MACRAES GOLD MINE

Macraes Phase Four Project

Golden Bar Open Pit Mine and Waste Rock Stack Extension – effects on surface water ecology

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Version:	24 March 2024 – Final

Cover photo:	GB02 monitoring site, Golden Bar Creek, looking upstream.

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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). 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, 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; 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) and the Coronation mine, on surface water ecology and water quality, have already been addressed in separate reports (Ryder 2022a, Ryder 2022b, Ryder 2023ca, Ryder 2023b).

GPUG Extension has been made under a separate consent application and this application has looked at potential loss of surface water flow due mine activities including underground mining in the vicinity of Deepdell Creek. This has no effect on the catchments potentially affected by Golden Bar stage 2.

This report focuses on the effects of the proposed extension to the Golden Bar Pit and associated WRS but includes consideration of cumulative effects arising from Stage 3 mining the Waikouaiti River North Branch.

1.2 Golden Bar Pit and Waste Rock Stack – brief descriptions

1.2.1 Existing mine

The existing Golden Bar Pit and associated WRS were originally consented in 2002 with mining commencing shortly thereafter and ending in 2006. The Golden Bar mining area is a 'satellite pit' located some 6.5 km southeast of the Frasers open pit, and about 60 kilometres north of Dunedin. It is bounded by the Shag River catchment to the north and east and the Waikouaiti River North Branch to the south. The pit and WRS are concentrated in the north western part of this area, on the south western slopes of Dunback Hill in an area bounded to the east and north by Golden Bar Road (Figure 1). The existing pit occupies an area of approximately 14 ha while the existing rehabilitated WRS covers approximately 33 ha.

1.2.2 Proposed extensions

The proposed extension of the Golden Bar Pit (Golden Bar Stage 2 Open Pit) consists of an approximately 200 m expansion to the north-east largely over ground previously disturbed from the first stage of mining at Golden Bar in 2004-2006, that has since been rehabilitated (figures 2 and 3). This land was previously used for equipment park up areas and crib facilities.

The highest point of the proposed pit rim extension is approximately 580 mRL and the deepest point is approximately 420 mRL, which is about 45m deeper than the previous pit.

Dewatering of the existing Golden Bar Pit will be necessary before mining recommences. This pit began filling once the first stage of mining concluded, and started to overflow in 2015. Dewatering will remove water accumulated within the pit and draw down the surrounding groundwater table. One of the options is for the pit water to be discharged to the Waikouaiti River North Branch catchment (Appendix B in GHD 2024). The other option is to pump some or all of the water back to Frasers Tailing Storage Facility for use in ore processing.

The proposed waste disposal will entail an extension of approximately 400m to the south-west and approximately 150 m to the northwest towards the existing silt pond. The final toe of the WRS will be located adjacent to the current silt pond (figures 2 and 3). Approximately half of the new footprint is over the previous waste rock stack which has since been rehabilitated, however there will be new disturbance for the south-west extension and along the flanks where the currently rehabilitated faces abut natural ground.

The south-west extension provides a cap above the gently sloping existing topography and does not extend below the level where the topography gets steeper at the edge of the Clydesdale Creek valley. The top level of the WRS is 610 mRL, which is about 70 m above the current WRS.

Ore will be transported directly to the process plant with mine trucks using the existing haul road along the west side of Golden Bar Road.

When mining ends, the pit will not be backfilled, and the pit void will eventually fill with water from rainfall, surface water runoff and groundwater ingress, and overflow to the south into Golden Bar Creek, as it does currently. It is estimated that it will take 35 to 42 years before the pit starts to overflow (GHD 2024). The slopes of the WRS will be shaped and revegetated progressively, using standard site rehabilitation techniques.

The effect of the extended pit and waste rock stack on the aquatic ecology of the surrounding watercourses in the Waikouaiti River North Branch catchment is the subject of this report.

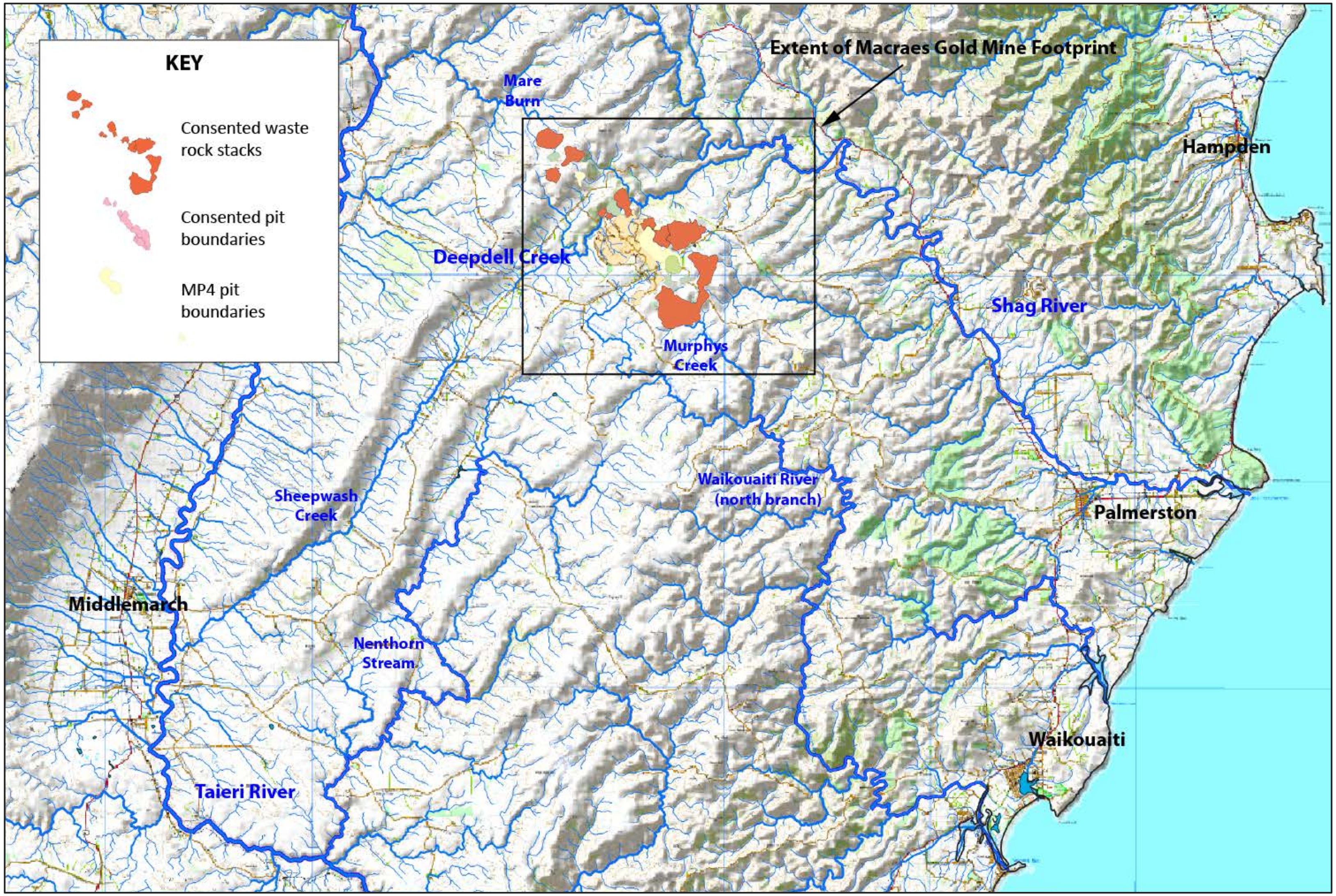


Figure 1. Map showing general location of the Macraes Gold Project and extent of existing mining operations. Golden Bar pit is located in the bottom right hand corner of the box indicating the extent Macraes Gold Mine footprint.

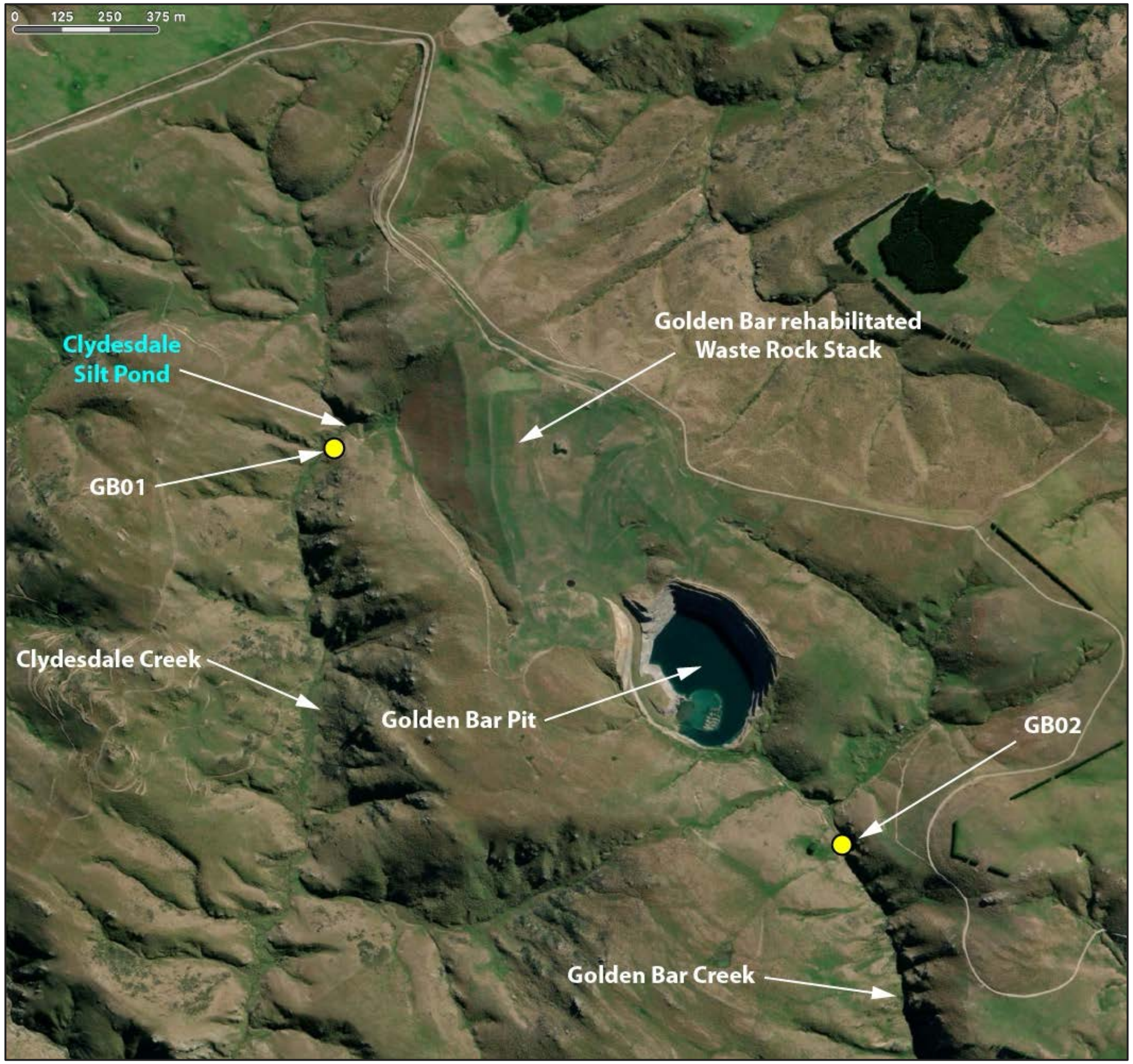


Figure 2. Aerial close-up map showing the existing Golden Bar Pit and rehabilitated WRS, Clydesdale and Golden Bar creeks and local surface water monitoring sites.

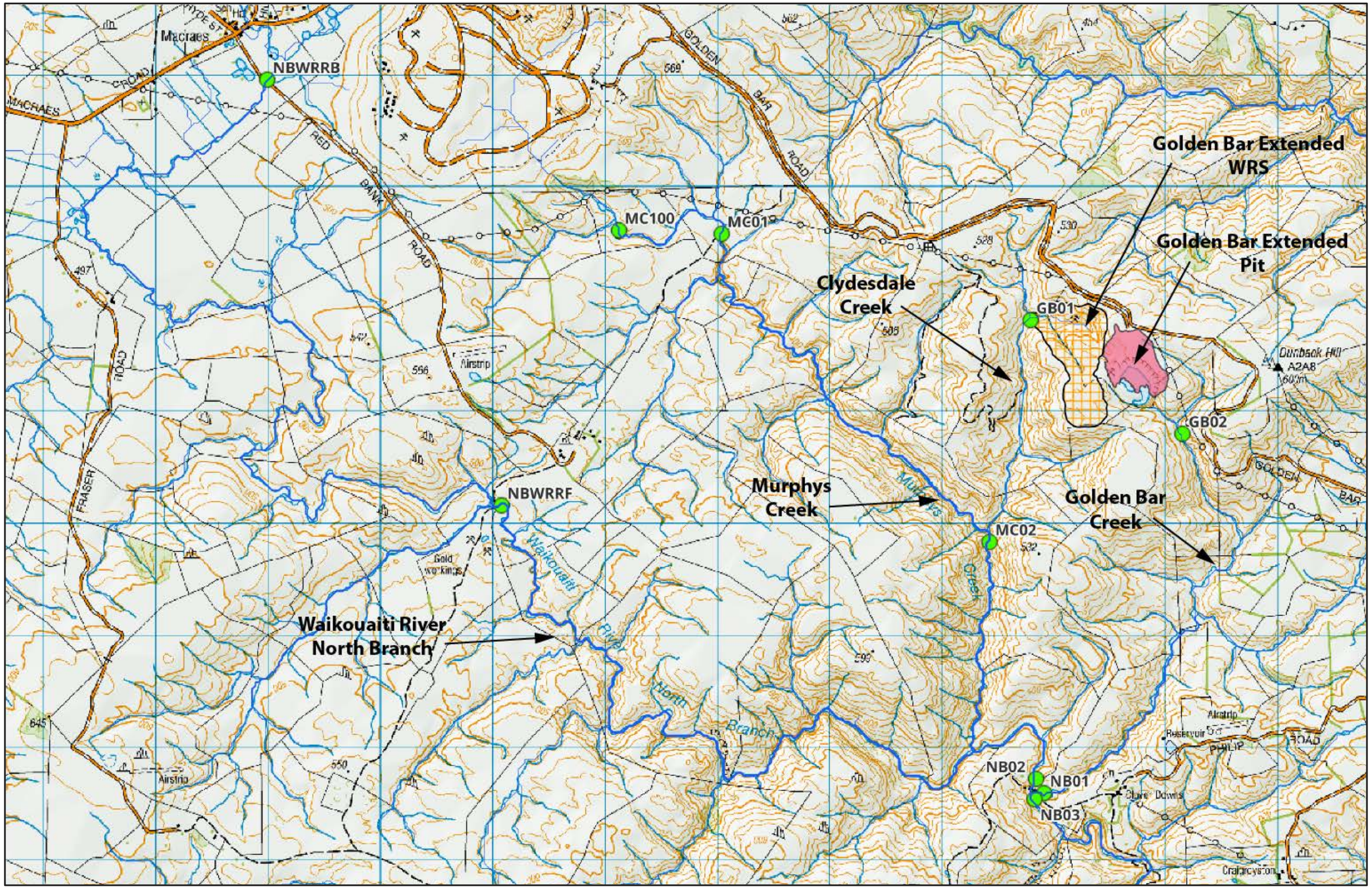


Figure 3. Map showing the proposed extensions to the Golden Bar mine and Waikouaiti River North Branch catchment surface water monitoring sites (green circles).

