# Dargues Gold Mine Aquatic Ecology Monitoring
# Spring 2024

Final report to the Aurelia Metals Ltd
Centre for Applied Water Science
University of Canberra

## Acknowledgements

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## Executive Summary

This report summarises the spring 2024 aquatic ecology surveys at Dargues Gold Mine (DGM) as required by their Biodiversity Management Plan (BMP). Habitat, water quality, and macroinvertebrate and fish communities were sampled at eight sites surrounding DGM in October 2024. Four groundwater monitoring bores were also sampled for stygofauna. Rainfall and subsequent discharge was relatively low in the three months leading up to sampling in October 2024.

Riparian condition at each of the sites was classed as either 'Excellent', 'Very good' or 'Good'. Generally, site condition improved in a downstream direction. Sites upstream of DGM had the poorest riparian condition, being located in agricultural land, with little to no riparian zone. The condition rating for sites AE1 and AE2 went from 'Very good' to 'Excellent' to and this was due to a decrease in the amount of sand present and an increase in detritus. For the fourth assessment in a row, backpack electrofishing was unable to be conducted and no macroinvertebrate sample was able to be taken at site AE6 because of low flow and overgrowth of submerged and emergent macrophytes.

Water quality varied between sites and was generally acceptable for all variables except electrical conductivity, which was high at five out of eight sites. Dissolved oxygen (% saturation) and pH were also outside of the Australian and New Zealand Environmental Conservation Council (ANZECC) guidelines at a single site, respectively.

Fish relative abundance decreased slightly between previous and current surveys, with species diversity remaining the same. Mountain galaxias (*Galaxias olidus*) were the most abundant species in spring 2024 (comprising 45 % of fish captured) and found at five of seven sites sampled. Short-finned eels were the most widespread (found at six of seven sites surveyed) in spring 2024. The was minimal difference, 21 less fish, between the previous and current assessment. Young-of-year Mountain galaxias were observed in the tens to thousands at four sites in spring 2024, indicating favourable conditions for spawning to occur this season.

Macroinvertebrate communities had a relatively high taxa richness across the suite of sites, with 52 taxa collected in spring 2024, one less than autumn 2024. Taxonomic richness ranged from 13 to 25 taxa per site, and SIGNAL Scores were between 4.04 and 6.00, indicating mild to moderate disturbance. There was no difference between macroinvertebrate communities from upstream and downstream of the DGM, based on samples taken from edge habitats. One site improved in SIGNAL2 condition from Quadrant 4 (urban, industrial, or agricultural pollution, or downstream effects of dams) to Quadrant 2 (community impairment, often caused by high salinity or nutrient levels), while the other sites remained the same when compared to autumn 2024. Overall, macroinvertebrate community health remained similar between autumn 2024 and spring 2024.

Stygofauna have been detected again in spring 2024, there were more individuals, but one less species captured when compared to autumn 2024. This is still a positive result as they are an important indicator of ecosystem health.

Ecological conditions in spring 2024 have been very similar to the autumn 2024 survey in relation to the fish and macroinvertebrate communities. Macroinvertebrate community health and fish numbers and diversity in spring 2024 were similar to autumn 2024.

Overall, the operation of DGM does not appear to be having a significant impact on the aquatic ecology of Majors Creek and Spring Creek. The mild to moderate ecological impairment at sites is likely due to longer-term land use impacts (e.g. land-clearing and historical mining). At this stage, no management intervention relating to DGM operations is required.

## Introduction

Dargues Gold Mine (DGM) is located 7 km north of Majors Creek and 16 km south of Braidwood, New South Wales, and is operated by Aurelia Metals Ltd. DGM was granted project approval in February 2012, and a Biodiversity Management Plan (BMP) was prepared in May 2012 (R. W. Corkery & Co. Pty. Limited. 2012). The monitoring of vegetation (flora), fauna, aquatic ecology, and stygofauna at DGM is a requirement of the BMP as a condition of the project's approval. Surveys occur in autumn and spring every year and have the following objectives:

• Monitor abiotic (physico-chemistry of water, habitat features) and biological (macroinvertebrate and fish communities) indicators of aquatic ecosystem health in Majors Creek and Spring Creek.

• Assess if there are changes between sites upstream and downstream of the mine or over time.

• Recommend mitigation and management options to reduce the impact on aquatic ecosystems.

This is the fifth report since CAWS has taken over the monitoring program. This report outlines the summary findings of the aquatic ecology and stygofauna monitoring for the spring 2024 survey.

## Methods

Spring samples were collected on the 16th – 17th October 2024. Temperatures ranged from 2.7 – 22°C. All sites were flowing during the survey period, though site AE6 was again very low, and overgrown with macrophytes and terrestrial plants.

### Sampling sites

Spring Creek runs adjacent to Dargues Gold mine and enters Majors creek ~1 km downstream of the mine. During the survey, eight sites were sampled which include three reference sites, AE7 and AE8 on Majors Creek upstream of the Spring Creek confluence and AE6 on Spring Creek, all of which are upstream of the mine. Three sites sampled downstream of the mine that may be impacted are AE5 on Spring Creek and AE3 and AE4 on Majors Creek. Sites AE1 and AE2 are approximately 6 km downstream from Dargues gold mine and are used to indicate how the aquatic ecology recovers from any potential disturbances at the sites closer to the mine as they are below the Araluen escarpment in a well vegetated conservation area (Figure 1).

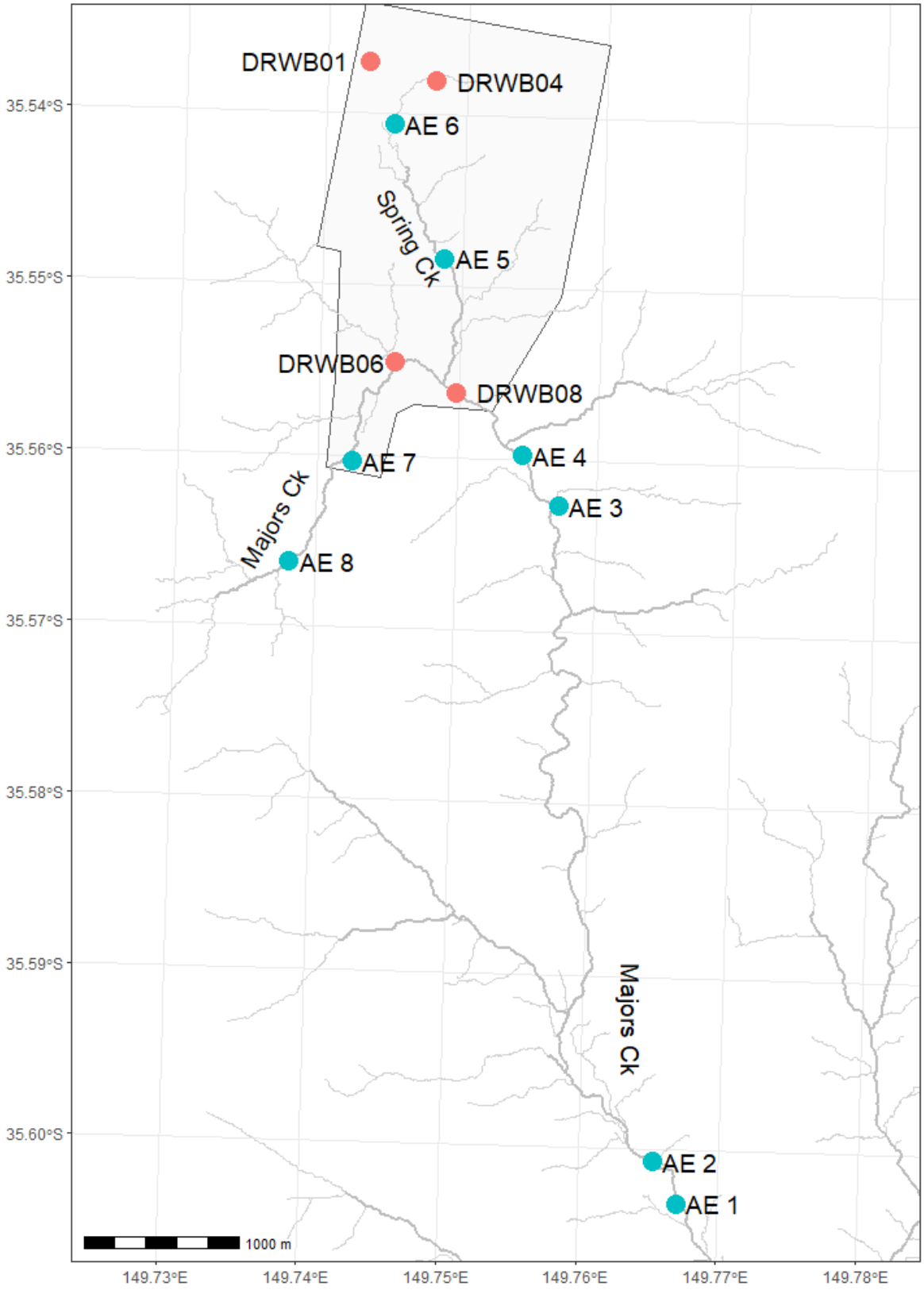


Figure 1. Map of sampling sites for the Dargues gold mine aquatic ecology monitoring program

### Habitat assessment

The riparian condition assessment was undertaken using a version of the Riparian, Channel and Environmental (RCE) inventory (Petersen Jr 1992) modified for Australian conditions (Chessman *et al.* 1997). The modified RCE has 13 descriptors, each with a score from 1 to 4. The total score for each site was calculated by summing the score for each descriptor and converting the result to a percentage of the highest possible score.

Sites with a high RCE score (up to 52, or 100%) indicate that the riparian zone is unmodified by human activity, while those with a low score have been substantially modified. Based on the original classification established by Peterson (1992), site condition was rated as:

- Poor for RCE scores of 0-24%
- Fair for RCE scores of 25-43%
- Good for RCE scores of 44-62%
- Very good for RCE scores of 63-81%
- Excellent for RCE scores of 82-100%.

### Physical and chemical water quality assessment

Water temperature, pH, electrical conductivity, turbidity, salinity and total dissolved solids (TDS) were measured at all sites using a calibrated Horiba U-52 water quality meter and dissolved oxygen was measured using a Hach portable DO meter. Total alkalinity was calculated by field titration to an end point of pH 4.5 (Eaton *et al.* 2005).

Water quality guideline values were based on the most conservative values from the ANZECC and ARMCANZ (2000) water quality guidelines for aquatic ecosystem protection in south-east Australian upland rivers.

### Macroinvertebrate sampling and analysis

An edge and riffle sample was taken at each site where possible. A 250-µm sweep net was used to collect macroinvertebrates following methods from the NSW AUSRIVAS protocol (Turak *et al.* 2004) for both edge and riffle habitats. Net contents were emptied into a white sorting tray and scanned for 40 minutes with the aim of collecting each invertebrate taxa and preserving them in 70% ethanol. If additional taxa were still being collected after 40 minutes, the sample was scanned for another 20 minutes. Edge and riffle samples were sorted and preserved separately. In the laboratory, invertebrates were identified to family using a Leica M80 dissecting microscope.

Each family was assigned a Stream Invertebrate Grade Number-Average Level (SIGNAL) score based on Chessman (2003). The SIGNAL score indicates how sensitive an invertebrate family is to disturbance and is used as an indication of habitat health. Families that are sensitive to pollution have scores between six and ten and are likely to only occur in healthy habitats, while those with scores below six can tolerate pollution and will occur in impacted stream habitats (Gooderham and Tsyrlin 2002). A signal score was derived for each survey site (following Chessman) (Chessman 2001).

Macroinvertebrate community data was analysed using the Primer v7 software package (PRIMER-E Ltd 2006). