deepdell Creek joins the Shag River approximately 8 km upstream of the OceanaGold Shag River Loop Road surface water compliance monitoring site and approximately 25.5 km upstream of the OceanaGold McCormicks monitoring site (Figures 1 and 2). The Cranky Jims Creek and Tipperary Creek catchments report to the Shag River in the section between these two monitoring sites.

The Shag/Waihemo catchment supports a diverse fish community with sixteen species having been recorded, including 14 native species and 2 sports fish (brown trout and brook char). Seven of the native species recorded are of conservation concern (ORC 2014). Since 2009, eleven species of freshwater fish have been collected from the Otago Regional Council SoE monitoring site at Craig Road, which is downstream of the McCormick monitoring site. Upland bullies have been among the most abundant species on all sampling occasions. Other species regularly caught are shortfin and longfin eels, common, bluegill and upland bullies and lamprey (ORC 2014).

Overall, phosphorus concentrations (dissolved reactive phosphorus and total phosphorus) in the lower Shag River/Waihemo at both regional monitoring sites (Craig Road and Goodwood Pump located further downstream of Craig Road) are trending down over time (Figure 5). All monitored forms of nitrogen are also decreasing at the Craig Road and Goodwood Pump monitoring sites[2] (Figure 5).

[1] ORC. 2014. Shag River/Waihemo catchment: water quality and ecosystem. Otago Regional Council ISBN 978-0-478-37681-4.

[2] Source: LAWA website. https://www.lawa.org.nz/explore-data/otago-region/river-quality/shag-river/shag-at-goodwood-pump

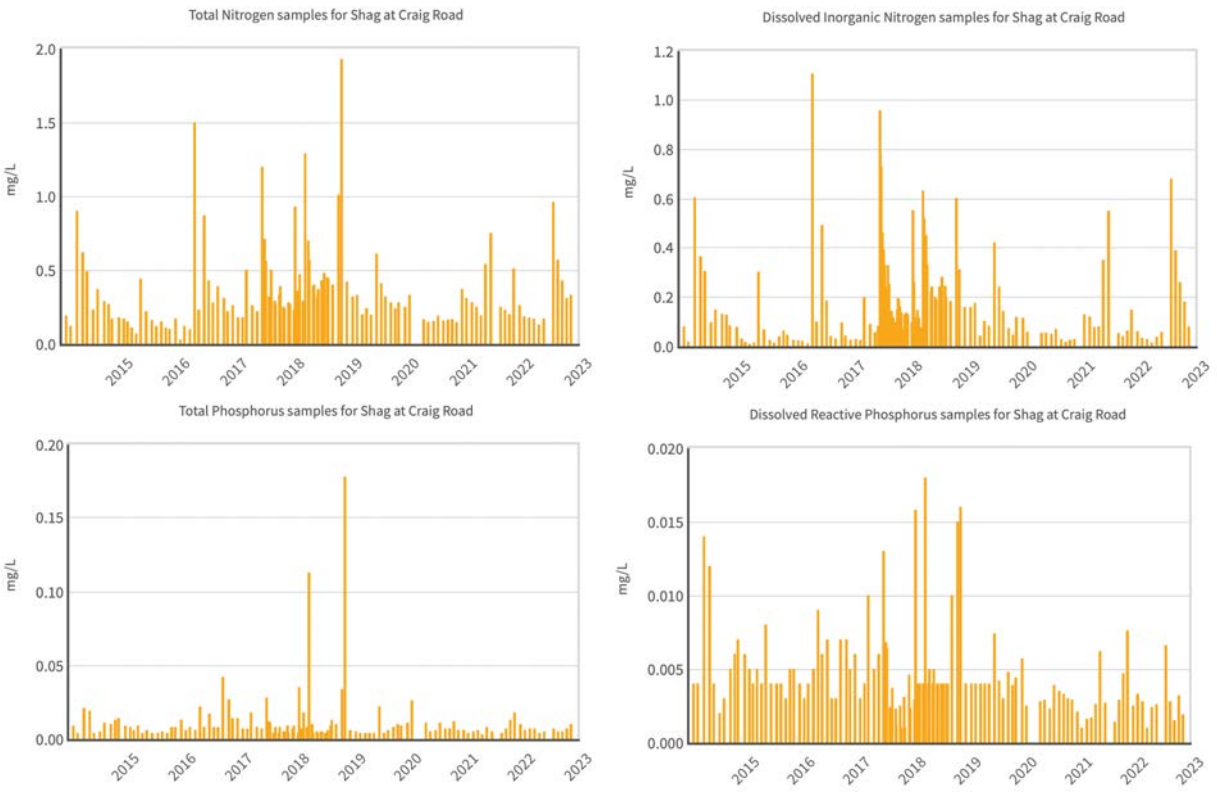

Figure 5. TN, DIN, TP and DRP concentrations over time at the Craig Road monitoring site on the Shag River. (Data and figure sourced from the LAWA website)

Sulphate concentrations do not exceed the surface water compliance limit of 250 g/m^3 at the Shag/Waihemo River Loop Road monitoring site. Metal concentrations have largely remained below laboratory detection limits and the concentrations measured at Loop Road have consistently remained below their relevant consent compliance limits.

2.1.3 Waikouaiti River North Branch

The headwaters of the Waikouaiti River North Branch lie at elevations of between 500 and 700 m a.s.l. with the Macraes Gold Mine at the very western end of the North Branch catchment (Figure 1).

The Waikouaiti River is one of Otago's three major rivers draining to the coast north of Dunedin. While it has a large catchment area, the river yields little water under normal conditions because of the low and sporadic rainfall the catchment receives (ORC 2008[3]). The lower reach of the North Branch has a median flow of approximately 590 L/sec and a MALF of approximately 170 L/sec.