2 EXISTING VALUES

2.1 General Character & Hydrology

The landscape in the general area of the Golden Bar Mine is extensively modified and consists of a relatively flat summit, that runs parallel with the Golden Bar Road, with slightly raised areas where the existing pit and waste rock stack lie. To the south, the land falls away to rugged hill country, with deeply incised waterways and occasional outcroppings of schist tors. Altitudes range from between about 500 and 600 m a.s.l. Rainfall tends to be low (600-800 mm per year), and the area is exposed to prevailing winds.

The existing rehabilitated Golden Bar WRS drains primarily to the Clydesdale Creek catchment. Clydesdale Creek is a tributary of Murphys Creek, which in turn is a tributary of the Waikouaiti River North Branch (figures 2 and 3). A silt pond (the Clydesdale Silt Pond) is located approximately 60 m downstream of the toe of the waste rock stack in the Clydesdale Creek catchment (Figure 2, Plate 1). Clydesdale Creek has a catchment area of approximately 357 ha and the extended waste rock stack would occupy approximately 48 ha or 13 % of the catchment.

Plate 1. Aerial of Clydesdale Silt Pond downstream of the toe of the rehabilitated Golden Bar WRS. Clydesdale Creek runs top to bottom.

The existing Golden Bar Pit, and its proposed extension, lies in the headwaters of Golden Bar Creek, a small tributary that joins the Waikouaiti River North Branch approximately 1.3 km downstream of the confluence of Murphys Creek and the Waikouaiti River North Branch (figures 2 and 3, Plate 2). Golden Bar Creek has a catchment area of approximately 930 ha and the extended mine pit would occupy approximately 29 ha or 3.1 % of the catchment.

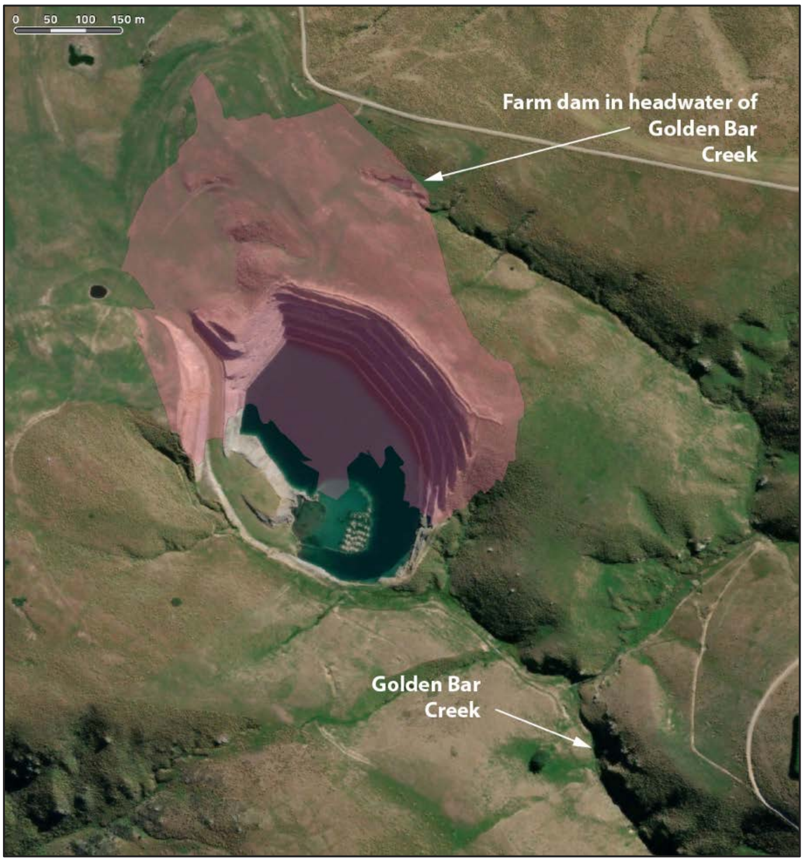


Plate 2. Aerial of the existing Golden Bar Pit showing the extent of proposed pit extension (shaded area) and upper Golden Bar Creek on the left hand side.

Both Clydesdale and Golden Bar creeks are typical of small first to third order streams in the Macraes area. Creek channels are often confined by steep rocky bluffs. The streams are generally narrow although wider in some areas where the valley floor opens out. The streams lie within valley floors that drain catchments predominantly covered in pasture and tussock land that is subject to cattle and sheep grazing, as well as feral deer, pigs, rabbits and hares. The streams are unfenced, so stock have unimpeded access to riparian margins and creek channels.

Golden Bar Creek has a farm dam formed of earth/soil across the upper most gully in which the creek forms (see Plate 2), and below it is a seepy, boggy-type section before a surface flow is visible and the channel stream-like features (Plate 3, top photos). The creek is very small in its upper reaches, with an estimated median flow of 5.2 L/sec and an estimated MALF of 1.8 L/sec at the GB02 monitoring site (Table 1). The Golden Bar Pit lake currently overflows into Golden Bar Creek, but even with that source of water, it carries very little flow in the upper reaches particularly in the drier months of the year. It was reported in the annual 2019 report on biological monitoring that: "*No fishing could be undertaken at GB02. Conditions at this site in summer generally create difficult conditions for electric fishing with very little surface water present and habitat for fish generally limited to small pools. In summer 2019 there were several sections of the creek with no visible flow. Stock (cattle) activity had been high in the creek prior to the summer survey, with crossing points, pugging and droppings throughout the creek.*" (Ryder Environmental 2020).

Plate 3. Top left: looking upstream in the headwaters of Golden Bar Creek just downstream of where the extended pit would encroach on the creek (photos courtesy of Craig Wilson). Top right: the creek channel just downstream of where the top left photo was taken. Middle left: Golden Creek at monitoring site GB02, December 2020. Middle right: GB02, December 2020, showing pugging of creek bed. Bottom left: GB02, March 2020. Bottom right: GB02, March 2021.

This creek has a monitoring site (GB02) located approximately 360 m downstream of the Golden Bar Pit, and another monitoring site located just upstream of the confluence with the Waikouaiti River North Branch (NB01), approximately 5 km downstream of the Golden Bar Pit. At NB01, the creek has an estimated median flow of 24 L/sec and an estimated MALF of 10 L/sec (Table 1).

As noted above, monitoring over recent years at GB02 has indicated evidence of stock grazing and encroachment into the wetted channel (Plate 3, middle right). Overall, however, the channel has largely remained in similar condition to that when it was first surveyed in 2004 (Plate 4).

Plate 4. Golden Bar Creek at monitoring site GB02, March 2004.

Clydesdale Creek has a much smaller catchment than Golden Bar Creek, but drains similar land (Figure 2). One of its headwater tributaries has been partly inundated by the existing rehabilitated WRS (Figure 2 and Plate 1) and, as noted above, has a silt pond associated with the rehabilitated WRS (Plate 1).

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 upstream of Clydesdale Creek is approximately 1,780 ha and 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 WRS. 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). 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 (Plate 5). The Murphys Creek and Waikouaiti River North Branch catchments show considerable evidence of previous (historic) mining activities.

Plate 5. Left: Murphys Creek MC02 monitoring site, April 2004. Right: same site, February 2022.

Table 1. NIWA New Zealand River Maps flow statistics[1] (L/sec) (source: GHD 2023a).

Statistic	**Clydesdale Ck. Upstream (GB01)**	**Clydesdale Ck. Bottom of catchment**	**Golden Bar Ck. Upstream (GB02)**	**Golden Bar Ck. Bottom of catchment (NB01)**	**Waikouaiti River North Branch (NB03)**
Catchment Area (ha)	134	367	182	930	7,567
Median flow	5.7	9.3	5.2	24.2	335
Mean flow	14.1	22.5	12.4	57.3	629
MALF flow	2.1	3.3	1.81	10.3	137

[1] Whitehead, A.L., Booker, D.J. 2020. NZ River Maps: An interactive online tool for mapping predicted freshwater variables across New Zealand. NIWA, Christchurch. https://shiny.niwa.co.nz/nzrivermaps/

2.2 Water quality

2.2.1 Surface water monitoring sites

As alluded to in the previous section, there are surface water quality monitoring sites in the upper Waikouaiti River North Branch catchment that have been established as a part of previous consenting processes associated with the Macraes Gold Project (Figure 3). Sites relevant to the Golden Bar mine are:

GB01	Clydesdale Creek immediately downstream of the Clydesdale silt pond
GB02	Golden Bar Creek immediately downstream of the Golden Bar Pit
MC02	Murphys Creek immediately downstream of the Clydesdale Creek confluence
NB02	Waikouaiti River North Branch immediately upstream of the Golden Bar Creek confluence
NB01	Golden Bar Creek immediately upstream of the confluence with Waikouaiti River North Branch
NB03	Waikouaiti River North Branch immediately downstream of the Golden Bar Creek confluence

MC02, NB01 and NB03 are also water quality consent compliance sites. A summary of the water quality compliance criteria associated with these sites is presented in Table 2.

Table 2. OceanaGold compliance limits for the Waikouaiti River North Branch catchment at sites MC02, NB01 and NB03. All units m^3/sec (mg/L) except for pH.

Compliance Parameter	Murphys Creek (MC02)[2]	Golden Bar Creek (NB01)[2]	Waikouaiti River North Branch (NB03)[3]
pH (pH units)	6.0 - 9.5	6.0 - 9.5	6.0 - 9.5
Arsenic**	0.15	0.15	0.01
Cyanide (WAD)	-	-	0.1[4]
Copper*	0.009	0.009	0.009
Iron	1.0	1.0	0.2
Lead[1]	0.0025	0.0025	0.0025
Zinc[1]	0.12	0.12	0.12
Sulphate	-	-	250[5]

* 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] Consents 2002.491, 2002.759 and 2002.763.
[3] Consents 96808, 2004.359, RM10.351.09, RM10.351.10 and RM 10.351.11.
[4] The cyanide (WAD) compliance limit at NB03 does not currently apply to activities at Golden Bar but exists on more recent consents authorizing activities in the NBWR catchment.
[5] The sulphate compliance limit at NB03 does not currently apply to activities at Golden Bar but exists on more recent consents authorizing activities in the NBWR catchment.

** 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 from 2013 to 2022 is presented in Table 3, while Table 4 summaries data since 2014. Concentrations over time for sulphate, ammoniacal-N and nitrate-nitrite-N (predominantly nitrate) are graphically presented in figures 4 and 5.

2.2.2 Golden Bar Mine

Water draining the existing rehabilitated Golden Bar WRS is alkaline with elevated nitrate-nitrite (nitrate-N)[6] and sulphate concentrations, and low ammoniacal-N concentrations (median concentrations since 2014 of 4.1, 1,170 and 0.01 g/m^3 respectively), as determined by monitoring at GB01 in the headwaters of Clydesdale Creek (tables 3 and 4). Cyanide and dissolved metal concentrations are low and below water quality guidelines. Conductivity and hardness are generally high and reflect the increase in sulphate concentrations as mining has expanded the catchment upstream of the monitoring sites. Recent monitoring data for site NB03 indicates that sulphate concentrations are within the compliance limit for this site (Figure 4). Concentrations of dissolved metals and cyanide are mostly all within consent compliance limits and often below laboratory detection limits.

Water quality in Golden Bar Creek is monitored at sites GB02 just downstream of the pit and NB01 just upstream of the confluence with the Waikouaiti River North Branch. This creek also has alkaline water (tables 3 and 4). Nitrate-nitrite-nitrogen (NNN) concentrations are typically two orders of magnitude lower than at GB01 and sulphate is typically an order of magnitude lower (median concentrations since 2014 of 0.023 and 130 g/m^3 respectively) (figures 4 and 5).

At the downstream end of Golden Bar Creek, at monitoring site NB01, typical NNN and sulphate concentrations are even lower (median concentrations since 2014 of 0.016 and 21 g/m^3 respectively) while cyanide and dissolved metal concentrations are relatively low and metal concentrations are within NB03 compliance limits (figures 4 and 5).

Monitoring site NB03 is located immediately downstream of the confluence of Golden Bar Creek and Waikouaiti River North Branch. Sulphate concentrations at this site are elevated relative to background levels, however, they are usually well below the consent compliance

[6] By far the majority of nitrate-nitrite in New Zealand surface waters, including those assessed in this report, consists of nitrate with nitrite comprising a very small fraction of the total.

criteria concentration of 250 g/m^3 (Figure 4). Similarly, cyanide and dissolved metal concentrations are usually well below their respective compliance criteria concentrations (tables 3 and 4). The pH is similar to other monitoring sites in this catchment.

Apart from several elevated readings in 2019 (range 0.882 – 2.810 g/m^3), NNN concentrations in recent years at site NB03 have been relatively low and ammoniacal nitrogen concentrations are usually below the laboratory detection limit of 0.01 g/m^3.

