Annexure 15:

Responses to s92 requests prepared by Greg Ryder Consulting in respect of aquatic ecology matters

MEMORANDUM

From	Dr Greg Ryder, Greg Ryder Consulting Ltd.
To	Dean Fergusson, Resource & Reserve Ltd.
Topic	Response to ORC s92 questions on Consent Application Number RM24.184 (Macraes Gold Mine MP4 Mine Expansion)
Date	30 August 2024

The Otago Regional Council (ORC) and their application reviewers have requested responses to a number of questions relating to the Macraes MP4 mine expansion AEE and effects on aquatic ecology and surface water quality[1].

The ORC questions are presented below in italics and my responses to them are set out in blue text.

Golden Bar Stage 2 Pit Extension

1.34 An application is made to disturb (mine) the bed of a tributary of Golden Bar creek (a length of 130 m including the pond). The relevant rule has been identified as RPW 13.5.3.1. While this is correct, I would also consider that the NES-F regulation 57 (river reclamations) is applicable. I note that AEE s3.6.2 describes this as a reclamation.

a) Please confirm that the below image and the yellow ellipse identify the correct tributary and roughly the correct location of the proposed reclamation.

b) Please indicate whether OGL agrees to apply under this regulation and please provide an assessment that describes the functional need for the reclamation in this location and applies the effects management hierarchy. If this is already provided as part of the application, please direct me to this assessment.
- Note: please see related question in the Surface Water and Aquatic Ecology section.

(a) Yes

(b) OGL will respond to this planning aspect separately.

Golden Bar WRS Extension

1.36 The AEE (s3.6.3) refers to a second reclamation: "…90 m of an already modified

[1] Letter from Shay McDonald (ORC Senior Consent Planner) to OceanaGold dated 24 July 2024. File: 999859517-10396

watercourse in the Clydesdale Creek catchment that runs along part of the toe of the existing rehabilitated WRS…". Does the below image show the correct tributary?

Yes.

5.2 Please update Appendix F of Appendix 13 to include summaries of current state (as has been done in Table 5.8 and 5.9 of Appendix 11). If the information requested above reveals an increase in nitrate from current, please assess the potential impacts on periphyton growth in the receiving environments (noting that this is identified as an issue in Appendix 22).

See response to 5.9. The same rationale applies here (i.e., Murphys Creek catchment) as it does to the Mare Burn catchment. Bioavailable phosphorus levels have remained very low in the Murphys Creek catchment.

Activities associated with Coronation open pit

5.7 Please confirm whether the dissolved metal concentrations in Table 2 of Appendix 20 are correct. The maximums for dissolved copper are much higher than the 95th percentiles in Appendix 11.

Not strictly comparing apples with apples. Table 2 of Appendix 20 summarises data for the period 2014-2022 as minimum, median and maximum concentrations for each site. The GHD report in Appendix 11 (tables 5.8 and 5.9) presents current and modelled future concentrations for each site as medians and 95th percentiles, based on source terms estimated from available site water quality data. So, the tables in the two reports present different statistics (maximum recorded concentration vs 95th percentile concentration) from two different time periods (2014-2022 vs 2020-2022). Maximum concentrations should almost always be higher than the 95th percentile concentrations and this is evident in the comparison.

5.8 Please provide more quantitative evidence regarding hydrological effects on Mareburn, including comparisons of dewatering effects against relevant hydrological statistics such as naturalised MALF (as has been done in other reports appended to the application). This is not an attempt to refute Dr Ryder's assessment. Rather to ensure that I have sufficient information to confirm it.

There is no regular monitoring of flows in the Mare Burn catchment, so I interrogated NIWA's NZ River Maps database (Shiny) and accessed modelled flow statistics for the Mare Burn catchment.