The upper reaches of the Murphys Creek and Waikouaiti River North Branch catchments show

[3] ORC. 2018. The Water Resources of the Waikouaiti River. ISBN 1-877265-73-X.

considerable evidence of previous (historic) mining activities, and the upper catchment now largely consists of modern-day mining operations and extensive pastoral farming with pockets of remnant tussock grasslands.

NBWRRB

Regular benthic macroinvertebrate sampling is undertaken at the NBWRRB monitoring site (Figure 2) subject to the presence of surface water sufficient to sample. Instream habitat contains stagnant or very slow-moving water, over pasture grass and soft sediment. Occasionally, a few fine gravels have been seen at the downstream end of the road bridge. The macroinvertebrate communities at NBWRRB in 2022 and 2023 were dominated by taxa tolerant of poor habitat and water quality conditions, with small crustaceans, chironomidae midges, molluscs (snails) and oligochaete worms abundant throughout the year.

In 2022 aquatic survey of NBWRRB, a range of fish were caught using electric fishing techniques, including a healthy population of upland bullies (62 caught, lengths 26-62 mm). No galaxiids were caught at this site in 2021, however in 2022 three individuals were captured (length range 42-48 mm), as well as one shortfin eel (length 112 mm) and one kōura. In the 2023 survey, 17 upland bullies and one galaxiid were caught. Accurate fish surveys at this site are difficult due to dense macrophyte (weed) cover and low water velocities, making electric fishing techniques more difficult to assess fish densities.

MC02

Murphys Creek catchment has its headwaters on the Macraes plateau, which includes parts of the Macraes Gold Mine (primarily, the Frasers South Waste Rock Stack). Its catchment area represents approximately 19 % of the Waikouaiti River catchment, of which a small proportion of land in the headwaters has been directly affected by mining. Murphys Creek joins with Clydesdale Creek downstream of the Golden Bar rehabilitated waste rock stack. The confluence of these creeks is located within a deep pool area, but just downstream is a shallow and narrow riffle section that flows into another pool (this area is monitoring site MC02 – Figure 2). The substrate of the creek is comprised of small and medium sized cobbles. The creek is bordered by exotic grasses and gorse, with areas of aquatic macrophytes within the creek.

Three galaxiids were caught during the 2018 fish survey of MC02. Erosion of the bank and subsequent changes to instream habitats at MC02 required the relocation of the site in 2018 to a short riffle section with bed substrate of cobbles and gravels approximately 100 m downstream of the previous site. Electric fishing at this new site in summer 2019 found only one galaxiid (51 mm long), with no fish observed during spot fishing in pools, runs, and riffles near the site and between the new and previous sites. Electric fishing at MC02 for the 2020

summer survey yielded four galaxiids and 15 galaxiids (52-72 mm long) in the 2021 survey. Forty two galaxiids and one longfin eel (~900 mm long) were caught during the February 2022 survey, while 15 galaxiids were caught in the 2023 survey (47-73 mm long). Long-term trend analysis has not been undertaken for fish surveys at Waikouaiti River catchment sites due to the difficulty to accurately assess the galaxiid population. However, data from the 2023 survey aligns with what has been previously observed. Galaxiid density at MC02 is on a par with densities since regular monitoring commenced in 2004 (Figure 6).