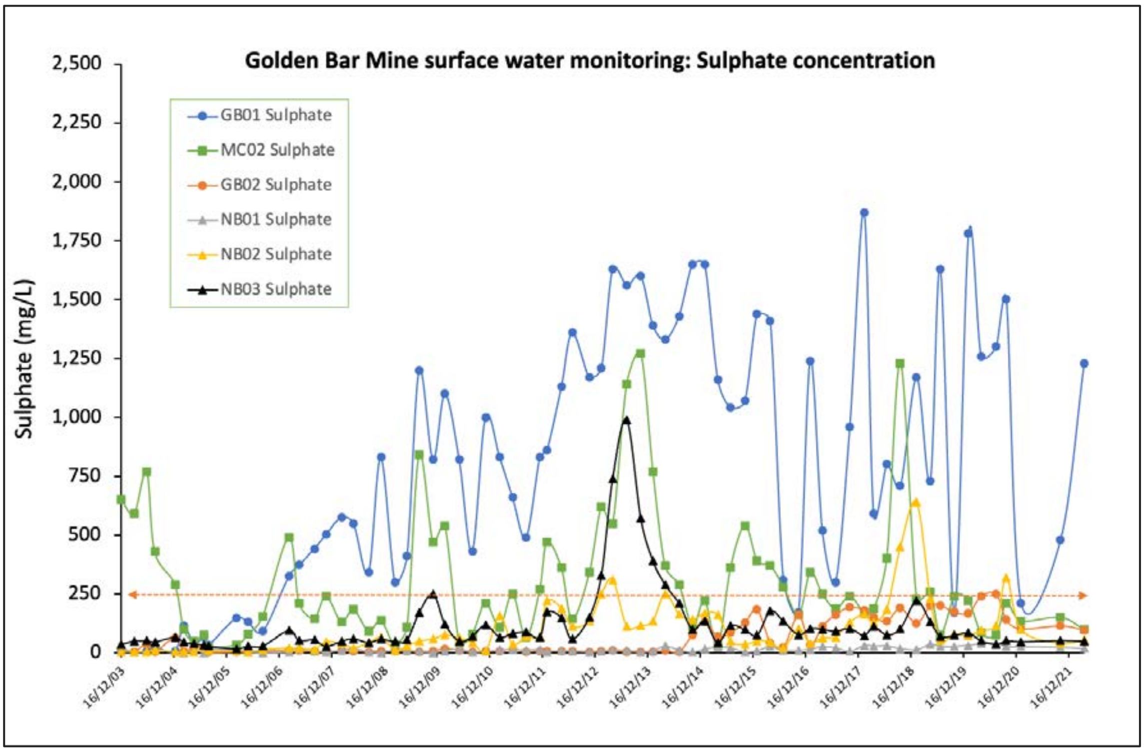


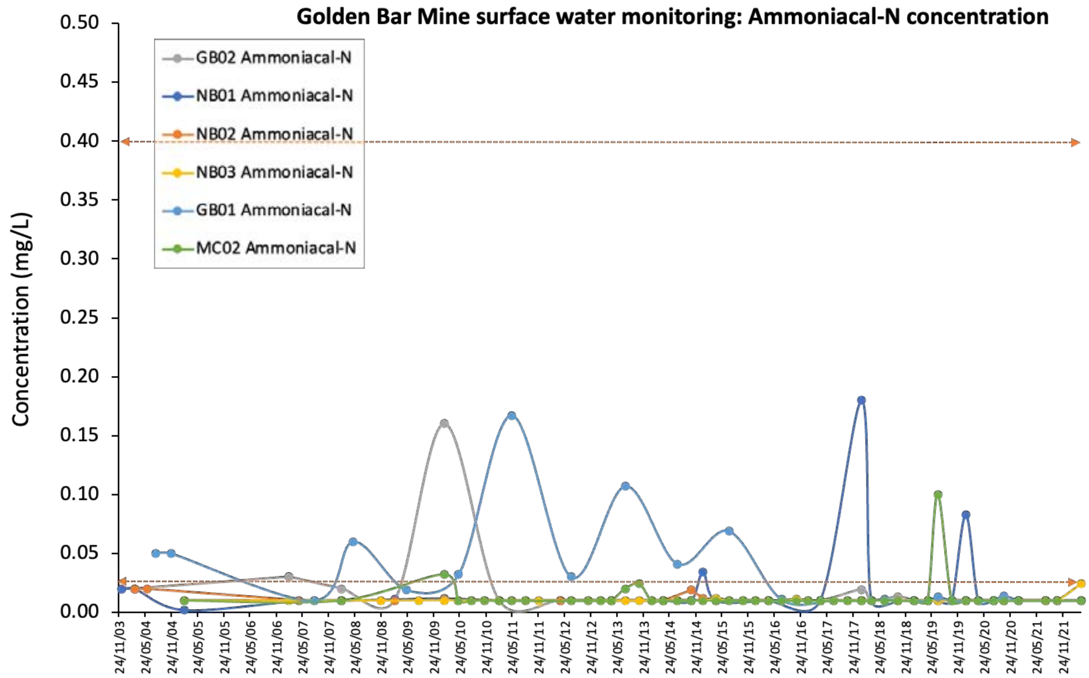
Figure 4. Sulphate concentrations over time at surface water monitoring sites in the vicinity of the Golden Bar Mine. Dashed horizontal line indicates the consent compliance limit for Waikouaiti River North Branch monitoring and compliance site NB03.

*Table 3. Water quality statistics for Golden Bar/Murphys Creek catchment surface water quality monitoring sites, Macraes Gold Project, **2003– 2022**.*

Parameter	GB01			GB02			MC02			NB01			NB02			NB03		
	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min
pH	8.2	7.7	6.3	8.3	7.6	6.6	9.1	8.0	6.6	8.1	7.8	6.0	9.5	8.0	6.2	9.5	8.0	6.7
Nitrate-Nitrite-N (g/m^3)	9.5	4.1	0.04	0.630	0.025	0.005	8.7	0.560	0.030	0.363	0.018	0.002	3.1	0.04	0.002	2.81	0.04	0.004
Ammoniacal-N (g/m^3)	0.167	0.011	0.010	0.160	0.010	0.010	0.100	0.010	0.010	0.180	0.010	0.002	0.020	0.010	0.010	0.024	0.010	0.002
Conductivity (µS/cm)	2830	1489	96	780	154	81	2380	553	132	33	19	12	1460	253	92	1975	269	18
Chloride (g/m^3)	14.7	11.0	5.0	17.0	8.9	4.4	21.0	9.0	5.0	18.0	11.0	1.1	16.4	8.0	5.0	19.0	8.5	5.0
Hardness-Total (g/m^3 as $CaCO_3$)	1920	975	200	470	77	17	1560	340	54	130	66	36	860	145	38	1140	124	41
Sulphate (g/m^3)	1870	820	3.3	250	15.2	2.0	1270	210	2.1	39	11	1.1	640	58	1.9	990	63.5	1.9
Arsenic-Diss (g/m^3)	0.036	0.001	0.001	0.385	0.007	0.001	0.010	0.0014	0.0010	0.088	0.013	0.004	0.025	0.002	0.001	0.016	0.004	0.001
Copper-Diss (g/m^3)	0.073	0.001	0.0005	0.016	0.001	0.001	0.035	0.0006	0.0005	0.002	0.001	0.001	0.002	0.001	0.001	0.005	0.001	0.001
Iron-Diss (g/m^3)	61.28	0.040	0.020	5.980	0.150	0.020	0.280	0.070	0.020	1.250	0.230	0.060	0.490	0.088	0.020	0.370	0.110	0.030
Lead-Diss (g/m^3)	0.050	0.0001	0.0001	0.0020	0.0001	0.0001	0.0020	0.0001	0.0001	0.002	0.0001	0.0001	0.002	0.0001	0.0001	0.002	0.0001	0.0001
Zinc-Diss (g/m^3)	0.054	0.012	0.005	0.004	0.001	0.001	0.0188	0.0010	0.0010	0.006	0.001	0.001	0.005	0.001	0.001	0.010	0.001	0.001
Cyanide (WAD) (g/m^3)	0.020	0.020	0.001	0.020	0.020	0.001	-	-	-	0.001	0.001	0.001	0.001	0.001	0.001	0.0300	0.001	0.001

*Table 4. Water quality statistics for Golden Bar/Murphys Creek catchment surface water quality monitoring sites, Macraes Gold Project, **2014– 2022**.*

Parameter	GB01			GB02			MC02			NB01			NB02			NB03		
	Max	**Median**	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**	**Min**
pH	8.2	7.8	7.3	8.3	8.1	7.4	9.1	8.0	6.6	8.1	7.9	7.6	8.8	7.95	7.4	8.6	7.9	6.7
Nitrate-Nitrite-N (g/m^3)	9.5	4.1	0.04	0.632	0.023	0.005	8.7	0.560	0.030	0.363	0.016	0.002	3.111	0.057	0.002	2.81	0.045	0.004
Ammoniacal-N (g/m^3)	0.069	0.010	0.010	0.019	0.010	0.010	0.100	0.010	0.010	0.180	0.010	0.010	0.019	0.010	0.010	0.024	0.010	0.010
Conductivity (µS/cm)	2830	1890	479	780	551	95	2380	695	155	282	200	142	1460	418	115	1975	319	121
Chloride (g/m^3)	13	10	5	17.0	7.95	5.0	21.0	9.0	5.0	15	10	7	10.0	7.6	5.0	19.0	8.8	5.0
Hardness-Total (g/m^3 as $CaCO_3$)	1920	1200	200	470	260	28	1560	340	54	130	79	46	860	162	39	1140	131	41
Sulphate (g/m^3)	1870	1170	171	250	130	3.9	1270	245	24	39	21	2.1	640	109	18	990	76	17
Arsenic-Diss (g/m^3)	0.002	0.001	0.001	0.069	0.0167	0.001	0.010	0.0013	0.0010	0.088	0.013	0.0038	0.0041	0.0014	0.0010	0.0161	0.0039	0.0014
Copper-Diss (g/m^3)	0.0013	0.001	0.0005	0.0007	0.0005	0.0005	0.035	0.0005	0.0005	0.0010	0.0005	0.0005	0.0008	0.0005	0.0005	0.005	0.0005	0.0005
Iron-Diss (g/m^3)	0.290	0.040	0.020	0.950	0.095	0.020	0.280	0.060	0.020	1.250	0.260	0.080	0.210	0.080	0.020	0.370	0.110	0.030
Lead-Diss (g/m^3)	0.0004	0.0001	0.0001	0.0001	0.0001	0.0001	0.0016	0.0001	0.0001	0.0001	0.0001	0.0001	0.0017	0.0001	0.0001	0.0016	0.0001	0.0001
Zinc-Diss (g/m^3)	0.026	0.0122	0.0047	0.0031	0.001	0.001	0.0188	0.0010	0.0010	0.002	0.001	0.001	0.0016	0.001	0.001	0.010	0.001	0.001
Cyanide (WAD) (g/m^3)	0.020	0.020	0.001	0.020	0.020	0.001	0.0300	0.0164	0.0010	0.001	0.001	0.001	0.001	0.001	0.001	0.0300	0.001	0.001



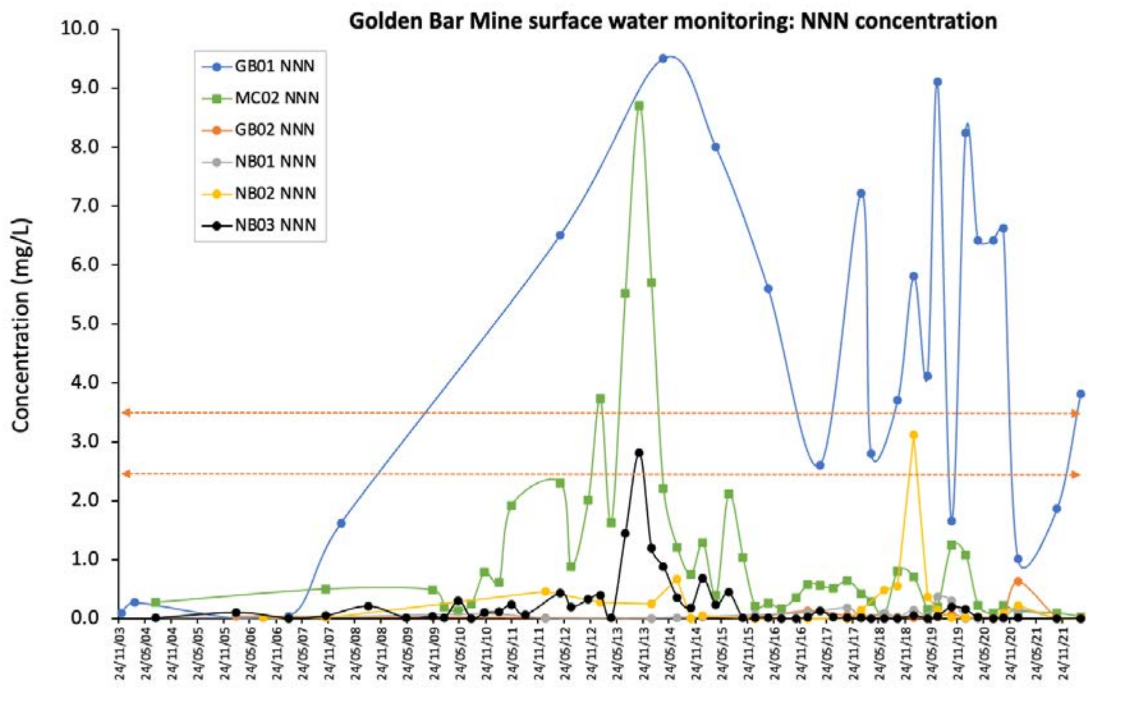


Figure 5. *Top: Ammoniacal-N concentrations over time at surface water monitoring sites in the vicinity of the Golden Bar Mine. Bottom dashed horizontal line indicates the annual median concentration for the NOF (NPS-FW) national bottom line, while the top dashed line represents the Annual 95th percentile for the NOF national bottom line. Bottom: NNN concentrations over time at the same sites. Bottom dashed horizontal line indicates the annual median concentration for the NOF (NPS-FW) national bottom line, while the top dashed line represents the Annual 95th percentile for the NOF national bottom line.*

2.3 Stream ecology

This section summaries the results of recent biological monitoring at surface water monitoring sites in the Waikouaiti River North Branch catchment and particularly in the vicinity of the Golden Bar Mine (from Alden *et al*. 2022 and 2023). Benthic algae (periphyton), aquatic plants (macrophytes) and benthic macroinvertebrates are monitored quarterly at sites MC02 and GB02 (as well as at other Waikouaiti River North Branch catchment sites). Fish populations are monitored annually, mostly in late summer, at these sites also.

2.3.1 Algae & macrophytes

The most recent reported surveys of Golden Bar Creek (GB02) and Murphys Creek (MC02) indicate that nuisance filamentous algae cover is relatively minor at these sites (Figure 6, top). Macrophyte cover is also relatively minor at MC02 but can be more significant at GB02 (Figure 6, bottom).

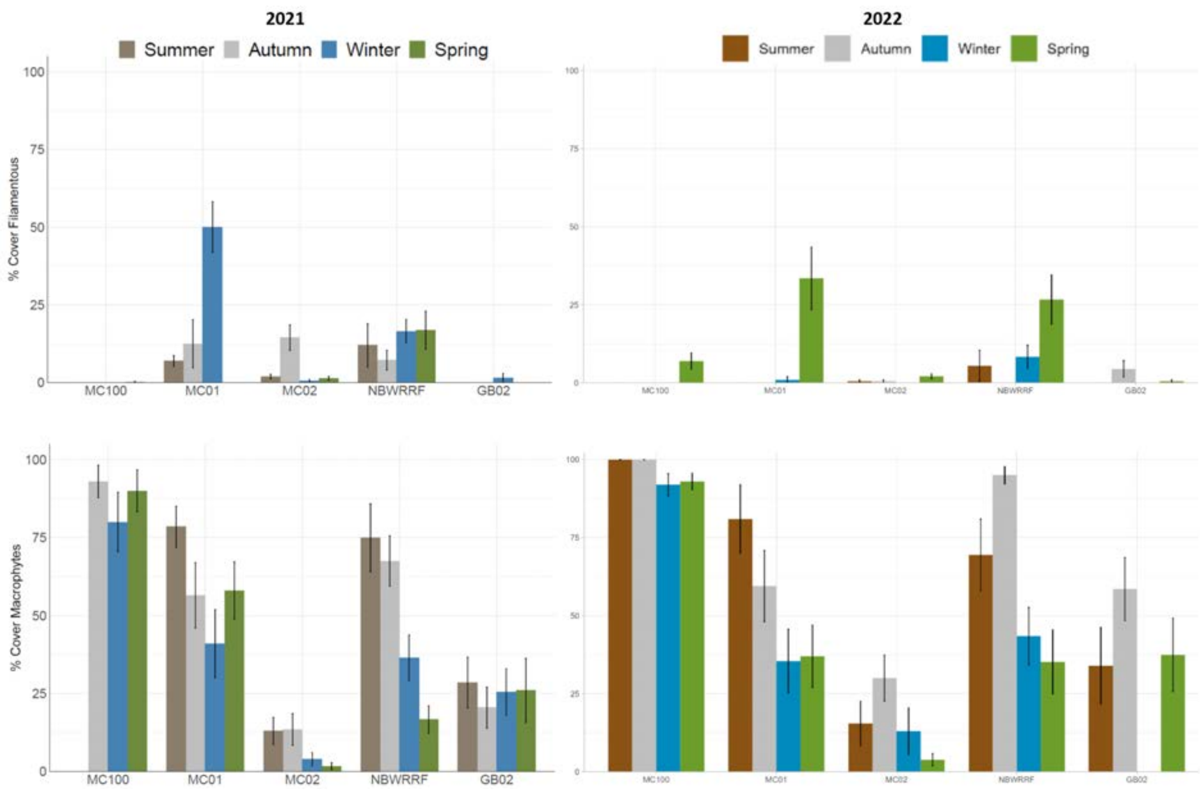


Figure 6. Average percent cover of filamentous algae (top) and macrophytes (bottom), Waikouaiti River North Branch catchment monitoring sites 2021 (left) and 2022 (right). Standard error bars are shown. No sampling at MC100 in summer 2021. No monitoring at GB02 in winter 2022 (due to lambing preventing access to the site).