The interrogation produced the following flow statistics for key Mare Burn catchment surface water sites (Table 1):

Table 1. Flow statistics for the Mare Burn and Trimbells Gully at surface water ecological monitoring sites. Source: NIWA's NZ River Maps database (Shiny)

Site	**MALF** (L/sec)	**Median** (L/sec)
Trimbells Gully ecological monitoring site (TGEMS)	14	30
MB01	26	57
MB02	49	127

GHD reported that a small reduction (~1 L/sec) is expected in the groundwater contributions to the Mare Burn flows due to pit dewatering. Assuming this equates to an equivalent loss of flow in the local surface waters of the Mare Burn catchment (conservative), the percentage estimated reductions of surface flow under low (MALF) and median flow conditions are also presented in Table 2 below.

Table 2. Flow statistics for the Mare Burn and Trimbells Gully at surface water ecological monitoring sites along with estimated percentage losses at the MALF and median flow, and the percentage retention of the MALF.

Site	**MALF** (L/sec)	**Reduction in MALF** (%)	**Retention of MALF** (%)	**Median Flow** (L/sec)	**Reduction in Median Flow** (%)
TGEMS	14	7.1	92.9	30	3.3
MB01	26	3.8	96.2	57	1.8
MB02	49	2.0	98.0	127	0.8

These estimated reductions are low. By way of example, two standard setting methods for minimum flow tend to be used in New Zealand. These are a percentage of a flow statistic (historic flow method) and methods that show how habitat changes incrementally with flow.

The minimum flow is a protection mechanism to reduce the effect of abstractions on aquatic biota and other values. In setting a minimum flow below which abstractions cease, or water restrictions are applied, the concept is that it should provide an acceptable level of protection for the stream (Jowett 1997[2]). MALF is often used as the low flow statistic against which protection levels are set. A protection level of 90% of the MALF can be regarded as a level at which there would be no measurable effect. This level of protection is exceeded at the three Mare Burn surface water monitoring sites (Table 2) under the estimated reductions in low flows due to pit dewatering, and adverse effects to aquatic biota are unlikely to result.

5.9 *Please confirm whether nitrate is expected to increase or decrease in the Mare burn, Appendix 11 and Appendix 20 contradict each other on this point. If an increase is expected Dr Ryder may need to re-visit the algal assessment in Section 4.3 of Appendix 20.*

[2] Jowett, I.G. 1997. *Instream flow methods: a comparison of approaches*. Regulated Rivers 13: 115-127.

With respect to <u>future</u> surface water concentrations of ammoniacal-N and nitrate-nitrite-N, I rely on the modelling results of GHD (2024). In that respect, GHD tables 5.8 and 5.9 show that there is a predicted increase in nitrate in the mining and post-mining scenarios. So, the comment I made in section 4.2 (page 18) of my Appendix 20 report is incorrect. However, the comment that both current and predicted long-term concentrations sit within NOF bands A or B of their respective NPS-FW attribute states and within current compliance limits, remains correct, although they represent toxicity risk and not risk of nuisance algae growths.

Despite the potential for an increase in nitrate concentrations at Mare Burn surface water monitoring sites, there should be no material change in the frequency of nuisance algae and plant growths. I base this assessment on the notion that algae and aquatic plants require both bioavailable forms of nitrogen (i.e., ammonia and nitrate) and phosphorus (dissolved reactive phosphorus - DRP) to grow to nuisance levels, providing other conditions are favourable (e.g., temperatures, stable low flows and low turbidity water). Ammonia concentrations in the Mare Burn catchment downstream of the mine are currently low and are expected to remain low during and after proposed mining expansions (GHD, 2024). Nitrate concentrations in the Mare Burn catchment downstream of the mine are currently sufficient to promote nuisance growths (subject to sufficient bioavailable phosphorus also being available). Elevated nitrate concentrations are probably due to a combination of leaching from the mine waste rock stack and farming in the upper Mare Burn catchment.