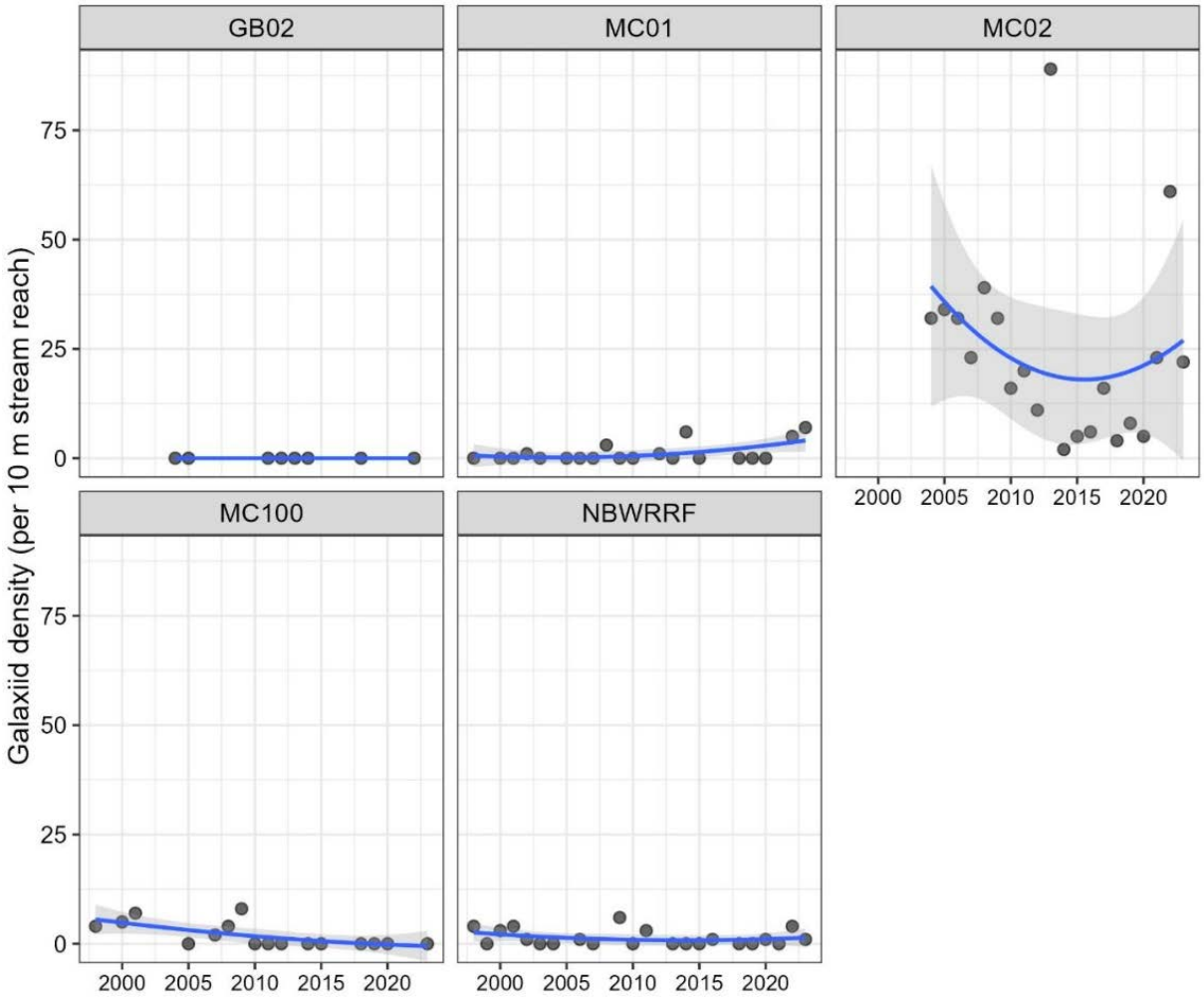

Figure 6. Galaxiid densities at Waikouaiti River catchment monitoring sites over time.

NB03

Monitoring site NB03 is located immediately downstream of the confluence of Golden Bar Creek and Waikouaiti River North Branch (Figure 2). No ecological monitoring is undertaken at this site, however regular water quality monitoring is undertaken.

Sulphate concentrations at this site are elevated relative to background levels, however, they are usually well below the consent compliance limit concentration of 250 g/m^3 (Table 1) apart from the first half of 2019 (range 290 – 990 mg/L) and late 2022 (range 300 – 340 m g/L) (Figure 7). Similarly, cyanide and dissolved metal concentrations are usually well below their respective compliance limit concentrations. The pH is similar to other monitoring sites in this catchment. Apart from several elevated readings in the first half of 2019 (range 0.882 – 2.810 g/m^3), nitrate-N concentrations in recent years at NB03 have been relatively low (Figure 7) and ammoniacal-N concentrations are usually below the laboratory detection limit of 0.01 g/m^3.

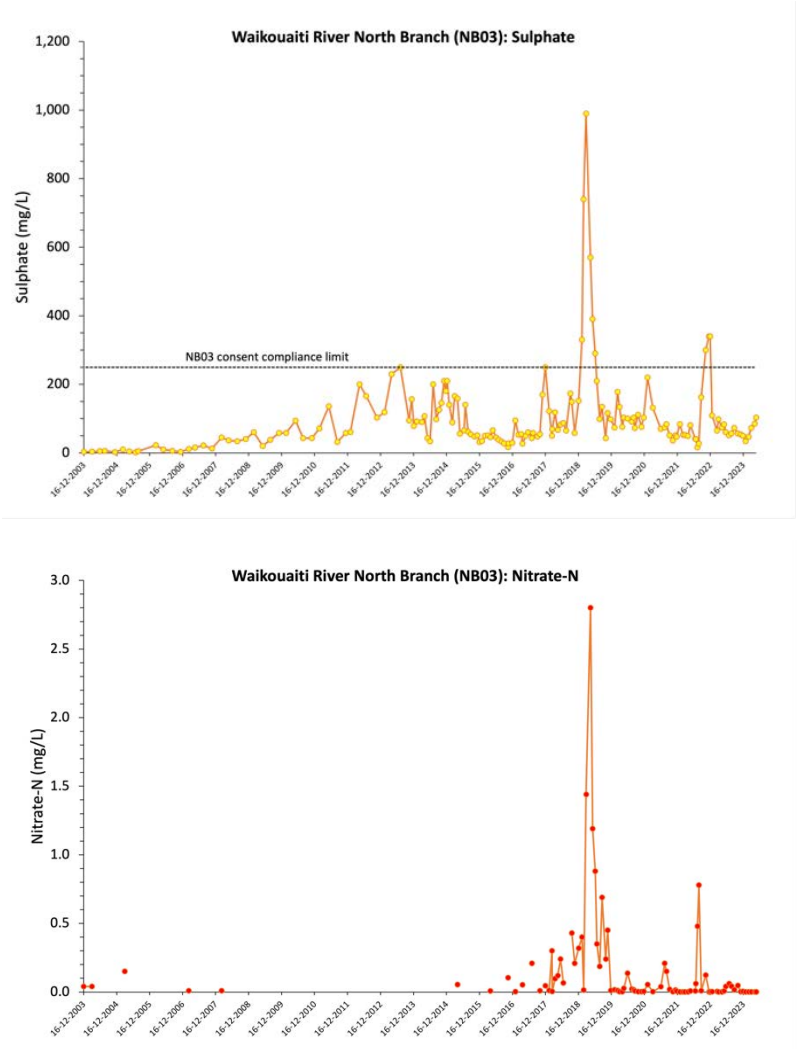

Figure 7. Sulphate (top) and Nitrate-N (bottom) concentrations over time at NB03 (2003-2023).

3 Assessment of Modelled Future Water Quality on Receiving Water Aquatic Life

3.1 Background

A key potential environmental effect associated with the development of MP4 stage 3 is changes in surface water quality over time as a result of the expansion of the mine, in particular the development of new or expanded pits and waste rock stacks.