Long-term macrophyte and periphyton monitoring data was available for all sites in the Waikouaiti River catchment (Table 5). Long-term trend analysis found that filamentous algae cover showed significant decreasing trends at MC02 and GB02, however only the trend at

MC02 was for a reasonable amount each year. Macrophyte cover at MC02 was significantly decreasing by 13% per year.

Table 5. Long-term trend analysis results for periphyton and macrophyte data for GB02 and MC02 monitoring sites in the Waikouaiti River North Branch catchment (up to and including 2022). Significant decreasing trends are highlighted in green. (source: Alden et al.*, 2023)*

% Cover	Trend	MC100	MC01	MC02	NBWRRF	GB02
	Data points (*n*)	79	80	72	80	70
Mat algae	Direction	Decreasing	Decreasing	Increasing	Decreasing	Decreasing
	% Annual Change	0.0	0.0	5.1	-0.9	0.0
	Confidence	Likely	Indeterminant	Indeterminant	Likely	Indeterminant
Filamentous algae	Direction	Increasing	Decreasing	Decreasing	Decreasing	Decreasing
	% Annual Change	0.0	0.0	-4.6	-0.7	0.0
	Confidence	Indeterminant	Likely	Virtually certain	Likely	Likely
Macrophytes	Direction	Increasing	Decreasing	Decreasing	Increasing	Increasing
	% Annual Change	4.3	-0.7	-13.1	1.5	2.7
	Confidence	Indeterminant	Likely	Virtually certain	Indeterminant	Indeterminant

2.3.2 Benthic macroinvertebrates

In 2021 and 2022 surveys (see appendices B and C for raw data), the mean density of invertebrates was typically lower at site GB02 than at other monitoring sites in the upper Waikouaiti River North Branch catchment (Figure 7, top). However, this site had the highest mean mayfly densities (in excess of 2,000 per m^2 in 2022, Figure 7, bottom), and QMCI scores indicative of 'good' habitat quality over both years (Figure 8) based on Stark and Maxteds' narrative terminology – see Table 6). In contrast, QMCI scores at MC02 indicated 'poor' habitat quality bordering to 'fair' (Figure 8). Low QMCI scores at MC02 are due to the invertebrate population being dominated by tolerant taxa, particularly *Potamopyrgus* snails, but also *Austrosimulium* and chironomid larvae (both dipterans) and aquatic worms (Appendix B and C).

Table 6. Narrative descriptions of NPS-FW National Objectives Framework (NOF) bands for QMCI scores 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**

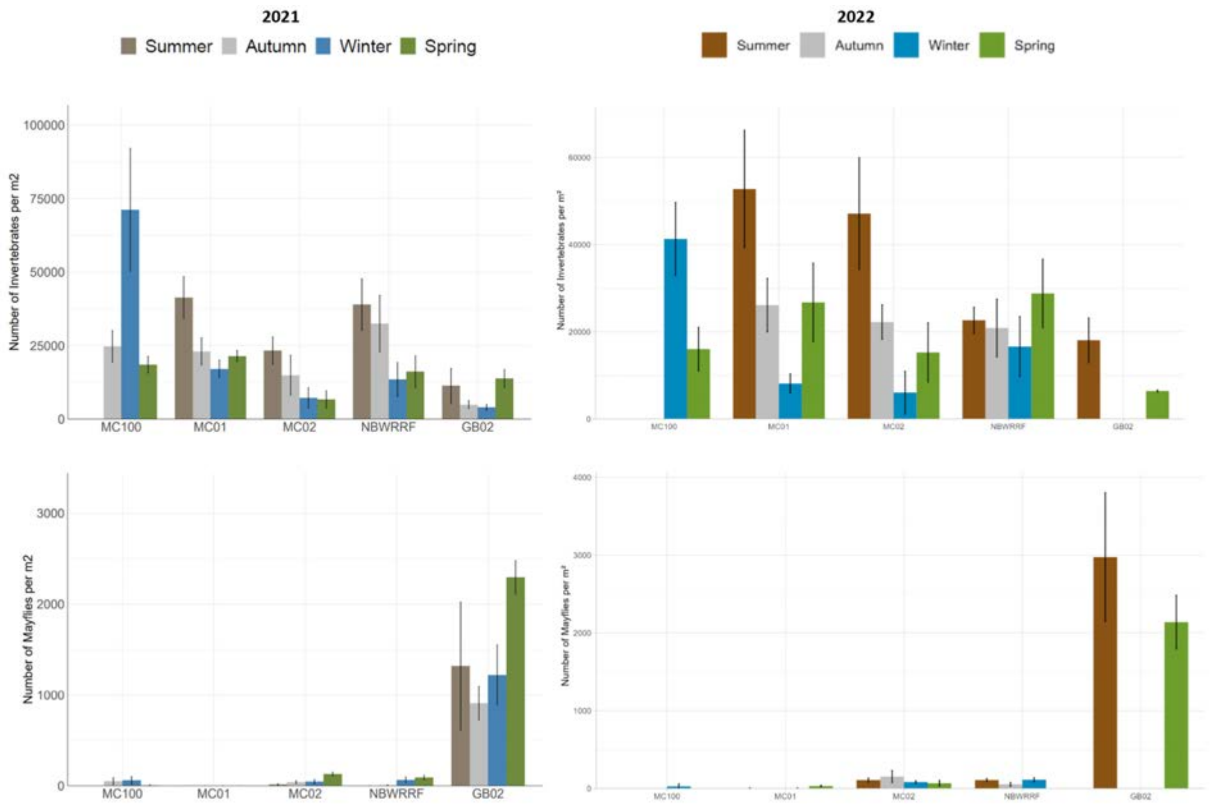


Figure 7. *Average total benthic macroinvertebrate densities (top) and average mayfly densities (bottom), Waikouaiti River North Branch catchment monitoring sites 2021 (left) and 2022 (right). Standard error bars are shown. No Surber samples from MC100 in summer 2021. No Surber samples from MC100 in summer or autumn 2022, or from GB02 in autumn 2022. No monitoring at GB02 in winter 2022 (due to lambing preventing access to the site).*

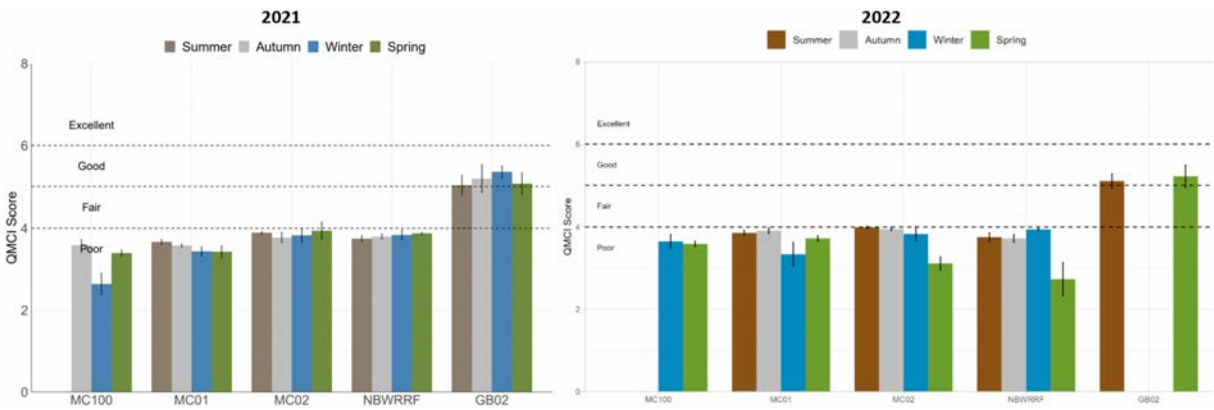


Figure 8. *Average QMCI scores, Waikouaiti River North Branch catchment, 2021 (left) and 2022 (right). Standard error bars are shown. No Surber samples from MC100 in summer 2021. No monitoring at GB02 in winter 2022 (due to lambing preventing access to the site).*

Long-term trends

Long-term macroinvertebrate data (more than 20 years) was available for undertaking statistical trend analyses at sites GB02 and MC02. The trend analyses indicated that the number of taxa was increasing at both sites, but these trends were not statistically significant

(Table 6). %EPT abundance, mayfly abundance (which is a component of EPT) and QMCI scores all showed a significant decreasing trend at MC02. GB02 had an increasing trend for all invertebrate indices, however these trends were not statistically significant (Table 7).

Table 7. Long-term trend analysis results for macroinvertebrate data for GB02 and MC02 monitoring sites in the Waikouaiti River North Branch catchment (up to and including 2022). Significant decreasing trends are highlighted in green. (source: Alden et al.*, 2023)*

	Trend	**MC02**	**GB02**
	Data range (*n*)	**71**	**60**
# of taxa	Direction % Annual Change Confidence	Increasing 1.0 Indeterminant	Increasing 3.0 Indeterminant
# of EPT taxa	Direction % Annual Change Confidence	Decreasing 0.0 Indeterminant	Increasing 3.8 Indeterminant
% EPT abundance	Direction % Annual Change Confidence	Decreasing -13.1 Virtually certain	Increasing 1.9 Indeterminant
QMCI	Direction % Annual Change Confidence	Decreasing -2.6 Virtually certain	Increasing 2.0 Indeterminant
Mayfly density (# / m^2)	Direction % Annual Change Confidence	Decreasing -20.7 Virtually certain	Increasing 22.8 Indeterminant

2.3.3 Fish populations and general distribution

The distribution of NZFFD records for fish (and kōura) in the upper Waikouaiti River North Branch catchment in shown in Figure 9.

<u>Galaxiids</u>

Surveys of fish populations in the upper Waikouaiti River North Branch (which includes Golden Bar) catchment have found Flathead galaxias (*Galaxias depressiceps*) to be the dominant species (Figure 9). It is widely distributed although it does not appear as common or abundant as in nearby catchments, such as Deepdell, Tipperary and Mare Burn.

Schedule 1A (natural values) of the ORC Regional Plan: Water identifies significant aquatic values of the Waikouaiti River catchment. Significant habitat of indigenous fauna stated in the plan for locations in the upper catchment of the Waikouaiti River North Branch include significant habitat for flathead galaxias and hybrid galaxias (see below), banded kōkopu (*Galaxias fasciatus*) and kōaro (*Galaxias brevipinnis*).

Fish surveys over many years now have not identified the presence of banded kōkopu or kōaro in the upper catchment. NZFFD records for banded kōkopu and kōaro in the Waikouaiti River catchment are only for waterways near the coast apart from one individual kōaro recorded by DOC in 2003 as being present in a tributary of the Waikouaiti River North Branch well upstream of the confluence with Murphys Creek.

The flathead galaxiid populations present in the Waikouaiti River catchment and surrounding catchments (Shag River and Taieri River catchments) are 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 km2), 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

Longfin (*Anguilla dieffenbachii*) and shortfin (*Anguilla australis*) eel (tuna) have been observed in Murphys Creek catchment, but are relatively uncommon. The longfin tuna is classified by the Department of Conservation as 'At Risk – Declining' (Dunn *et al.* 2018). Upland bully (*Gobiomorphus breviceps*) and brown trout (*Salmo trutta*) are also present in the upper catchment but in low abundance.

Annual fish surveys at MC02 and GB02

A summary of the annual fish survey data for flathead galaxias at sites GB02 and MC02 since regular monitoring commenced is presented in Table 8. In terms of recent fish surveys at these two sites, one longfin eel (550 mm long) was caught in Golden Bar Creek at site GB02 during the annual 2018 fish survey of the area.

No fishing could be undertaken at GB02 for the 2019 summer survey. Conditions at this site in summer generally create difficult conditions for electric fishing, with very little surface water present and habitats for fish generally limited to small pools. In summer 2019, there were several sections of the creek with no visible flow. Stock (cattle) activity had been high in the creek prior to the survey, with crossing points, pugging and droppings evident throughout the creek.

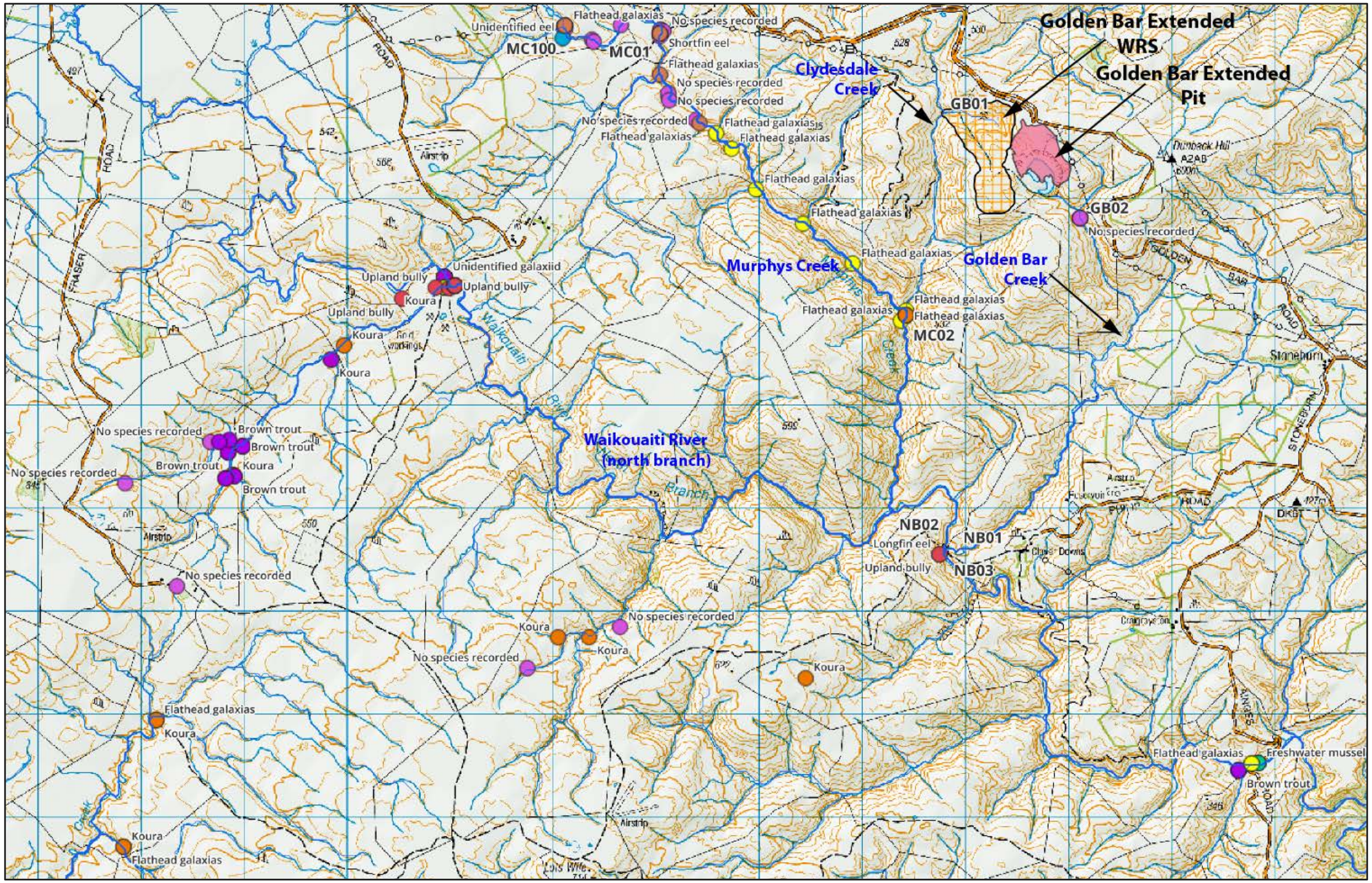


Figure 9. Map showing the NZFFD records for fish and kōura in the upper Waikouaiti River North Branch catchment in the vicinity of the Golden Bar mine.