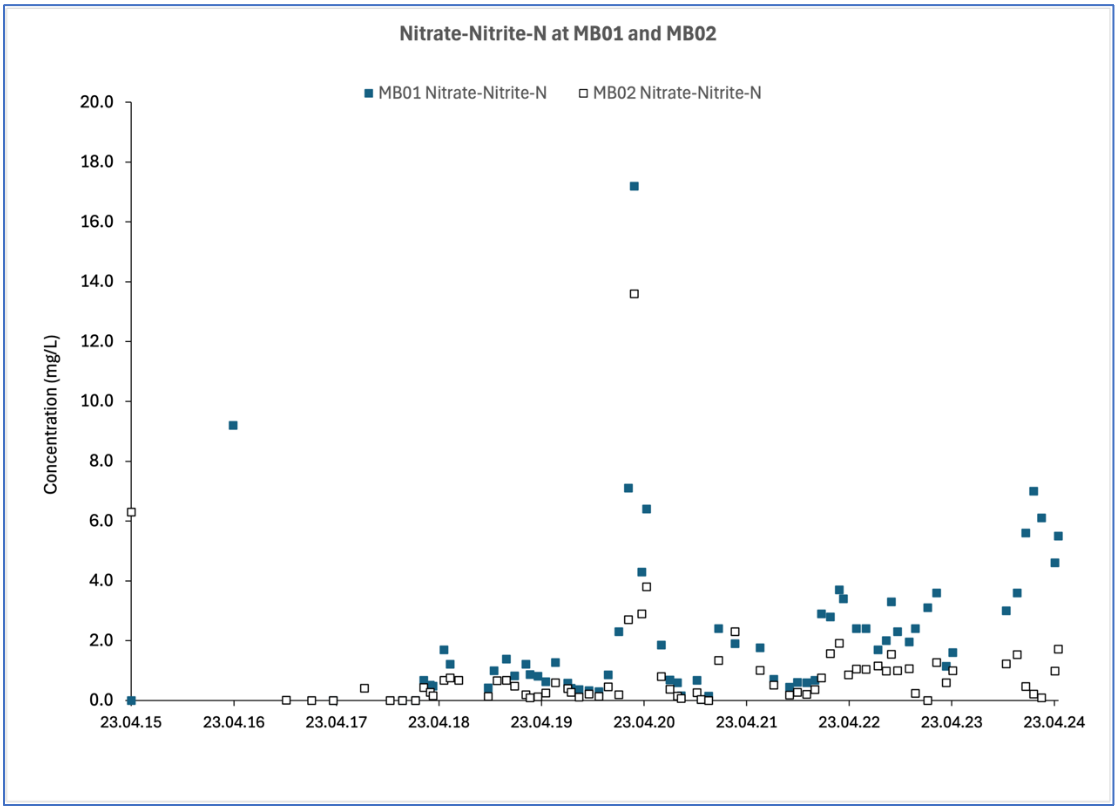

Figure 1. Nitrate-nitrite-N concentrations at MB01 and MB02 over time.

The N:P ratio, known as the Redfield ratio, is often used as a guide for determining which nutrient is potentially limiting algae growth in lakes and rivers. Typically, ratios of the bioavailable forms of these nutrients (dissolved inorganic nitrogen – DIN and DRP are assessed in rivers and streams. DIN:DRP ratios of >15:1 indicate P-limitation, ratios of <7:1 indicate N-limitation, and co-limitation may exist between 7:1 and 15:1 (McDowell, 2009[3]). These ratios have also been used by MfE (2007[4]).

N:P ratios at MB01 and MB02 are several orders of magnitude greater than 15:1, indicating strong P-limitation. Currently, based on monitoring since early 2002, DRP concentrations are very low in the upper Mare Burn catchment monitoring sites. They are typically less than the laboratory detection limits, which have ranged between 0.004 and 0.001 mg/L. Such levels are unlikely to be sufficient to produce nuisance algae and plant growth, because, as noted above, both nitrogen and phosphorus are required in sufficient concentration to create opportunities for nuisance growth. Phosphorus is the limiting nutrient in restricting nuisance algae and plant growths in surface waters of the upper Mare Burn catchment, and there is no evidence that concentrations have increased since mining commenced in the Mare Burn catchment.

The current concentrations at the two Mare Burn monitoring sites, while requiring more data over time to be properly assessed, appear to sit within the NPS-FW NOF band A attribute state[5]. There is no evidence to suggest that DRP levels in the upper Mare Burn catchment will increase over time as a result of mining expansions. The substitution of mining activities for pastoral grazing in the upper catchment is probably a positive change with respect to controlling phosphorus levels in surface waters.