For the Waikouaiti River North Branch catchment, GHD (2024) modelled surface water quality for scenarios that included during mining and following the closure of mining operations (long-term, i.e., following overtopping of Golden Bar pit lake) and seepages from waste rock stacks. The key periods assessed in this report are:

1. **Mining** (2027-2029) – During active mining where WRSs are under construction and pits are being dewatered and excavated. Active management of mine water is in place.
2. **Long-term** (~2230+) – The extended Golden Bar pit is projected to overflow having reached the overflow level, all surfaces are rehabilitated (other than pit walls), seepage from Frasers and Golden Bar WRSs have reached peak predicted values, all mine waters discharging to the environment other than where in-perpetuity pumping and treatment provisions are made.

For Deepdell Creek and Shag River/Waihemo, two additional scenarios were modelled and assessed to illustrate the cumulative effects within the Deepdell/Shag catchment (GHD 2024). These scenarios are:

1. **Basecase + dilution from Camp Creek dam** (or suitable alternative). Includes the operation of the Camp Creek dilution reservoir.
2. **Basecase + no dilution from Camp Creek dam** (or suitable alternative). Excludes the construction and operation of a dilution water source.

GHD (2024) provide a detailed commentary on the trajectories of predicted contaminant concentrations over time, based on the modelling assumptions identified in their report. Results presented in the following section examine key predicted contaminant concentrations in relation to current consent compliance limits and recognised water quality guidelines to protect freshwater aquatic life.

Note that predictions for cyanide, while having a compliance limit concentration at some compliance limit monitoring sites, have not been presented in this report. Cyanide is only associated with mine tailings (not waste rock stack leachate) and appears to have never been detected above the laboratory detection limit at Macraes receiving surface water monitoring sites. While it has been detected in mine underdrains, these waste streams are fed back into the Macraes Gold Mine's water management system (i.e., is they are re-circulated), and cyanide readily breakdowns when exposed to the environment. Iron predictions have not been presented either as elevated concentrations are due to naturally high background levels in the catchment.

3.2 Comparison of results with compliance limits and default guidelines

Tables 3 to 9 compare the GHD's water quality modelling results (GHD 2024) with respective existing consent compliance limits, ANZ default and proposed guideline values for 95% species protection, British Columbia Ministry of the Environment guidelines for sulphate (hardness dependent – noting that there are no New Zealand default guidelines for sulphate), and NPS-FW NOF band attribute states for ammoniacal-N and nitrate-N.

These tables show that, for mining and long-term scenarios, virtually all modelled parameters (contaminants) at all surface water compliance sites meet the ANZ default guidelines for 95% species protection, and for copper they meet proposed guidelines for 95% species protection, based on bioavailable copper and factoring in dissolved organic carbon. For sulphate, they will meet the British Columbia guidelines when hardness is taken into account and remain below existing sulphate compliance limits. There are a few parameters which are predicted to just exceed current ANZ default guideline values at some monitoring sites (particularly copper), and these are highlighted in yellow in the tables. These 'exceedances', however, are minor (in elevation above the 'threshold'), and are arguably within the margin of error associated with the modelling. They also do not take into account any corrections for the likes of hardness or dissolved organic carbon, which have recently been recommended as factors affecting toxicity that should be taken into account in assessing toxicity for some contaminants (Gadd *et al*. 2017[4]), as shown in the tables for bioavailable copper.

Bioavailable forms of nitrogen (primarily ammoniacal-N and nitrate-N) and phosphorous (dissolved reactive phosphorous or DRP), in sufficient concentration, can potentially cause nuisance algae and plant growths in surface waters. There is a predicted increase in bioavailable nitrogen in the mining and post-mining scenarios at some monitoring sites, and even current concentrations of bioavailable nitrogen at some sites are sufficient to promote nuisance growths if other environmental factors are variable. This is not

[4] Gadd, J., Milne, J., and Hickey, C. 2017. Copper and zinc aquatic toxicity: Frequently Asked Questions. Prepared for Environment Canterbury. NIWA CLIENT REPORT No: 2017129AK.

uncommon in New Zealand catchments dominated by horticultural and pastoral farming practices. However, bioavailable phosphorus (DRP) concentrations are low in surface waters draining the Macraes Gold Mine, and are low enough to be limiting growth. Future mining operations are not anticipated to cause increases in surface water phosphorus concentration, therefore algae and plant growths are not anticipated to degrade surface waters in the future, as a result of mining activities.

3.3 Effects on physical character

No changes to surface water flow regimes are anticipated aside from some potential minor and temporary changes to flow in Deepdell Creek, the upper Mare Burn catchment and the upper Waikouaiti River Norther Branch catchment.

Baseflow reduction in Deepdell Creek for the GPUG mine and proposed extension is predicted to be minor at an average of about 0.24 to 0.54 L/sec, with up to 0.11 L/sec of this reduction attributable to the GPUG extension. However, a conservative approach to flow management has been recommended, including undertaking longitudinal flow surveys previously undertaken at the start and end of summer under low flow conditions for the first two years of mining the GPUG extension (Ryder 2023c). There are no direct effects on the water quality of Deepdell Creek as a result of mining at GPUG and the GPUG extension. With no anticipated change in water quality due to GPUG operations, and no more than minor changes in flow, which are recommended to be monitored under summer low flow conditions, there are no anticipated effects on the stream ecosystem.

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 (Ryder 2024a).

No other modifications to the physical character of surface waters are anticipated aside from a temporary increase in flow in the Waikouaiti River North Branch, as a result of dewatering the Golden Bar pit, and some loss of ephemeral and intermittent watercourses in the headwaters of the Golden Bar catchment.

The Golden Bar pit will have to be drained before mining can commence and this may take approximately 1.25 years to complete at an assumed discharge rate of 30 L/sec. An additional 30 L/sec represents a relatively moderate (25 %) increase in the MALF, which is unlikely to change the physical character of the creek under low flow conditions. Adverse flow-on effects on the creek's ecology are therefore unlikely (Ryder 2024b). It is recommended that, if this dewatering to the Waikouaiti River North Branch is adopted, the discharge is pumped to the river channel at or downstream of the Murphys Creek confluence using suitable methods to avoid erosion and to ensure that existing water quality compliance criteria are not exceeded.

The extended Golden Bar Pit encroaches into the very top of the Golden Bar Creek watercourse for a distance of 120 m. The first 50 m or so is a constructed farm pond with an earth dam and below this is a damp section of channel before a surface flow is visible. This section of watercourse does not meet the definition of a 'river' under the ORC water plan.

Table 3. *Current and predicted long-term water quality statistics for **Deepdell Creek** at surface water monitoring site **DC07** compared against DC08 surface water compliance limits and water quality guidelines (ANZG 2018, NPS-FW B band attribute states, alternative published guidelines for sulphate and iron, and proposed NZ guideline for bioavailable copper). CC = Camp Creek dam. All units mg/L.*

† DC07 has no compliance limit for ammoniacal-N and nitrate-N, however, the threshold in the table is included as a placeholder based on the NPS-FW attribute state that has been adopted in more recent Macraes Gold Mine consent compliance limits.
** Recommended for application for slightly to moderately disturbed ecosystems (for protection of 95% of species).*
*** Bioavailability-based toxicity guideline value for copper in NZ. Note that assessments should be made after adjustment for bioavailability using an algorithm that include adjusting for dissolved organic carbon. Based on Gadd et al. (2023[5]). Values listed are for 95% of species protected (equivalent to a B band attribute).*
Bioavailable copper.

Parameter (all units mg/L)	**Deepdell Creek compliance limits for DC08**	**DGV guidelines** (ANZG 2018) (Deepdell Creek's REC is Cool Dry Hill)	**Alternative guideline**	**Attribute state** NPS-FW (2020) (B band - 95% species protection level)	**DC07 – CC dilution** **Mining Long-term** median & (95th percentile)	**DC07 – no dilution** **Mining Long-term]** median (95th percentile)
Ammoniacal-N	0.24†			>0.03 and ≤0.24 annual median >0.05 and ≤0.40 annual 95th percentile	0.014 (0.028) 0.013 (0.02)	0.014 (0.031) 0.013 (0.023)
Nitrate-N	2.4†			>1.0 and ≤2.4 annual median >1.5 and ≤3.5 annual 95th percentile	0.73 (2.5) 0.67 (1.6)	0.74 (3.4) 0.68 (3.3)
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	110 (390) 11 (360)	110 (510) 100 (550)
Dissolved Arsenic	0.15	For As(III) 0.024* For As(V) 0.013*		N/A	0.003 (0.012) 0.0036 (0.011)	0.0032 (0.015) 0.004 (0.012)
Dissolved Copper	0.009	0.0014*	Bioavailable Cu**	N/A	0.001 (0.0012) for both	0.001 (0.0012) for both

[5] Gadd *et al.*, 2023. *Implementing bioavailability-based toxicity guideline values for copper and zinc in Aotearoa New Zealand: Interim technical guidance for scientists and practitioners, focusing on freshwater applications.* Prepared by NIWA for MBIE Envirolink and Horizons Regional Council.

Parameter (all units mg/L)	**Deepdell Creek compliance limits for DC08**	**DGV guidelines** (ANZG 2018) (Deepdell Creek's REC is Cool Dry Hill)	**Alternative guideline**	**Attribute state** NPS-FW (2020) (B band - 95% species protection level)	**DC07 – CC dilution Mining Long-term** median & (95th percentile)	**DC07 – no dilution Mining Long-term]** median (95th percentile)
			≤0.00047 median ≤0.00073 95th %		0.0001 (0.00012) for both##	0.0001 (0.00012) 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 further data are required to establish a figure appropriate for New Zealand waters.	N/A	0.19 (0.23) 0.19 (0.22)	0.19 (0.23) 0.18 (0.22)
Dissolved Lead	0.0025	0.0034*		N/A	<0.00016 (<0.0002) for both	<0.00016 (<0.0002) for both
Dissolved Zinc	0.12	0.008*		N/A	0.0023 (0.0045) 0.0022 (0.0035)	0.0023 (0.0057) 0.0022 (0.0055)

Table 4. *Current and predicted long-term water quality statistics for **Deepdell Creek** at surface water monitoring site **DC08** compared against DC08 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, and proposed NZ guideline for bioavailable copper). CC = Camp Creek dam. All units mg/L.*

† DC08 has no compliance limit for ammoniacal-N and nitrate-N, however, the threshold in the table is included as a placeholder based on the NPS-FW attribute state that has been adopted in more recent Macraes Gold Mine consent compliance limits.

** Recommended for application for slightly to moderately disturbed ecosystems (for protection of 95% of species).*

*** The alternative guideline for copper is taken from Gadd et al. (2023) and is expressed as bioavailable copper, which is dissolved copper corrected for the dissolved organic carbon of the water. Values listed are for 95% of species protected (equivalent to a B band attribute).*

Bioavailable copper.

Parameter (all units mg/L)	**Deepdell Creek compliance limits for DC08**	**DGV guidelines** (ANZG 2018) (Deepdell Creek's REC is Cool Dry Hill)	**Alternative guideline**	**Attribute state** NPS-FW (2020) (B band - 95% species protection level)	**DC08 – CC dilution** **Mining Long-term** median & (95th percentile)	**DC08 – no dilution** **Mining Long-term**] median (95th percentile)
Ammoniacal-N	0.24†			>0.03 and ≤0.24 annual median >0.05 and ≤0.40 annual 95th percentile	0.014 (0.026) 0.013 (0.02)	0.014 (0.029) 0.013 (0.022)
Nitrate-N	2.4†			>1.0 and ≤2.4 annual median >1.5 and ≤3.5 annual 95th percentile	0.68 (2.3) 0.63 (1.6)	0.69 (3.1) 0.63 (3.0)
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	99 (360) 100 (330)	100 (460) 100 (520)
Dissolved Arsenic	0.15	For As(III) 0.024* For As(V) 0.013*		N/A	0.003 (0.011) 0.0036 (0.011)	0.0031 (0.015). 0.0041 (0.011)
Dissolved Copper	0.009	0.0014*	Bioavailable Cu** ≤0.00047 median ≤0.00073 95th %	N/A	0.001 (0.0012) 0.001 (0.0011) 0.0001 (0.00012) 0.0001 (0.00011) ##	0.001 (0.0012) for both 0.0001 (0.00012) for both##
Cyanide (WAD)	0.1	0.007*		N/A	Not assessed	Not assessed

Parameter (all units mg/L)	**Deepdell Creek compliance limits for DC08**	**DGV guidelines** (ANZG 2018) (Deepdell Creek's REC is Cool Dry Hill)	**Alternative guideline**	**Attribute state** NPS-FW (2020) (B band - 95% species protection level)	**DC08 – CC dilution** **Mining Long-term** median & (95th percentile)	**DC08 – no dilution** **Mining Long-term**] median (95th percentile)
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 further data are required to establish a figure appropriate for New Zealand waters.	N/A	0.19 (0.23) 0.19 (0.22)	0.19 (0.23) 0.18 (0.22)
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	0.0022 (0.0043) 0.0022 (0.0035|)	0.0022 (0.0053) 0.0022 (0.0052)

Table 5. *Current and predicted long-term water quality statistics for the **Shag River** surface water monitoring site at **Loop Road** compared against Loop Road 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, and proposed NZ guideline for bioavailable copper). All units mg/L.*

† Loop Road has no compliance limit for ammoniacal-N and nitrate-N.

* Recommended for application for slightly to moderately disturbed ecosystems (for protection of 95% of species).

** The alternative guideline for copper is taken from Gadd *et al*. (2023) and is expressed as bioavailable copper, which is dissolved copper corrected for the dissolved organic carbon of the water. Values listed are for 95% of species protected (equivalent to a B band attribute).

Bioavailable copper.

Parameter (all units mg/L)	**Shag River compliance limits for Loop Road**	**DGV guidelines** (ANZG 2018) (Shag River's REC is Cool Dry Hill)	**Alternative guideline**	**Attribute state** NPS-FW (2020) (B band - 95% species protection level)	**CC dilution** **Mining Long-term** median & (95th percentile)	**CC no dilution** **Mining Long-term**] median (95th percentile)
Ammoniacal-N	–†			>0.03 and ≤0.24 annual median >0.05 and ≤0.40 annual 95th percentile	0.011 (0.013) 0.01 (0.013)	0.011 (0.013) 0.01 (0.013)
Nitrate-N	–†			>1.0 and ≤2.4 annual median >1.5 and ≤3.5 annual 95th percentile	0.21 (0.44) 0.21 (0.48)	0.21 (0.45) 0.21 (0.48)
Sulphate	250	(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	21 (56) 22 (74)	20 (56) 21 (74)
Dissolved Arsenic	0.01	For As(III) 0.024* For As(V) 0.013*		N/A	0.0027 (0.0039) 0.0028 (0.0039)	0.0027 (0.004) 0.0028 (0.004)
Dissolved Copper	0.009	0.0014*	Bioavailable Cu** ≤0.00047 median ≤0.00073 95th %	N/A	0.001 (0.0012) for both 0.0001 (0.00012) for both##	0.001 (0.0012) for both 0.0001 (0.00012) for both##
Cyanide (WAD)	–	0.007*		N/A	Not assessed	Not assessed
Iron (total)	0.2	(Insufficient data to derive a reliable trigger value)	ANZG (2018) suggest the current Canadian	N/A	0.2 (0.24) for both	0.2 (0.24) for both

Parameter (all units mg/L)	**Shag River compliance limits for Loop Road**	**DGV guidelines** (ANZG 2018) (Shag River's REC is Cool Dry Hill)	**Alternative guideline**	**Attribute state** NPS-FW (2020) (B band - 95% species protection level)	**CC dilution Mining Long-term** median & (95th percentile)	**CC no dilution Mining Long-term]** median (95th percentile)
			guideline level of 0.3 mg/L could be used as an interim indicative working level but further data are required to establish a figure appropriate for New Zealand waters.			
Dissolved Lead	0.0025	0.0034*		N/A	0.00015 (0.00081) for both	0.00015 (0.00019) 0.00015 (0.00081)
Dissolved Zinc	0.12	0.008*		N/A	0.0016 (0.002) for both	0.0016 (0.002) for both

Table 6. *Current and predicted long-term water quality statistics for the **Shag River** surface water monitoring site at **McCormicks** compared against McCormicks 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, and proposed NZ guideline for bioavailable copper). All units mg/L.*

† McCormicks has no compliance limit for ammoniacal-N and nitrate-N.
** Recommended for application for slightly to moderately disturbed ecosystems (for protection of 95% of species).*
*** The alternative guideline for copper is taken from Gadd et al. (2023) and is expressed as bioavailable copper, which is dissolved copper corrected for the dissolved organic carbon of the water. Values listed are for 95% of species protected (equivalent to a B band attribute).*
Bioavailable copper.

Parameter (all units mg/L)	**Shag River compliance limits for McCormicks**	**DGV guidelines** (ANZG 2018) (Shag River's REC is Cool Dry Hill)	**Alternative guideline**	**Attribute state** NPS-FW (2020) (B band - 95% species protection level)	**CC dilution Mining Long-term** median & (95th percentile)	**CC no dilution Mining Long-term]** median (95th percentile)
Ammoniacal-N	–†			>0.03 and ≤0.24 annual median >0.05 and ≤0.40 annual 95th percentile	0.021 (0.052) 0.01 (0.012)	0.021 (0.053) 0.01 (0.012)
Nitrate-N	–†			>1.0 and ≤2.4 annual median >1.5 and ≤3.5 annual 95th percentile	0.21 (0.42) 0.21 (0.44)	0.21 (0.42) 0.21 (0.44)
Sulphate	250	(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	26 (67) 27 (73)	25 (68) 27 (73)
Dissolved Arsenic	0.01	For As(III) 0.024* For As(V) 0.013*		N/A	0.0064 (0.017) 0.003 (0.039)	0.0064 (0.017) 0.003 (0.0039)
Dissolved Copper	0.009	0.0014*	Bioavailable Cu** ≤0.00047 median ≤0.00073 95th %	N/A	0.0016 (0.0035) 0.00099 (0.0012) 0.00016 (0.00035) 0.00099 (0.000122)	0.0016 (0.0036) 0.00099 (0.0012) 0.00016 (0.00035) 0.00099 (0.00012)
Cyanide (WAD)	–	0.007*		N/A	Not assessed	Not assessed
Iron (total)	0.2	(Insufficient data to derive a reliable trigger value)	ANZG (2018) suggest the current Canadian	N/A	0.24 (0.33) 0.2 (0.23)	0.24 (0.34) 0.2 (0.23)

Parameter (all units mg/L)	**Shag River compliance limits for McCormicks**	**DGV guidelines** (ANZG 2018) (Shag River's REC is Cool Dry Hill)	**Alternative guideline**	**Attribute state** NPS-FW (2020) (B band - 95% species protection level)	**CC dilution Mining Long-term** median & (95th percentile)	**CC no dilution Mining Long-term]** median (95th percentile)
			guideline level of 0.3 mg/L could be used as an interim indicative working level but 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	0.0016 (0.002) for both	0.0016 (0.002) for both

Table 7. *Current and predicted long-term water quality statistics for the **Waikouaiti River North Branch** catchment surface water monitoring site at Murphys Creek **MC02** compared against MC02 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 and proposed NZ guideline for bioavailable copper). All units mg/L.*

† MC02 has no compliance limit for ammoniacal-N and nitrate-N.

* Recommended for application for slightly to moderately disturbed ecosystems (for protection of 95% of species).

The elevated copper concentrations are all modelled with an associated elevated hardness (in excess of 400 mg/L). Based on the hardness related compliance criteria, the hardness related copper compliance limit would be 0.035 mg/L, therefore the water quality at MC02 is expected to be within the consent compliance limits.

** The alternative guideline for copper is taken from Gadd *et al*. (2023) and is expressed as bioavailable copper, which is dissolved copper corrected for the dissolved organic carbon of the water. Values listed are for 95% of species protected (equivalent to a B band attribute).

Bioavailable copper.

Parameter (all units mg/L)	**Waikouaiti River NB compliance limits for MC02**	**DGV guidelines** (ANZG 2018) ((Waikouaiti River North Branch is Cool Dry Hill)	**Alternative guideline**	**Attribute state** NPS-FW (2020) (B band - 95% species protection level)	**Mining** **Long-term** median & (95th percentile)
Ammoniacal-N	0.24†			>0.03 and ≤0.24 annual median >0.05 and ≤0.40 annual 95th percentile	0.01 (0.012) for both
Nitrate-N	2.4†			>1.0 and ≤2.4 annual median >1.5 and ≤3.5 annual 95th percentile	0.15 (0.19) 0.88 (1.3)
Sulphate	1000	(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	12 (23) 300 (440)
Dissolved Arsenic	0.15	For As(III) 0.024* For As(V) 0.013*		N/A	0.0026 (0.0032) 0.0026 (0.0032)
Dissolved Copper	0.009	0.0014*	Bioavailable Cu** ≤0.00047 median ≤0.00073 95th %	N/A	0.001 (0.0012) 0.0011 (0.0013)# 0.00012 (0.00014)##
Cyanide (WAD)	–	0.007*		N/A	Not assessed

Parameter (all units mg/L)	**Waikouaiti River NB compliance limits for MC02**	**DGV guidelines** (ANZG 2018) ((Waikouaiti River North Branch is Cool Dry Hill)	**Alternative guideline**	**Attribute state** NPS-FW (2020) (B band - 95% species protection level)	**Mining** **Long-term** median & (95th percentile)
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 further data are required to establish a figure appropriate for New Zealand waters.	N/A	0.2 (0.24) 0.18 (0.22)
Dissolved Lead	0.0025	0.0034*		N/A	0.00015 (0.00018) 0.00019 (0.00023)
Dissolved Zinc	0.12	0.008*		N/A	0.0015 (0.0018) 0.0036(0.0052)

Table 8. *Current and predicted long-term water quality statistics for the **Waikouaiti River North Branch** catchment surface water monitoring site at **NBWRRF** compared against NBWRRF 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 and proposed NZ guideline for bioavailable copper). All units mg/L.*

† NBWRRF has no compliance limit for ammoniacal-N and nitrate-N.

* Recommended for application for slightly to moderately disturbed ecosystems (for protection of 95% of species).

The alternative guideline for copper is taken from Gadd *et al*. (2023) and is expressed as bioavailable copper, which is dissolved copper corrected for the dissolved organic carbon of the water. Values listed are for 95% of species protected (equivalent to a B band attribute).

Bioavailable copper.

Parameter (all units mg/L)	**Waikouaiti River NB compliance limits for NBWRRF**	**DGV guidelines†** (ANZG 2018) (Waikouaiti River North Branch is Cool Dry Hill)	**Alternative guideline**	**Attribute state** NPS-FW (2020) (B band - 95% species protection level)	**Mining Long-term** median & (95th percentile)
Ammoniacal-N	–†			>0.03 and ≤0.24 annual median >0.05 and ≤0.40 annual 95th percentile	0.011 (0.014) 0.013 (0.017)
Nitrate-N	–†			>1.0 and ≤2.4 annual median >1.5 and ≤3.5 annual 95th percentile	0.21 (0.44) 0.44 (0.82)
Sulphate	1000	(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	38 (170) 130 (280)
Dissolved Arsenic	0.15	For As(III) 0.024* For As(V) 0.013*		N/A	0.0026 (0.0032) 0.0026 (0.0033)
Dissolved Copper	0.009	0.0014*	Bioavailable Cu** ≤0.00047 median ≤0.00073 95th %	N/A	0.0011 (0.0013) 0.0012 (0.0015) 0.0001 (0.00013) 0.00012 (0.00015)
Cyanide (WAD)	–	0.007*		N/A	Not assessed
Iron (total)	1.0	(Insufficient data to derive a reliable trigger value)	ANZG (2018) suggest the current Canadian	N/A	0.2 (0.24) 0.19 (0.23)

Parameter (all units mg/L)	**Waikouaiti River NB compliance limits for NBWRRF**	**DGV guidelines†** (ANZG 2018) (Waikouaiti River North Branch is Cool Dry Hill)	**Alternative guideline**	**Attribute state** NPS-FW (2020) (B band - 95% species protection level)	**Mining Long-term** median & (95th percentile)
			guideline level of 0.3 mg/L could be used as an interim indicative working level but further data are required to establish a figure appropriate for New Zealand waters.		
Dissolved Lead	0.0025	0.0034*		N/A	0.00015 (0.00019) 0.00016 (0.0002)
Dissolved Zinc	0.12	0.008*		N/A	0.0017 (0.0022) 0.0022 (0.0032)

Table 9. *Current and predicted long-term water quality statistics for the **Waikouaiti River North Branch** catchment surface water monitoring site at **NB03** compared against NB03 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 and proposed NZ guideline for bioavailable copper). All units mg/L.*

† NB03 has no compliance limit for ammoniacal-N and nitrate-N, however the MB02 limits are implied to be applicable at NB03 as a term of reference.

* Recommended for application for slightly to moderately disturbed ecosystems (for protection of 95% of species).

** The alternative guideline for copper is taken from Gadd *et al*. (2023) and is expressed as bioavailable copper, which is dissolved copper corrected for the dissolved organic carbon of the water. Values listed are for 95% of species protected (equivalent to a B band attribute).

Bioavailable copper.

Parameter (all units mg/L)	**Waikouaiti River NB compliance limits for NB03**	**DGV guidelines** (ANZG 2018) ((Waikouaiti River North Branch is Cool Dry Hill)	**Alternative guideline**	**Attribute state** NPS-FW (2020) (B band - 95% species protection level)	**Mining Long-term** median & (95th percentile)
Ammoniacal-N	0.24†			>0.03 and ≤0.24 annual median >0.05 and ≤0.40 annual 95th percentile	0.011 (0.015) 0.011 (0.012)
Nitrate-N	2.4†			>1.0 and ≤2.4 annual median >1.5 and ≤3.5 annual 95th percentile	0.17 (0.27) 0.42 (0.61)
Sulphate	1000	(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	19 (68) 120 (190)
Dissolved Arsenic	0.15	For As(III) 0.024* For As(V) 0.013*		N/A	0.0029 (0.0097) 0.0039 (0.0083)
Dissolved Copper	0.009	0.0014*	Bioavailable Cu** ≤0.00047 median ≤0.00073 95th %	N/A	0.001 (0.0012). 0.0017 (0.0035) 0.0001 (0.00012) 0.00017 (0.00035)
Cyanide (WAD)	–	0.007*		N/A	Not assessed
Iron (total)	1.0	(Insufficient data to derive a reliable trigger value)	ANZG (2018) suggest the current Canadian	N/A	0.19 (0.21) 0.19 (0.22)

Parameter (all units mg/L)	**Waikouaiti River NB compliance limits for NB03**	**DGV guidelines** (ANZG 2018) ((Waikouaiti River North Branch is Cool Dry Hill)	**Alternative guideline**	**Attribute state** NPS-FW (2020) (B band - 95% species protection level)	**Mining Long-term** median & (95th percentile)
			guideline level of 0.3 mg/L could be used as an interim indicative working level but further data are required to establish a figure appropriate for New Zealand waters.		
Dissolved Lead	0.0025	0.0034*		N/A	0.00015 (0.00017) 0.00016 (0.00018)
Dissolved Zinc	0.12	0.008*		N/A	0.0016 (0.0018) 0.0023(0.003)

4 Summary & Conclusion

Based on the information presented in section 3.2, I do not expect to see any changes in the composition of the aquatic faunal of the streams and rivers affected by the MP4 mine expansion. Provided GHD's proposed water mitigation options are implemented and managed (GHD 2024), there are no anticipated material changes to the physical character of the receiving waters as a result of the cumulative effects of the proposed mining expansion, and no material changes to the hydrological character of the receiving waters. Predicted short and long-term changes in water quality in Deepdell Creek-Shag River and North Branch Waikouaiti River satisfy default (i.e. conservative) guideline values. Apparent Cu 'exceedances' are minor in elevation above the 'threshold', and do not take into account any corrections for the likes of hardness or dissolved organic carbon, which have recently been recommended as factors affecting toxicity that should be undertaken. These corrections will be favourable, as shown in Tables 3 to 9. Elevated iron levels in Deepdell Creek are a result of naturally high background levels in the catchment.

I recommend that hardness and dissolved organic carbon are included (if not already) to the regular monitoring programme for surface water parameters, along with pH and temperature, as these appear to have potential to strongly influence the toxicity of water quality parameters, particularly some metals.

5 REFERENCES

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APPENDIX A: NPS-FW NOF attribute states for ammonia & nitrate

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.

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.