Electric fishing was not undertaken at GB02 in the 2020 summer again due to a lack of flow. Instead, spot fishing was undertaken of habitats upstream and downstream of the site. No fish were caught or observed. Electric fishing was attempted at site GB02 in late summer 2021, however only spot fishing of habitats upstream and downstream of the site was possible, again due to very low flows. No fish were caught or observed. No fish were caught or observed at this site during the 2022 summer survey.

Table 8. Galaxiid counts and population estimates for monitoring sites GB02 and MC02, 2004-2022. '–' = unable to be sampled due to low flows. Note 2018 data is from fishing undertaken in winter 2018.

Year	MC02		GB02	
	Count	Pop'n estimate (per 10m)	Count	Pop'n estimate (per 10m)
2004	32	32	0	0
2005	29	34	0	0
2006	30	32	-	-
2007	15	23	-	-
2008	42	39	-	-
2009	26	32	-	-
2010	15	16	-	-
2011	15	20	0	0
2012	6	11	0	0
2013	26	89	0	0
2014	2	2	0	0
2015	5	5	-	-
2016	7	6	-	-
2017	18	16	-	-
2018	3	4	0	0
2019	4	8	-	-
2020	4	5	-	-
2021	15	20	0	0
2022	42	61	0	0

Year	MC02	GB02
	Average length (mm)	
2004	51	-
2005	60	-
2006	62	-
2007	55	-
2008	48	-
2009	51	-
2010	46	-
2011	50	-
2012	58	-
2013	49	-
2014	72	-
2015	53	-
2016	51	-
2017	50	-
2018	68	-
2019	60	-
2020	54	-
2021	59	-
2022	57	-

Three galaxiids were caught at MC02 during the 2018 survey. 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. However, electric fishing was also undertaken at the previous site in summer 2019, as the site contained a short riffle section, with four galaxiids (48-74 mm long) being caught.

Electric fishing at MC02 for the 2020 summer survey yielded four galaxiids and 15 galaxiids (52-72 mm long) and four galaxiids were caught during the 2021 survey. Forty two galaxiids and one longfin eel (~900 mm long) were caught during the February 2022 survey.

2.4 Summary

Water quality

Sulphate concentrations fluctuate widely at site GB01 (Clydesdale Creek) and are generally high due to its proximity to the Clydesdale silt pond which receives variable seepage and runoff from Golden Bar WRS. This appears to influence sulphate concentrations further downstream at MC02 (Murphys Creek) and NB03 (Waikouaiti River North Branch), although the compliance limit of 250 g/m^3 at NB03 has been met on all sampling occasions since 2014. Sulphate concentrations are consistently low in lower Golden Bar Creek (NB01). Cyanide and dissolved metal concentrations are low and below water quality guidelines. Ammoniacal-N concentration are low in both creeks, while NNN concentrations are low in Golden Bar Creek but elevated in Clydesdale Creek.

Apart from several elevated readings in 2019, NNN concentrations in recent years at compliance site NB03 have been relatively low and ammoniacal nitrogen concentrations are usually below the laboratory detection limit of 0.01 g/m^3.

Benthic macroinvertebrates

The benthic macroinvertebrate fauna of the upper Waikouaiti River North Branch, including Murphys Creek, is not noted for its ecological significance. No taxa have been identified as having high conservation value and monitoring sites are mostly dominated by taxa that are tolerant of average to poor water and habitat quality conditions although site GB02 in Golden Bar Creek typically has a much higher density of mayflies than at other monitoring sites.

Land use (including the presence of stock), flow conditions and dominance of macrophytes at some sites are multiple stressors interacting and affecting the quality of macroinvertebrate communities at Waikouaiti River North Branch upper catchment monitoring sites. However, the decline in macroinvertebrate indices over time at some sites may also be attributed to mining activities.

Kōura

Freshwater crayfish or kōura (*Paranephrops zealandicus*) are present in tributaries of the upper Waikouaiti River North Branch catchment although they do not appear as abundant as in Deepdell Creek, Mare Burn and Tipperary Creek catchments. Kōura have been classified as ‘At Risk – Declining’ with the qualifier ‘Partial Decline’ (Grainger *et al.* 2018).

Fish

The flathead galaxias is common and a widely distributed native fish species throughout the Macrae's district, and is common throughout the upper catchment of the Waikouaiti River North Branch, although not as common as in Deepdell Creek, Mare Burn and Tipperary Creek catchments. It is also likely that they are present in the lower section of Clydesdale Creek (they have been recorded in Murphys Creek at MC02, that is, just downstream of the confluence with Clydesdale Creek). They appear to be absent in the upper section of Golden Bar Creek, but are likely to present further downstream where flows are more reliable (and they have been recorded recently as being present further downstream in the Waikouaiti River North Branch).

Longfin and shortfin eel (tuna) have been observed in Murphys Creek catchment, but are relatively uncommon. One longfin eel was observed in Golden Bar Creek at site GB02 during the 2018 annual fish survey of the area. Upland bully and brown trout are also present in the upper catchment but in low abundance, and have not been recorded in Golden Bar Creek.

3 ASSESSMENT OF EFFECTS & RECOMMENDED MITIGATION

3.1 Pit dewatering

To recommence mining of the Golden Bar pit, dewatering of the existing pit will be required first. The pit began filling once mining concluded in 2005 and reached overflow in 2015. Dewatering of the open pit will remove water accumulated within the pit and draw down the surrounding groundwater table (GHD 2023).

3.1.1 Hydrology & physical character

If the pit lake is to be dewatered to local waterways, a dewatering rate of at least 30 L/sec has been estimated to allow for Golden Bar Pit to be dewatered over a period of approximately 1.25 years to meet timing constraints (GHD 2024). If the discharge needs to be pumped to the Waikouaiti River North Branch catchment, it is recommended that the discharge point is located at or below the Murphys Creek confluence). The Waikouaiti River North Branch at the Murphys Creek confluence has an estimated median flow of 302 L/sec and a MALF of 121 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 (see section 3.1.3 below). Alternatively, the discharge could be split between catchments (e.g., Clydesdale and Golden Bar creeks) to avoid significant changes in their hydrological characteristics. Other dewatering configurations are possible including a mix of dewatering to local water ways and all or some dewatering by pumping back to Frasers Pit.

If local dewatering is used, suitable measures to 'introduce' the pit water into the river are recommended to avoid potential localised erosion. This could involve diffusing the flow via several pipes near the river to spread the entry of discharge water over a wider section of the river, lowering the velocity of the discharge water. Alternatively, discharging all the flow into the head of a pool may be sufficient to suppress local turbulence.

It is recommended that if dewatering to the Waikouaiti River North Branch is adopted, the channel at, and immediately downstream of the discharge point(s), be monitored in the initial stages of the Golden Pit lake dewatering discharge, and should significant erosion be detected, the discharge velocity reduced by further flow spreading.

For mine operational reasons, some or all of the dewatering could be pumped to the Frasers Tailing Storage Facility to supplement available processing water. This may also be necessary to manage arsenic levels in the discharge water (see section 3.1.2). Prior to implementing the pit dewatering, OceanaGold will make a closer assessment of the chosen option(s) to ensure hydrological and other effects are consistent with managing potential effects like erosion, stream flows, water quality and ecological criteria or limits.

3.1.2 Water quality

GHD (2023) undertook a modelling exercise to assess the effects of the Golden Bar Pit dewatering on the water quality of potential receiving waters. GHD's analysis concluded that arsenic and sulphate are the two contaminants that have the greatest potential to exceed existing compliance criteria at NB03 (Table 9), although modelling indicates that, at the 95th percentile, sulphate concentrations are likely to improve temporarily while dewatering is being undertaken. This is due to the pit water sulphate concentration being lower than the modelled inflows to NB03 via the Waikouaiti River North Branch upstream catchment (GHD 2023).

It is noted that recent water quality monitoring has shown that ammoniacal-N and NNN concentrations are below laboratory detection limits (0.01 and 0.002 g/m^3 respectively) and so unlikely to be of concern.

Recent sampling of the pit water quality by Mine Waste Management (MWM) found good oxygen levels throughout most of the water column (MWM 2024) and oxygen levels in the discharge are likely to be suitable for discharge into surface water provided water is not drawn from the bottom half of the pit. Water column temperatures in the pit in March 2023 were <13 °C and suitable for supporting stream aquatic life.

Table 9. Arsenic and sulphate concentration statistics at NB03 (Waikouaiti River North Branch) together with current consent compliance limits. Data sourced from GHD (2023a).

Pit discharge scenarios for NB03	**Sulphate** (mg/L)			**Arsenic** (mg/L)		
	Median	Average	95th	Median	Average	95th
GB Pit overflowing (current)	109	180	572	0.004	0.005	0.009
Dewatering (30 L/sec)	154	174	377	0.039	0.045	0.103
Compliance limit (maximum conc.)		250			0.010	

GHD (2024) recommended several management options to reduce the arsenic and sulphate concentrations in surface waters:

- Manage discharge to reduce the risk of exceeding the existing compliance criteria for sulphate at the NB03 monitoring site. This could include active management of discharges to the upper Waikouaiti River North Branch and Murphys Creek catchments, then ceasing or reducing dewatering where concentrations do not allow for some level of dilution at compliance sites.

- Manage discharge to reduce the risk of exceeding the existing compliance criteria for arsenic as described previously outlined for sulphate. This would require more active intervention than for sulphate as a greater level of dilution is required and would likely increase the dewatering timeline significantly.
- Manage in-pit arsenic concentrations through treating pit lake waters prior to commencing dewatering operations[7]. This would be done with the aim of reducing in-pit lake concentrations to a point where a similar dilution is required to achieve arsenic compliance in the receiving environment as required for sulphate compliance.
- If necessary, dewatering the residual arsenic rich pit lake water to FTSF.

3.1.3 Ecology

There is nothing unique about the aquatic plant and periphyton communities of the Clydesdale, Golden Bar or Murphys creeks, and there is nothing to suggest that the Waikouaiti River North Branch at NB03 (which is not monitored regularly for stream ecology) is any different. Historically, since European colonisation, this has been a farming and mining area with little or no deliberate protection of watercourses from stock access, resulting in nutrient inputs into surface waters and associated proliferations of plants and periphyton under favourable conditions.

Fish communities in the Waikouaiti River North Branch in the vicinity of NB03 and further downstream are typical of that found in the wider Waikouaiti River North Branch catchment (common bully, upland bully, flathead galaxias, longfin eel, brown trout), and kōura are also present. The proposed discharge of pit water will not materially alter the physical habitat of the river and water quality will remain similar to the current situation (see below). Consequently, changes to the benthic flora and fauna and fish communities are not expected. The discharge is for a relatively short period of time (approximately 1.25 years). As noted above, monitoring of the creek's physical environment (i.e., to check for erosion and scouring) at and downstream of the discharge point(s) is recommended.

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[7] For example, active treatment plants can be constructed where ferric chloride ($FeCl_3$) is used to treat arsenic impacted waters. These plants may also require the addition of hydrated lime to maintain pH. The process forms a floc, which is then removed by large tank clarifiers with clean water being discharged (MWM, 2024).

3.2 Effects of the extended Golden Bar Pit and WRS

3.2.1 Water quality

GHD (2024) developed a model to determine the movement of groundwater and seepage water to surrounding surface waters as a result of the proposed extensions to the Golden Bar mine. This model was coupled to an existing water balance model to estimate effects of the mine extension on receiving water quality. Model predictions of water quality during mining (2026-2027) and long-term after mine closure (2125-2130) at sites GB01, GB02, NB01 and NB03 were 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. This assessment is summarised in Table 10 and discussed below.

Ammoniacal-N and Nitrate-Nitrite-N

Monitoring frequency does not follow NPS-FW 2020 protocols however, as a general guide, predicted future nitrate concentrations would most likely place all monitoring sites in the NOF bands A or B for ammoniacal-N and nitrate-N (both for protection against toxic effects of these forms of nitrogen – see Appendix A).

Sulphate

GHD (2024) report that the water balance model shows that, in general, sulphate concentrations within the immediate receiving environment (Clydesdale Creek and Golden Bar Creek) are predicted to increase post closure relative to the mining phase, due to the increase in sulphate mass from seepage water (from the Golden Bar WRS and Golden Bar pit lake) with time. Median modelled sulphate concentrations are predicted to increase (from mining to closure) from 213 to 368 g/m^3, 10 to 276 g/m^3 and 10 to 76 g/m^3 at locations GB01, GB02 and NB01, respectively. Adjustments to the model to account for climate change results in lower sulphate concentrations at the three monitoring sites than those presented above (GHD 2024).

While there are no sulphate compliance limits for sites GB01, GB02 and NB01, the predicted changes in concentration at these sites over time are below the current consent compliance limit for NB03 (250 mg/L, Table 1) and would largely meet the British Columbia guideline of 309 mg/L for soft/hard to hard water (76-180 mg/L[8]) (Table 10). 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.

[8] Median hardness at these monitoring sites currently is in excess of 76 mg/L.

Recent toxicity testing conducted using Taieri flathead galaxias (eggs and larvae), seepage water from local waste rock stacks and Mare Burn water, showed no effects at a sulphate concentration greater than 1,000 g/m^3 (Ryder 2019). Toxicity testing of sulphate concentrations under controlled laboratory conditions by the author found that a concentration of 360 g/m^3 had no effect on *Deleatidium* mayfly larvae relative to control stream water containing almost no sulphate (2 g/m^3). *Deleatidium* larvae are relatively sensitive to water quality and are relatively common at GB02.

Cyanide and metals

Arsenic, cyanide, copper, iron, lead and zinc are predicted to meet ANZG default guideline values (95% species protection) throughout the operational period of the mine and the post closure period, with the exception of arsenic at GB02 (post closure) and copper at GB01.

GB01 is not a compliance monitoring site as it is located right at the base of the waste rock stack and has limited opportunity to receive any dilution of water from the wider Clydesdale Creek catchment.

Similarly, a compliance monitoring point at GB02 on Golden Bar Creek is inappropriate for the same reason as for GB01. GB02 typically has very little flow in late summer and has been previously reported as being dry on occasions. There appears to be no permanent fish community. The Golden Bar Creek NB01 site, located just upstream of the confluence with the Waikouaiti River North Branch, is a more appropriate site for compliance (Figure 3). Note that cumulative effects in the Waikouaiti River North Branch are discussed in Ryder (2024b).

Table 10. Current and predicted long-term water quality statistics for Waikouaiti River North Branch catchment surface water monitoring site NB03 compared against default water quality guidelines (ANZG 2018), NPS-FM NOF national bottom lines and alternative published guidelines for sulphate and iron.

** Recommended for application for slightly to moderately disturbed ecosystems (for protection of 95% of species). † Water quality data for GB01, GB02 and NB01 from tables 8, 9 and 10 of GHD Golden Bar report dated 1 November 2023. †† Water quality data for NB03 from Table 31 of GHD Stage III – Surface and Groundwater Assessment (2024). Note that the first NB03 column is the cumulative effect at NB03 with the Golden Bar discharge and background NBWR water quality unmitigated, and the second NB03 column is predicted water with mitigation in place.*

Parameter (all units mg/L)	**DGV guidelines†** (ANZG 2018) (Waikouaiti River North Branch's REC is Cool Dry Hill)	**Alternative guideline**	**Attribute state** NPS-FM (2020) (B band - 95% species protection level)	**GB01†** **Mining Long-term** [2026-2027] [2125-2130] median (95th percentile)	**GB02†** **Mining Long-term** [2026-2027] [2125-2130] median (95th percentile)	**NB01†** **Mining Long-term** [2026-2027] [2125-2130] median (95th percentile)	**NB03 Unmitigated††** **Mining Long-term** median (95th percentile)	**NB03 Mitigated††** **Mining Long-term** median (95th percentile)
Ammoniacal-N			>0.03 and ≤0.24 annual median >0.05 and ≤0.40 annual 95th percentile	0.01 (0.012) for both	0.010 (0.012) 0.003 (0.010)	0.010 (0.012) 0.008 (0.011)	0.012 (0.94) 0.011 (0.015)	0.012 (0.02) 0.011 (0.013)
Nitrate-N			>1.0 and ≤2.4 annual median >1.5 and ≤3.5 annual 95th percentile	0.4 (1.7) 0.6 (1.9)	0.2 (0.2) 0.1 (0.2)	0.2 (0.2) 0.1 (0.2)	0.3 (0.94) 0.27 (0.82)	0.29 (0.94) 0.26 (0.43)
Sulphate	(No guideline specified)	309 mg/L for moderately soft/hard to hard water (76-180 mg/L) Ministry of Environment, British Columbia (2013) However, for water with hardness >250mg/L CaCO3 sulphate toxicity should be assessed on a site-specific basis. Ministry of Environment, British Columbia (2013)		213 (1300) 368 (1522)	10 (12) 276 (342)	10 (12) 76 (194)	100 (480) 89 (420)	93 (460) 69 (150)
Dissolved Arsenic	For As(III) 0.024* For As(V) 0.013*			0.002 (0.003) for both	0.003 (0.003) 0.108 (0.135)	0.003 (0.003) 0.029 (0.076)	0.0031 (0.0095) 0.0039 (0.0086)	0.0029 (0.0088) 0.0039 (0.0084)
Dissolved Copper	0.0014*			0.01 (0.02) 0.02 (0.06))	0.001 (0.001) for both	0.001 (0.001) for both	0.002 (0.007) 0.0021 (0.0076)	0.0019 (0.0057) 0.0017 (0.0035)
Cyanide (WAD)	0.007*			–	–	–	–	–
Iron (total)	(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.		0.17 (0.23) 0.16 (0.22)	0.20 (0.25) 0.05 (0.20)	0.20 (0.25) 0.16 (0.22)	0.19 (0.21) 0.19 (0.22)	0.19 (0.21) 0.19 (0.22)
Dissolved Lead	0.0034*			0.0002 (0.0004) 0.0002 (0.0005)	0.0002 (0.0002) 0.0001 (0.0002)	0.0002 (0.0002) for both	0.00016 (0.00021) for both	0.00016 (0.0002) for both
Dissolved Zinc	0.008*			0.00? (0.02) 0.01 (0.02)	0.002 (0.002) 0.006 (0.3007)	0.002 (0.002) 0.004 (0.006)	0.0021 (0.0046) 0.0021 (0.0045)	0.002 (0.0043) 0.002 (0.0027)

3.2.2 Ecology & Habitat Loss

The predicted changes in water quality during the operational and post closure of the Golden Bar mine, as described above, are unlikely to alter the make-up of the benthic invertebrate and fish communities of local receiving waters. Golden Bar Creek appears to support a very small fish population in its headwaters near the Golden Bar Pit (only one eel has been observed in all surveys) and this is probably due to a periodic lack of water associated with drier months of the year. Field notes going back several years often note the difficulty in collecting invertebrate samples due to the lack of surface flow. Despite this, and stock access creating pugging in places, the benthic invertebrate community is relatively healthy with a higher presence of EPT taxa than at other monitoring sites in the upper Waikouaiti River North Branch catchment. Seepage water from the extended waste rock stack is not expected to make its way into Golden Bar Creek.

The extended Golden Bar Pit encroaches into the very top of the Golden Bar Creek (plates 2 and 6) 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 boggy section of channel before a surface flow is visible (based on observations from a site visit in July 2023; Craig Wilson, Ahika, pers. comm.). Therefore, the length of ephemeral or intermittent stream habitat lost as a result of expanding the pit is 70 m.

Another watercourse on the opposite side of Golden Bar Pit, in the Clydesdale Creek catchment, would be directly affected by the expansion of the WRS. The watercourse has a continuous defined channel for 160 m in a section upstream of the existing Clydesdale Silt Pond (Plate 7) and while a surface flow was observed in July 2023, it most likely has an intermittent flow. As it reaches the toe of the WRS it goes underground and does not form a defined channel again until downstream of the silt pond (Craig Wilson, Ahika, pers. comm.), which is effectively Clydesdale Creek at the GB01 monitoring site. Thus, it does not have surface flow connectivity and is isolated from the remainder of the Clydesdale Creek catchment.

Surveys of the aquatic fauna in this general area of the catchment prior to the commencement of mining at Golden Bar found gullies to support very low densities of invertebrates dominated by snails (*Potamopyrgus*), which are tolerant of poor water quality and habitat conditions, as evidenced by the low QMCI scores of between 2.9 and 3.3 (Ryder Consulting 2002). Clydesdale Creek is not monitored regularly for ecology, but is much smaller than Golden Bar Creek and is also unlikely to support a fish community in its upper reaches[9].

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[9] The upper headwaters of Clydesdale Creek was surveyed for fish and benthic invertebrates in 2002, prior to mining. No fish were captured or seen (Ryder Consulting 2002).

While stream ecology values associated with both watercourses described above are low, it is recommended that an equivalent length of local (to the Macraes area) stream habitat (160 m in total), with similar or potentially better ecological values, be identified and protected to offset the loss of the watercourses.

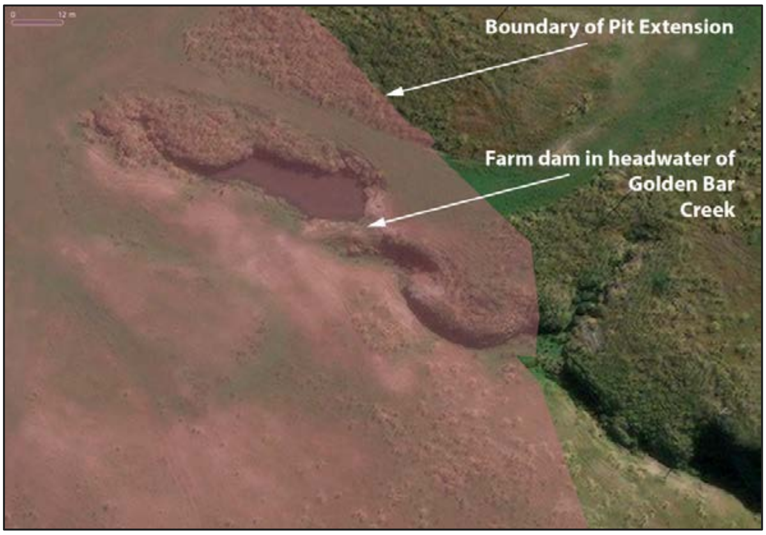

Plate 6. Close-up aerial showing farm pond and headwater of Golden Bar Creek that would be lost due to the extension of the Golden Bar Pit.

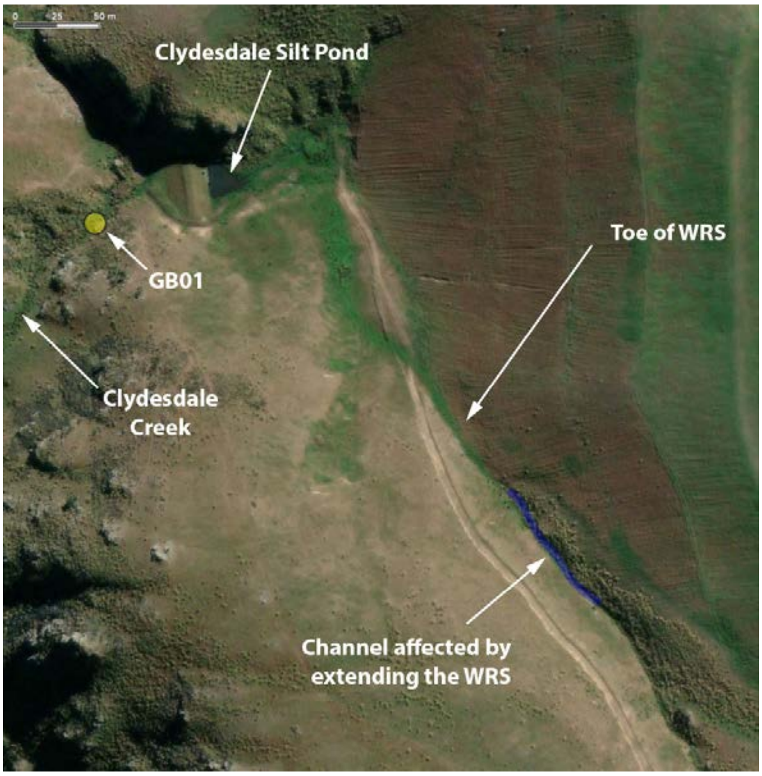

Plate 7. Close-up aerial showing channel that would be lost due to the extension of the Clydesdale WRS. Also identified is the existing Clydesdale Silt Pond, Clydesdale Creek and the GB01 surface water monitoring site.

4 SUMMARY & CONCLUSION

The proposed expansion of the Golden Bar Mine at the Macraes Gold Project involves expanding the existing Golden Bar Pit and expanding the existing rehabilitated WRS. Expanding the pit will result in the loss of 120 m of the very top headwater of Golden Bar Creek (of which 50 m is a farm pond and earth dam and 70 m at most is ephemeral or intermittent stream channel) and 160 m of an already modified watercourse in the Clydesdale Creek catchment that runs along part of the tow of the existing rehabilitated WRS. Although these watercourses have low ecological values from a stream ecology perspective (i.e., unprotected from stock access, very low flows in some months of the year, poor invertebrate community composition and no or very low fish abundance and diversity), some form of offsetting is recommended in the form of protecting and enhancing a combined equivalent length of small stream habitat (280 m long watercourse, ≥30 cm wide at baseflow). Watercourses in the proposed nearby Murphys Ecological Enhancement Area appear to provide similar physical habitat to that described above, and a suitable management plan to accompany that enhancement area will result in improved watercourse habitat with consequential improvements to stream aquatic life.

The 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. 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 (see below) and to ensure that existing water quality compliance criteria are not exceeded.

It is recommended that the Waikouaiti River North Branch channel at and immediately downstream of the discharge area be monitored in the initial stages of the Golden Pit dewatering, and should significant erosion be detected (e.g., erosion that results in bank collapse and sediment smothering the river bed outside of a zone of mixing zone (which, for the upper Waikouaiti River North Branch, a 50 m length is recommended), implement management options to control this to acceptable levels, such as spreading the discharge to nearby receiving water courses more widely, pre-discharge pools, armouring a small part of the stream channel or diverting some or all dewatering flow to the Frasers Tailing Storage Facility.

Modelling by GHD (2024) indicates compliance with the current consented water quality standards within Golden Bar Creek and Murphys Creek are expected to be maintained during mining and post closure of the mine, including when following cessation of mining, Golden Bar Pit fills and begins spilling to Golden Bar Creek. Compliance site NB01 is predicted to meet ANZG default guidelines for all contaminants assessed during and following mining, although arsenic 95th percentile and maximum concentrations may exceed the default guideline for long-term scenarios. However the predicted maximum concentration of 0.076 mg/L is similar to the recent recorded maximum concentration of 0.052 mg/L and the benthic fauna of Golden Bar Creek is in good condition. Spilling from the pit (as it currently does) is likely to benefit the creek ecology through more reliable surface water flow during summer low flow conditions.

Water quality at NB03 reflecting cumulative effects in the Waikouaiti North Branch catchment are discussed in Ryder (2024b). Monitoring should continue to ensure that concentrations remain within existing water quality compliance limits for NB03.

5 REFERENCES

Alden, B., Goldsmith, R., and Ludgate, B. 2022. Macraes Gold Mine Annual Surface Water Biological Monitoring: 2021. Prepared for Oceana Gold (NZ) Limited.

Alden, B., Goldsmith, R., and Ludgate, B. 2023. Macraes Gold Mine Annual Surface Water Biological Monitoring: 2022. Prepared for Oceana Gold (NZ) Limited.

Department of Conservation. 2004. New Zealand non-migratory galaxiid fishes recovery plan 2003-13. *Threatened Species recovery Plan 53*. New Zealand Department of Conservation, Wellington.

Dunn, N.R., Allibone, R.M., Closs, G.P., Crow, S.K., David, B.O., Goodman, J.M., Griffiths, M., Jack, D.C., Ling, N., Waters, J.M. and Rolfe, J.R. 2018. Conservation status of New Zealand freshwater fishes, 2017. *New Zealand Threat Classification Series 24*. Department of Conservation, Wellington, New Zealand.

GHD. 2023. Golden Bar dewatering assessment. Prepared for Oceana Gold New Zealand Ltd.

GHD. 2024. Macraes Phase IV: Golden Bar – Surface and Groundwater Assessment. Prepared for Oceana Gold New Zealand Ltd.

Grainger, N., Harding, J., Drinan, T., Collier, K., Smith, B., Death, R., Makan, T. and Rolfe, J. 2018. Conservation status of New Zealand freshwater invertebrates, 2018. *New Zealand Threat Classification Series 28.* Department of Conservation, Wellington, New Zealand.

Jones, P.E. 2014. Life history variation in the *Galaxias vulgaris* complex: implications for interactions with invasive salmonids. A thesis submitted for the degree of Doctor of Philosophy in Zoology. Department of Zoology, University of Otago.

MWM. 2024. Macraes Mine Phase 4.3: Environmental Geochemistry Assessment OceanaGold Macraes Mine Site

Ryder Consulting. 2002. Ecological surveys in the vicinity of the proposed Golden Bar Expansion. Prepared by Ryder Consulting Limited for GRD Macraes.

Ryder Environmental. 2018. Oceana Gold (NZ) Limited - Macraes. Annual surface water biological monitoring: Macraes Flat 2017. Report prepared by Ryder Environmental Limited for Oceana Gold (NZ) Limited.

Ryder Environmental. 2020. Oceana Gold (NZ) Limited - Macraes. Annual surface water biological monitoring: Macraes Flat 2017. Report prepared by Ryder Environmental Limited for Oceana Gold (NZ) Limited.

Ryder, G.I. 2022a. Macraes Phase Four Project: Back Road Waste Rock Stack Aquatic Ecology Assessment. Report prepared for Oceana Gold (NZ) Limited.

Ryder, G.I. 2022b. Macraes Phase Four Project: Top Tipperary Tailings Storage Facility Raise: Cranky Jims & Tipperary Creek Aquatic Ecology Assessment. Report prepared by Greg Ryder Consulting for Oceana Gold (NZ) Limited.

Ryder, G.I. 2023. Macraes Phase Four Project: Golden Point Underground Mine & Proposed Extension – Effects on Deepdell Creek. Report prepared by Greg Ryder Consulting Limited for Oceana Gold (NZ) Limited.

Ryder, G.I. 2024a. Macraes Phase Four Project: Coronation Mine & Proposed Extension – Effects on the Mare Burn catchment. Report prepared by Greg Ryder Consulting Limited for Oceana Gold (NZ).

Ryder, G.I. 2024b (in prep.). Macraes Phase Four Project Stage III – Surface water assessment: Cumulative effects.

Stark, J.D. and Maxted, J.R. 2007. A biotic index for New Zealand's soft-bottomed streams. *New Zealand Journal of Marine and Freshwater Research*. **41**: 43-61.

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.

APPENDIX B: MC02 AND GB02 MACROINVERTEBRATE MONITORING DATA FOR 2021

TAXON March 2021	MCI score	MC02 1	MC02 2	MC02 3	MC02 4	MC02 5	GB02 1	GB02 2	GB02 3	GB02 4	GB02 5
ACARINA	5										
ARACHNIDA											
Dolomedes species	5							1			
CNIDARIA											
Hydra species	3										
COLEOPTERA											
Elmidae	6		2	2	5						
Hydraenidae	8										
Hydrophilidae	5		1								
Scirtidae	8								1	2	3
COLLEMBOLA	6				1		2			4	2
CRUSTACEA											
Cladocera	5										
Copepoda	5										
Isopoda	5										
Ostracoda	3	1	1				16		3	7	3
Paracalliope fluviatilis	5					1	72	16	83	194	960
Paraleptamphopus species	5										
Paranephrops zealandicus	5										
DIPTERA											
Aphrophila species	5										
Austrosimulium species	3		1	6	1	2	14	2	9	71	205
Chironomidae	2	9	16	24	14	14	1	1	3	7	4
Empididae	3										
Ephydridae	4										
Eriopterini	9										
Hexatomini	5						1				
Limonia species	6										
Mischoderus species	4										
Muscidae	3					1					
Paradixa species	4										
Paralimnophila skusei	6									2	1
Psychodidae	1										
Stratiomyidae	5										
EPHEMEROPTERA											
Deleatidium species	8		1	1	1		153	9	8	18	76
Neozephlebia scita	7										
HEMIPTERA											
Mesoveliidae	-								1		
Microvelia macgregori	5										
Saldidae	5				1						
MECOPTERA											
Nannochorista philpotti	7									1	
MEGALOPTERA											
Archichauliodes diversus	7	1			2						
MOLLUSCA											
Gyraulus species	3	1	5	1	7	8					
Physa / Physella species	3	24	8	37	31	11					
Potamopyrgus antipodarum	4	1214	552	385	647	1338	67	12	29	38	60
Sphaeriidae	3					1				1	3
NEMATODA	3										
NEMATOMORPHA	3										
NEMERTEA	3		2	1							
ODONATA											
Xanthocnemis zealandica	5										
OLIGOCHAETA	1	3	11	9	3	3	2		1	2	6
PLATYHELMINTHES	3		26		1	16	6	1	4		41
PLECOPTERA											
Austroperla cyrene	9										
Stenoperla species	10										
Zelandobius species	5										
Zelandoperla species	10			1							
TRICHOPTERA											
Hudsonema alienum	6						4		1	4	13
Hudsonema amabile	6					2					
Hydrobiosidae early instar	5										
Hydrobiosis umbripennis group	5					2					
Hydropsyche - Aoteapsyche group	4	5	14	36	10	29	8	2			
Oeconesus species	9								1	3	
Olinga species	9										
Oxyethira albiceps	2	50	25	2	2	8					
Paroxyethira species	2										
Plectrocnemia species	8										
Polyplectropus species	8	1		1	1					2	
Psilochorema species	8	3	5	7	3		6	1	1		3
Pycnocentria species	7										
Pycnocentrodes species	5										
Triplectides species	5										
Number of invertebrates (per sample)		1312	670	513	730	1436	352	45	145	356	1380
Number of taxa		11	15	14	16	14	13	9	13	15	14
QMCI score		3.9	3.8	3.8	3.9	3.9	5.9	5.2	4.7	4.6	4.8

TAXON June 2021	MCI score	MC02 1	2	3	4	5	GB02 1	2	3	4	5
ACARINA	5										
COLEOPTERA											
Antiporus species	5										
Elmidae	6						1	1	2		1
Hydraenidae	8				1						
Scirtidae	8										
COLLEMBOLA	6		1				1				
CRUSTACEA											
Cladocera	5										
Ostracoda	3	2				5	4	12	10	7	1
Paracalliope fluviatilis	5						20	4	80	11	60
Paraleptamphopus species	5										
Paranephrops zealandicus	5										
DIPTERA											
Aphrophila species	5										
Austrosimulium species	3	5	7		4	7	5	4	15	12	6
Chironomidae	2	4	10		6	3		2	19		10
Empididae	3										
Ephydridae	4										
Hexatomini	5										
Mischoderus species	4										
Molophilus species	5										
Muscidae	3					1					
Paradixa species	4						1				
Paralimnophila skusei	6										
Stratiomyidae	5										
EPHEMEROPTERA											
Deleatidium species	8	3	1	1		3	37	33	27	64	21
HIRUDINEA	3										
MECOPTERA											
Nannochorista philpotti	7						1	1			
MEGALOPTERA											
Archichauliodes diversus	7			2							
MOLLUSCA											
Gyraulus species	3	4	1		4	3					
Physa / Physella species	3	5	2	7	10						
Potamopyrgus antipodarum	4	162	192	273	356	1578	7	32	210	74	124
Sphaeriidae	3				1					1	
NEMATODA	3										
NEMERTEA	3										
ODONATA											
Xanthocnemis zealandica	5					1					
OLIGOCHAETA	1	2	59	11	48	21		2	3	5	
PLATYHELMINTHES	3	6	2		8	8	1		7		
PLECOPTERA											
Austroperla cyrene	9										
Stenoperla species	10										
Zelandobius species	5	1						1	1		5
Zelandoperla species	10										
TRICHOPTERA											
Hudsonema alienum	6							1	5	1	1
Hudsonema amabile	6				1	3					
Hydrobiosidae early instar	5	1						3			
Hydrobiosis umbripennis group	5	2			1	2		6			
Hydropsyche - Aoteapsyche group	4	9	11	30	47	23	1	1			
Oeconesidae	9								5	1	
Olinga species	9										
Oxyethira albiceps	2	1	2		2	1		1			1
Paroxyethira species	2										
Polyplectropus species	8						12				7
Psilochorema species	8	2	2	3	9	3			2		
Pycnocentria species	7										
Pycnocentrodes species	5	1									
Tiphobiosis species	6										
Triplectides species	5										
Number of invertebrates (per sample)		210	290	327	498	1662	91	104	386	176	237
Number of taxa		16	12	7	14	15	12	15	13	9	11
QMCI score		3.9	3.3	3.9	3.7	4.0	6.3	5.2	4.4	5.4	4.6

TAXON September 2021	MCI score	MC02 1	MC02 2	MC02 3	MC02 4	MC02 5	GB02 1	GB02 2	GB02 3	GB02 4	GB02 5
ACARINA	5										
ARACHNIDA											
Dolomedes species	5										
COLEOPTERA											
Antiporus species	5										
Elmidae	6	2			1	2	2				
Hydraenidae	8										
Scirtidae	8										
COLLEMBOLA	6		1		1	1				3	
CRUSTACEA											
Copepoda	5							1			
Ostracoda	3	2			1	3	3	1	2	2	2
Paracalliope fluviatilis	5						6	6	10	47	51
Paraleptamphopus species	5										
DIPTERA											
Aphrophila species	5										
Austrosimulium species	3	8	9	3	4	9	1	1		4	
Ceratopogonidae	3								1		
Chironomidae	2	6	5	2	1	9	6	6	5	8	
Empididae	3										
Eriopterini	9										
Hexatomini	5										
Mischoderus species	4										
Molophilus species	5										
Muscidae	3										
Neolimnia species	3										
Paralimnophila skusei	6										
Sciomyzidae	3										
Stratiomyidae	5										
EPHEMEROPTERA											
Deleatidium species	8		1	2	5	1	60	51	24	91	18
HEMIPTERA											
Microvelia macgregori	5										
MEGALOPTERA											
Archichauliodes diversus	7				1						
MOLLUSCA											
Gyraulus species	3		2								
Physa / Physella species	3										
Potamopyrgus antipodarum	4	760	209	100	18	111	105	23	31	97	43
Sphaeriidae	3										
NEMATODA	3			2			1	1			
NEMERTEA	3										
ODONATA											
Anisoptera	5						1				
Xanthocnemis zealandica	5							1			
OLIGOCHAETA	1	30	20	21	2	22	9	6		1	1
PLATYHELMINTHES	3						1	2		2	
PLECOPTERA											
Austroperla cyrene	9		2								
Stenoperla species	10										
Zelandobius species	5						1	4	3	19	3
Zelandoperla species	10										
TRICHOPTERA											
Costachorema species	7										
Hudsonema alienum	6						2	2	2	6	2
Hudsonema amabile	6	1									
Hydrobiosidae early instar	5						1	1			
Hydrobiosis umbripennis group	5	1	1			2					
Hydropsyche - Aoteapsyche group	4	5	37		7	6	10	1		6	
Oeconesidae	9										
Oeconesus species	9										
Olinga species	9										
Oxyethira albiceps	2	1	1								
Paroxyethira species	2										
Polyplectropus species	8								5		
Psilochorema species	8	2	1	1	1			2		1	1
Pycnocentria species	7							1			
Pycnocentrodes species	5				1						
Number of invertebrates (per sample)		818	289	131	43	166	209	110	83	287	121
Number of taxa		11	12	7	12	10	15	17	9	13	8
QMCI score		3.9	3.8	3.5	4.4	3.5	5.0	5.8	5.4	5.5	5.1

TAXON November 2021	MCI score	MC02 1	MC02 2	MC02 3	MC02 4	MC02 5	GB02 1	GB02 2	GB02 3	GB02 4	GB02 5
ACARINA	5								1		
CNIDARIA											
Hydra species	3										
COLEOPTERA											
Antiporus species	5										
Elmidae	6			4	4		2	1	1	1	
Hydraenidae	8					1					
Lancetes species	5										
Liodessus species	5										
Rhantus pulverosus	5										
Scirtidae	8						1				
COLLEMBOLA	6						1		1	1	
CRUSTACEA											
Ostracoda	3						2		1	5	7
Paracalliope fluviatilis	5				2		368	61	98	149	134
Paraleptamphopus species	5										
DIPTERA											
Aphrophila species	5				1	1					
Austrosimulium species	3	2	5	11	3	1	45	6	66	30	5
Calopsectra species	4										
Ceratopogonidae	3										
Chironomidae	2	11	30	17	9	13	58	12	30	5	5
Empididae	3								1		
Ephydridae	4									1	
Hexatomini	5										
Muscidae	3						1				
Paradixa species	4										
Paralimnophila skusei	6						1				1
Sciomyzidae	3										
Stratiomyidae	5										
EPHEMEROPTERA											
Deleatidium species	8	2	5	6	6	7	106	89	111	73	80
HEMIPTERA											
Microvelia macgregori	5										
MEGALOPTERA											
Archichauliodes diversus	7	2		2	2						
MOLLUSCA											
Gyraulus species	3		1			1					
Physa / Physella species	3					1					
Potamopyrgus antipodarum	4	220	110	36	20	635		19	173	186	733
Sphaeriidae	3						4				
NEMATODA	3										
NEMERTEA	3										
ODONATA											
Xanthocnemis zealandica	5										
OLIGOCHAETA	1	13	8	12	1	21	7	1	4	2	
PLATYHELMINTHES	3						2				
PLECOPTERA											
Acroperla species	5										
Austroperla cyrene	9										
Megaleptoperla species	9						1				
Stenoperla species	10										
Taraperla species	7										
Zelandobius species	5						1		1		
TRICHOPTERA											
Hudsonema alienum	6						17	6	24	1	4
Hudsonema amabile	6										
Hydrobiosidae early instar	5										
Hydrobiosis claviqera group	5										
Hydrobiosis umbripennis group	5	1	2	2	2	4	1			1	
Hydropsyche - Aoteapsyche group	4	38	7	12		14	1			1	
Oeconesus species	9						1				
Olinga species	9										
Oxyethira albiceps	2	1	6	1		4					
Paroxyethira hendersoni	2										
Paroxyethira species	2										
Polyplectropus species	8						1				3
Psilochorema species	8			3	5	3	1	1			
Pycnocentria species	7										
Pycnocentrodes species	5										
Number of invertebrates (per sample)		290	174	106	55	706	622	196	512	456	972
Number of taxa		9	9	11	11	13	21	9	13	13	9
QMCI score		3.8	3.5	3.7	4.7	3.9	5.1	6.1	4.9	4.9	4.5

APPENDIX C: WAIKOUAITI RIVER NORTH BRANCH MACROINVERTEBRATE MONITORING DATA FOR 2022

Summer 2022		MCI tolerance	MC01					MC02					GB02					NBWRRF					NBWRRB	MC100
ORDER	TAXON	value	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	KN	KN
ACARINA	ACARINA	5	1	1	1	1						1									1		1	
ARACHNIDA	*Dolomedes*	5	1																			1		
CNIDARIA	*Hydra*	3	1																		2			
COLEOPTERA	Elmidae	6						4				2			2	1	1							
	Hydraenidae	8						2									1							
	Rhantus	5																					2	
	Scirtidae	8																						20
	Staphylinidae	5																						
COLLEMBOLA	COLLEMBOLA	6		1	2		2							1	1	1	3		1		9	15	17	100
CRUSTACEA	Cladocera	5																	1					
	Copepoda	5																	1					
	Ostracoda	3	45	409	2	33	33	3				1	13		12	5	1	4	8	2	6		27	320
	Paracalliope	5											134	30	569	327	450							
	Paraleptamphopus	5																						
	Paranephrops	5																						
DIPTERA	*Aphrophila*	5																						
	Austrosimulium	3	3	1	1		3					1	9	14	57	23	6	13	40	217	41	366		3
	Chironomidae	2	2	1	4			3	5	3	12	5	1		14	2	12		4	5	1	11	223	120
	Dolichopodidae	3																						
	Empididae	3																						
	Ephydridae	4																				1		
	Eriopterini	9			1																			
	Hexatomini	5			1																			
	Limonia	6																						
	Mischoderus	4																						
	Muscidae	3	1						1						2							2		
	Paradixa	4												1			1							7
	Paralimnophila	6																						1
	Sciomyzidae	3																			1			
	Stratiomyidae	5													2		1						4	40
	Zelandotipula	6																					4	
EPHEMEROPTERA	*Austroclima*	9																						
	Deleatidium	8					1	7	2	5	2	6	29	50	153	187	176	3	7	4	3	5		1
HEMIPTERA	*Microvelia*	5											1		1		2				4	3	7	23
	Saldidae	5																						
	Sigara	5																						1
LEPIDOPTERA	*Hygraula*	4																						
MEGALOPTERA	*Archichauliodes*	7							3	1		1												
MOLLUSCA	*Gyraulus*	3	49	17	4	29	30	16	2	1	5	17						21	17	20	14	11	58	
	Physa = Physella	3	16	3	10	8	10	22		3	9	13						1	4	5	2	2	3	60
	Potamopyrgus	4	1043	1681	422	2550	3481	1639	108	1669	2273	3253	212	56	428	130	292	928	999	819	505	174	1	19140
	Sphaeriidae	3	74	49		7	15					1						36	41	2				
NEMATODA	NEMATODA	3	1				2												1					1
NEMERTEA	NEMERTEA	3						2		1	2	7		1				6	1	1	16	5	1	
ODONATA	*Xanthocnemis*	5	1	5	1	11	2					1						1	1					39
OLIGOCHAETA	OLIGOCHAETA	1	46	149	34	16	31	38	3	17	21	19	2		10	1	10	14	19	6	4	9	23	40
PLATYHELMINTHES	PLATYHELMINTHES	3	3	4		9		11		6	4	12	2	1	17	4	16	10	14	16	5	7		
	Temnohaswellia	3																						
PLECOPTERA	*Austroperla*	9																						
	Spaniocerca	8																						
	Stenoperla	10																						
	Taraperla	7															1							
	Zelandobius	5																						
	Zelandoperla	10																						
TRICHOPTERA	*Hudsonema*	6	109	33	8	29	15			1	4	1		2	35	12	35		2	1				10
	Hydrobiosidae early instar	5											2									1		
	Hydrobiosis	5						2	3	1						4	2			1		1		
	Hydropsyche - Aoteapsyche	4						63	62	3	22	3	1	10	2		5		2		2			
	Neurochorema	6																						
	Oeconesidae	9											2		6		1							
	Olinga	9																						
	Oxyethira	2							1			2					1		1		1	1		
	Paroxyethira	2																						
	Polyplectropus	8											1	1	1									
	Psilochorema	8			1			4	6			6			3	4	7			1		1		2
	Pycnocentria	7																						
	Pycnocentrodes	5																	1					
	Zelolessica	10																						
Number of invertebrates (per sample)			1396	2354	492	2693	3625	1816	196	1711	2354	3352	409	167	1315	701	1024	1037	1165	1100	617	616	371	19928
Number of taxa			16	13	14	10	12	14	11	12	10	19	13	11	18	13	21	11	20	14	17	18	13	18
QMCI score			3.9	3.6	3.8	4.0	4.0	3.9	4.1	4.0	4.0	4.0	4.6	5.3	4.9	5.5	5.2	3.9	3.9	3.8	3.9	3.4	2.5	4.0

Autumn 2022		MCI tolerance value	MC01					MC02					NBWRRF					GB02	NBWRRB	MC100
ORDER	TAXON		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	KN	KN	KN
ACARINA	ACARINA	5		1	1	1														
CNIDARIA	*Hydra*	3														2	1			1
COLEOPTERA	Elmidae	6							1									2		
	Hydraenidae	8						1		1										
	Rhantus	5																	3	
	Scirtidae	8	1		11														1	3
COLLEMBOLA	COLLEMBOLA	6	1		12					2				1				2	13	143
CRUSTACEA	Ostracoda	3	54	93	7	1	6	15		1			1	1	3	3	5	476	14	455
	Paracalliope	5											3					112	1	
	Paraleptamphopus	5																		
	Paranephrops	5																		
DIPTERA	*Aphrophila*	5							1							1	1			
	Austrosimulium	3	24	7	24	33	20						7	187	166	118	42	1		11
	Chironomidae	2						24	3	1	1	1	5	3		34	20	15	17	5
	Empididae	3																		
	Hexatomini	5																		
	Limonia	6																2		
	Mischoderus	4																		
	Muscidae	3												2			2		2	1
	Nothodixa	4																		
	Paradixa	4																		5
	Paralimnophila	6	2															2		1
	Psychodidae	1																		
	Sciomyzidae	3														1				
	Stratiomyidae	5																	3	3
	Tipulidae	5																	18	1
EPHEMEROPTERA	*Austroclima*	9																		
	Deleatidium	8						4	18	3	5	1	1	5	4	1		235		
	Zephlebia	7																		
HEMIPTERA	*Diaprepocoris*	5																		
	Microvelia	5			1															
LEPIDOPTERA	*Hygraula*	4																		
MECOPTERA	*Nannochorista*	7																4		
MEGALOPTERA	*Archichauliodes*	7									1	1								
MOLLUSCA	*Gyraulus*	3	1		1	1		32	5	4	1	11	8	2	2	6	8		17	
	Lymnaeidae	3																		
	Physa = Physella	3	2	1	3	3	2	4	1	5	5	5			5	5	6		3	5
	Potamopyrgus	4	1306	287	1314	1330	377	1239	921	395	728	713	118	1110	1132	880	132	207	1	5729
	Sphaeriidae	3	15	32	12	4	1							35	2	1	3			1
NEMATODA	NEMATODA	3	1																	
NEMERTEA	NEMERTEA	3						1	4		9	4	1							
ODONATA	*Austrolestes*	6																		
	Xanthocnemis	5	4		1	4	3						1			1				21
OLIGOCHAETA	OLIGOCHAETA	1	31	24	31	2	2	18	9	3	53	5	2	13	1	9	3	7	851	45
PLATYHELMINTHES	PLATYHELMINTHES	3	9	1	1		2	1				18	2	9	10		9	1		10
PLECOPTERA	*Austroperla*	9																		
	Stenoperla	10																		
	Taraperla	7																1		
	Zelandobius	5			2	1							2	1			1	2		
	Zelandoperla	10																		
TRICHOPTERA	*Hudsonema*	6	25	23	44	11	14	3			1					1		24		13
	Hydrobiosidae early instar	5													2			1		
	Hydrobiosis	5						1	2									2		
	Hydropsyche - Aoteapsyche	4						7	107	2	16	1								
	Neurochorema	6																		
	Oeconesidae	9																1		
	Olinga	9																		
	Oxyethira	2						2				2	4	3	3	16	13	1		53
	Paroxyethira	2						5									1			
	Polyplectropus	8									1							30		
	Psilochorema	8						2	13	2	3	1						1		
	Pycnocentria	7																		
	Pycnocentrodes	5						1												
Number of invertebrates (per sample)			1476	469	1465	1391	427	1360	1085	419	824	763	155	1372	1330	1079	247	1129	944	6506
Number of taxa			14	9	15	11	9	17	12	11	12	12	13	13	11	15	15	22	13	19
QMCI score			3.9	3.7	4.0	4.0	4.0	3.9	4.1	4.0	3.8	3.9	3.8	3.8	3.9	3.8	3.4	4.7	1.3	3.9

Winter 2022		MCI tolerance value	MC100					MC01					MC02					NBWRRF					NBWRRB
ORDER	TAXON		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	KN
ACARINA	ACARINA	5	1									1				1							1308
CNIDARIA	*Hydra*	3																					1
COLEOPTERA	Elmidae	6						1					1		1								
	Hydraenidae	8						1					1										
	Liodessus	5																					1
	Rhantus	5																					1
	Scirtidae	8																					
COLLEMBOLA	COLLEMBOLA	6									1												2
CRUSTACEA	Copepoda	5					1																
	Ostracoda	3	90	159	21	33	73		5		1	1	1						1	1	1		138
	Paracalliope	5		1								1											
	Paraleptamphopus	5																					3720
DIPTERA	*Aphrophila*	5																					
	Austrosimulium	3	2					7				17	2	6	2	3		3	4	4	4	5	
	Ceratopogonidae	3				1																	
	Chironomidae	2	5	1	1		1		2		1	3		2	3	8	3			2			2
	Empididae	3																					
	Hexatomini	5																					
	Limonia	6																					
	Mischoderus	4																					
	Muscidae	3																					
	Paradixa	4																					
	Paralimnophila	6	3					1		2													
	Stratiomyidae	5	1																				2
EPHEMEROPTERA	*Ameletopsis*	10																					
	Deleatidium	8			6					1			5	4	3	1	4	1	5	6	4	7	
HEMIPTERA	*Microvelia*	5									1												1
	Sigara	5																					2
MEGALOPTERA	*Archichauliodes*	7															1						
MOLLUSCA	*Gyraulus*	3		1				1				1	1		1		3	1					19
	Physa = Physella	3				3					2	2							1			2	2
	Potamopyrgus	4	1980	1440	328	2220	1180	251	63	111	236	546	882	10	5	7	82	105	1602	591	676	166	13
	Sphaeriidae	3	11	5	3	1	1	45	3			6						1	5	1	1	1	
NEMATODA	NEMATODA	3				18	16				3												300
NEMERTEA	NEMERTEA	3											2						9	2	5		
ODONATA	*Xanthocnemis*	5	2		1	1	1					1											
OLIGOCHAETA	OLIGOCHAETA	1	291	31	189	13	67	59	21	154	8	35	51	2	3	2	4	4	17	23	6		19980
PLATYHELMINTHES	PLATYHELMINTHES	3										1							6	2	21	3	
PLECOPTERA	*Austroperla*	9			3																		
	Zelandobius	5	3		2	2	11	1			2	2											
	Zelandoperla	10																					
TRICHOPTERA	*Hudsonema*	6	8	1	8	5	10	6	1		4	13							1				
	Hydrobiosidae early instar	5																					
	Hydrobiosis	5						1					1										
	Hydropsyche - Aoteapsyche	4											69	12	9	2	6		3	1		1	
	Oeconesidae	9																					
	Olinga	9																					
	Oxyethira	2	4	1	1	1	1		5			1	1						1	9	1	7	2
	Plectrocnemia	8																					
	Polyplectropus	8																					
	Psilochorema	8				1				1			5	1	1		1		3	1	1		
	Pycnocentria	7																					
	Pycnocentrodes	5																					
Number of invertebrates (per sample)			2401	1640	563	2299	1362	374	100	269	259	631	1022	37	28	24	104	115	1658	643	720	192	25494
Number of taxa			13	9	11	12	11	11	7	5	10	15	13	7	9	7	8	6	13	12	10	8	17
QMCI score			3.6	3.8	3.0	4.0	3.8	3.4	3.2	2.3	3.9	3.8	3.9	4.1	4.0	3.2	4.0	3.9	4.0	3.9	4.0	4.0	1.8

Spring 2022		MCI tolerance value	MC100					MC01					MC02					GB02					NBWRRF					NBWRRB
ORDER	TAXON		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	KN
ACARINA	ACARINA	5			7			1										1				3	1					
CNIDARIA	*Hydra*	3																										2
COLEOPTERA	Elmidae	6											12	2	2	3	1	1		2								
	Hydraenidae	8											1		1													
	Lancetes	5										1																
	Scirtidae	8	1	1		1			1		4										1	1						
COLLEMBOLA	COLLEMBOLA	6		1	3	2	2	1			3			1								1		1				2
CRUSTACEA	Copepoda	5																			1							
	Ostracoda	3	59	29	95	200	125	13	11	5	6	8	2	1		2	2	19	2	6	5	26	5	4		2		114
	Paracalliope	5							1			1						43	84	67	34	58						
	Paraleptamphopus	5																			1							1
	Paranephrops	5																										
DIPTERA	*Aphrophila*	5																										
	Austrosimulium	3	6	21	1	40	326	56	3	78	275	246	6	3	4	7		8	21	9	6	2	2	21			1	
	Chironomidae	2	13	21	14	31	61	85	20	22	84	39	242	125	90	123	36	50	65	18	11	30	182	897	140	76	182	120
	Empididae	3																										
	Hexatomini	5																										
	Limonia	6																			1							
	Mischoderus	4																										
	Muscidae	3						1																				2
	Paradixa	4	1			1																1						
	Paralimnophila	6		2				1		1										1	1							
	Stratiomyidae	5				1					1											1						
	Zelandotipula	6																										
EPHEMEROPTERA	*Ameletopsis*	10																										
	Austroclima	9																										
	Deleatidium	8						2		2	1	2	1	8	3	2		78	57	110	125	58						
	Neozephlebia	7																										
	Zephlebia	7																										
HEMIPTERA	*Microvelia*	5	6	5		1	2		1	1	1							1	5	1	3	3	1		3		2	14
	Sigara	5																										
MECOPTERA	*Nannochorista*	7																			3	2						
MEGALOPTERA	*Archichauliodes*	7														1												
MOLLUSCA	*Gyraulus*	3								1			2	1	1	13	9						32	61	20	36	1	86
	Physa = Physella	3			1	1		3	1		2	2		2										10	2	5	2	2
	Potamopyrgus	4	231	488	160	274	884	445	411	706	2069	597	1195	60	10	593	97	3	2	9	42	28	124	288	1367	953	36	36
	Sphaeriidae	3			2	2	4	11	5	2	3	3											3		4	1		
NEMATODA	NEMATODA	3	1									6	1				1					1						6
NEMATOMORPHA	NEMATOMORPHA	3																										
NEMERTEA	NEMERTEA	3											2				7						1	1		4		
ODONATA	*Xanthocnemis*	5	1	3	2	5		1	8		13	2											5			1	1	
OLIGOCHAETA	OLIGOCHAETA	1	12	21	8	15	2	23	9	16	7	5	86	27	28	94	41	4	5	5	7	30	61	729	64	40	143	46
PLATYHELMINTHES	PLATYHELMINTHES	3						1	1	1							1		4	12	1	1		3	6	6	1	1
PLECOPTERA	*Stenoperla*	10																										
	Zelandobius	5					1				1							1	1									
	Zelandoperla	10																										
TRICHOPTERA	*Hudsonema*	6	2		1	2		2	1	2	11							1	21	2	7	1						
	Hydrobiosidae early instar	5																										
	Hydrobiosis	5																		1								
	Hydropsyche - Aoteapsyche	4											6	9	4	6							1					
	Oeconesidae	9																										
	Olinga	9														2												
	Oxyethira	2		1	3	6			1		1		12	8	6	5	10	12	7	1	12	7	115	50	15	12	38	
	Paroxyethira	2														1									1	1	2	
	Polyplectropus	8												1				7	1		6	17						
	Psilochorema	8											4	13	12	5	4	1	2									
	Pycnocentria	7																										
	Pycnocentrodes	5																										
	Tiphobiosis	6																										
Number of invertebrates (per sample)			333	593	297	582	1407	646	474	837	2482	912	1572	261	161	857	209	230	277	244	267	271	533	2065	1622	1137	409	432
Number of taxa			11	11	12	15	9	15	14	12	16	12	14	14	11	14	11	15	14	14	18	19	13	11	10	12	11	13
QMCI score			3.7	3.8	3.5	3.4	3.6	3.5	3.8	3.8	3.8	3.6	3.5	3.0	2.7	3.4	3.0	5.0	4.7	5.8	5.9	4.7	2.5	2.0	3.7	3.7	1.9	2.7