The most recent monitoring data for periphyton and macrophyte cover at Mare Burn catchment monitoring sites (2023, summer only due to access restrictions during other seasons) indicated that filamentous algae cover was below the 30% NZ periphyton guideline and mat algae cover was below the cover guideline of 60% (Biggs 2000[6]) (Figure 2). While these guidelines may not be optimal for stream environments like those in the upper Mare Burn catchment, they provide some level of guidance.

---

[3] McDowell, R.W. *et al*. 2009. Nitrogen and phosphorus in New Zealand streams and rivers: control and impact of eutrophication and the influence of land management. NZ Journal of marine and freshwater Research, 2009, Vo.43 985-995

[4] MfE (Ministry for the Environment). 2007. Lake Water Quality in New Zealand: Status in 2006 and Recent Trends 1990–2006. Ministry for the Environment, Wellington, New Zealand.

[5] Ecological communities and ecosystem processes are similar to those of natural reference conditions. No adverse effects attributable to DRP enrichment are expected.

[6] Biggs, B.F. 2000. New Zealand Periphyton Guideline: Detecting, monitoring and managing enrichment of streams. Prepared for MfE. NIWA.

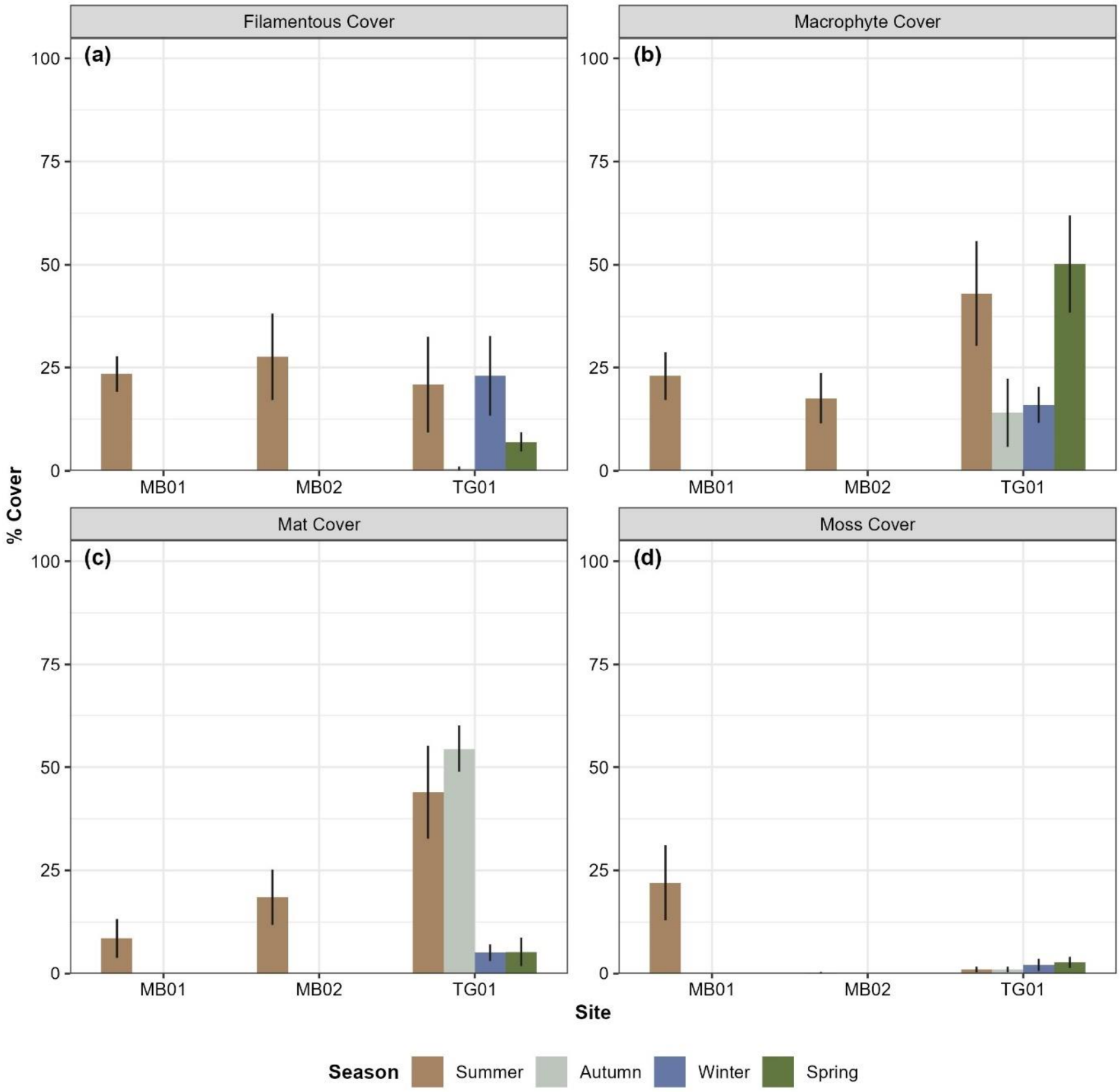

Figure 2. Mean (± standard error) percent cover of macrophytes and periphyton at Mare Burn catchment sites, 2023 (no access to MB01 or MB02 in autumn, winter or spring).

Activities associated with Golden Bar open pit

5.10 Please explain the order of magnitude difference in current copper concentrations at GB01 presented in Appendix 12 (Table 10) and Appendix 21 (Table 4). The results in Appendix 12 are not consistent with Dr Ryder's assessment that "dissolved metal concentrations are low and below water quality guidelines".

The Appendix 21, Table 4 data in my report is based on monitoring data collected between 2014 and 2022. The GHD data in Appendix 12, Table 10 is based on modelling outputs between 2022 and 2025. There is also probably also some rounding of the data in the GHD report. GHD have since amended their modelled copper concentrations for GB01 (and MC02 and NB03) after discovering a model error. This is described in GHD's response to information request 5.3. GHD note that the amended results now better represent the concentration range seen in the current monitoring data at these locations. For example, the current (2022-2025) modelled copper median and 95th percentile concentrations for GB01 are 0.0016 and 0.0023 mg/L respectively. These concentrations compare favourably with a monitored median concentration of 0.0006 mg/L and a 95th percentile concentration of 0.0024 mg/L (2014-2022). These current copper concentration statistics would place GB01 in Band A of the proposed revised guidelines using bioavailable copper (Gadd *et al*., 2023).

5.12 For what reason has the 70 metres of gully within the footprint of the extended Golden Bar pit been classified as a river?

Ecologists from Whirika have determined that the upper section of the watercourse is not a 'river', as defined in the Otago Regional Plan: Water. It does not have ephemeral or intermittent stream habitat. The downstream point at which the watercourse can be considered a 'river' is shown in Figure 3.

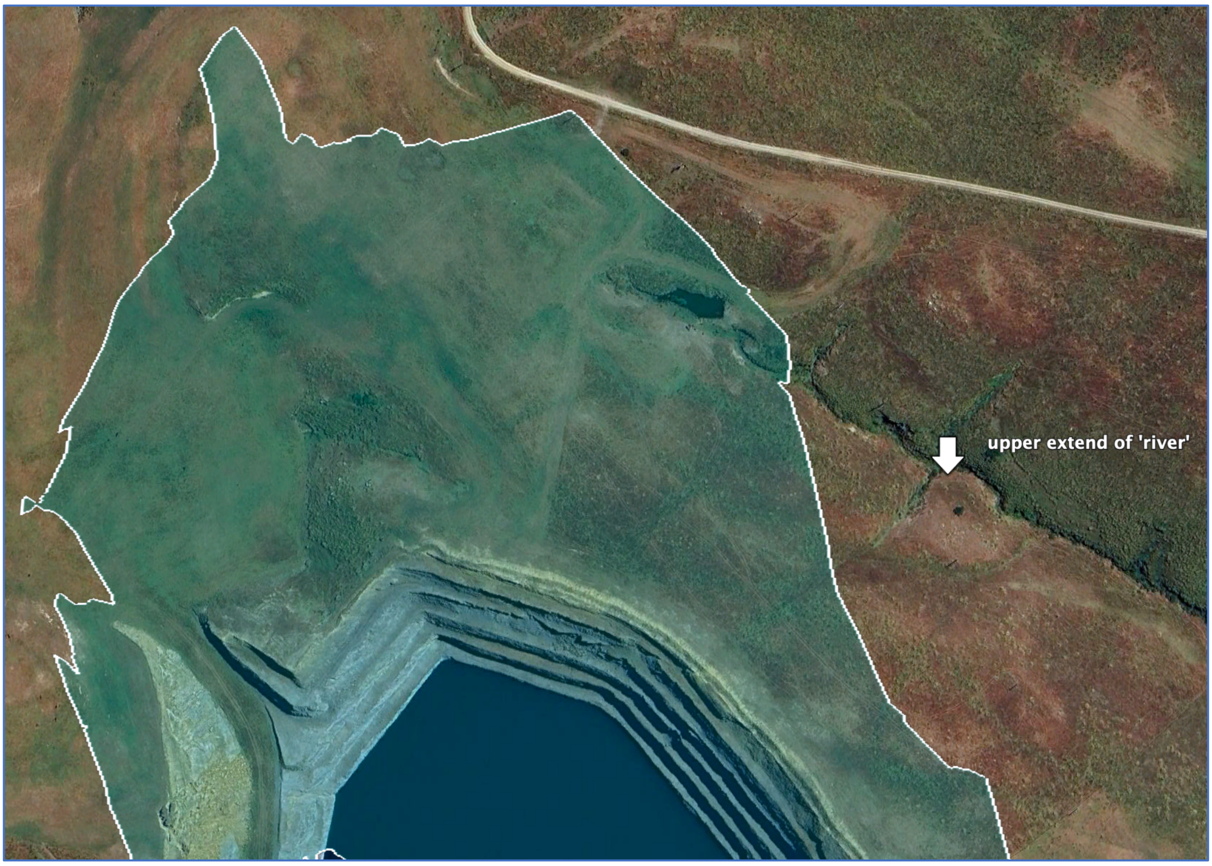

Figure 3. Gold Bar pit with proposed boundary of extended pit superimposed. The watercourse at issue is on the right and the upper extend of its 'river' classification is shown by the white arrow.

Activities associated with Northern Gully silt pond

5.13 Please provide a (short) assessment of the potential for sediment discharges from the Northern Gully silt pond to generate adverse effects such as conspicuous *changes in visual clarity or significant adverse effects on aquatic life.*

The review of operations at the Macraes Gold Mine by Engineering Geology Ltd concluded that "*the existing erosion and sediment control practices have worked well and the similar practices proposed for the MP4 Project are expected to be robust and effective*"[7]. New disturbance of Northern Gully WRS will result in the discharge of some sediment to the Northern Gully silt pond. The silt pond itself is a primary erosion and sediment control feature and will act to minimise the release of sediment to Northern Gully. Consequently, there is no reason to suggest that future sediment discharges from the Northern Gully silt pond into the Northern Gully tributary of Deepdell Creek, and from there into Deepdell Creek itself, are likely to increase or exacerbate.

Notwithstanding the above assessment, it is useful to present the results of recent sediment cover monitoring in the bottom end of Northern Gully and in Deepdell Creek downstream of the Northern Gully confluence. Seasonal monitoring of fine sediment cover commenced at Deepdell Creek sites DC01, DC03, and DC08 during Spring monitoring in 2020 and includes visually estimating the percentage of fine sediment (<2 mm in particle size) cover on the streambed of a riffle, run, and pool at each site.

Not surprisingly, sediment cover was higher in pools than in riffle and run habitats at all three sites (Table 3). Riffle and run habitats had little to no fine sediment cover at all sites on most sampling occasions. If these results are considered against the NPS-FM 2020 deposited fine sediment attribute states[8], DC08 (located downstream of the Northern Gully confluence) would be in the highest band A[9], and the other sites would probably be in band A or B. On the other hand, DC01, which is upstream of potential mining sediment sources, has higher sediment cover in pools relative to DC03 and DC08, which are much further downstream.

The Northern Gully tributary is small and relatively steep, falling about 85 m over its length of about 585 m between the Northern Gully silt pond and the confluence with Deepdell Creek (Figure 1). It is difficult to access and while conspicuous changes in the visual clarity of its flow as a result of discharges from the silt pond. Discharges from the NGSP are not anticipated provided the silt pond continues to be maintained in accordance with the Erosion and Sediment Control Plan. GHD's response to this RFI provides further mitigation measures should they be considered necessary.

---

[7] Engineering Geology Limited. 2024. *Macraes Phase 4 Project - Erosion and Sediment Control Report*. Appendix 10, MP4 AEE. Prepared for Oceana Gold (New Zealand) Limited.

[8] Appendix 2B, Table 16 – Deposited Fine Sediment. *2020 National Policy Statement for Freshwater Management.* Note these attribute states assess percentage fine sediment cover of the streambed in run habitats.

[9] The band A narrative states: "*Minimal impact of deposited fine sediment on instream biota. Ecological communities are similar to those observed in natural reference conditions.*"

Table 3. Percentage fine sediment (<2mm particle size) cover at Deepdell Creek sites.

Year	Season	DC01			DC03			DC08		
		Riffle	Run	Pool	Riffle	Run	Pool	Riffle	Run	Pool
2020	Spring	0	5	90	5	7	50	0	0	1
2021	Summer	0	5	90	5	10	50	0	0	0
	Autumn	0	0	30	0	0	50	0	0	0
	Winter	0	0	20	0	2	30	0	0	0
	Spring	0	0	80	0	0	50	0	2	5
2022	Summer	0	0	70	0	5	20	0	0	0
	Autumn	0	2	75	0	0	10	0	0	0
	Winter	-	-	-	0	0	20	0	2	20
	Spring	0	5	70	0	10	10	0	5	15
2023	Summer	0	0	15	0	0	10	0	0	2
	Autumn	0	0	10	0	0	50	0	0	2
	Winter	0	15	20	0	0	40	0	0	2
	Spring	0	2	40	0	0	60	0	2	15

The macroinvertebrate community of the creek as determined by sampling at NG01 (Figure 4) is dominated by *Paracalliope* and *Paraleptamphopus* amphipods (i.e., small crustaceans), and this is consistent with the community composition at least since 2015 (Ryder Consulting 2016[10]). Both of these amphipods are commonly found in soft bottom stream environments around New Zealand and are relatively tolerant of fine sediments. Previous studies have found them to be sensitive to a wide range of contaminants (e.g., Burnett 1972, Hickey and Vickers 1994, Hall and Golding 1998[11]) and their relative sensitivity suggests that *Paracalliope* may be one of the most vulnerable species to contaminants. Their abundance at NG01 over time suggests that contamination in the Northern Gully tributary is not an issue.

At times, some galaxiids and crayfish have previously been observed at NG01, in a small pool immediately downstream of a waterfall at times. However, the low water levels, and often extensive beds of watercress, do not provide a stable environment to sustain a large fish community.

[10] Ryder Consulting. 2016. *Macraes Flat Gold Mine: Annual surface water biological monitoring 2015*. Prepared for Oceana Gold (NZ) Limited by Ryder Consulting Limited.
[11] Burnet, A. M. R. 1972. *Effects of paraquat on invertebrates in a Canterbury stream, New Zealand*. New Zealand Journal of Marine and Freshwater Research 6(4): 448-455.
Hickey, C. W. and Vickers, M. L. 1994. *Toxicity of ammonia to nine New Zealand freshwater invertebrate species*. Archives of Environmental Toxicology 26: 292-298.
Hall, J.A. and Golding, L.A. 1998. *Standard methods for whole effluent toxicity testing: development and application*. Report no. MFE80205. NIWA report for the Ministry for the Environment.

Figure 4. Google Earth image showing the Northern Guy tributary with the Northern Gully silt pond at the top of the image and Deepdell Creek at the bottom. Inset photo is a photo of the NG01 monitoring site taken in the summer 2023 survey.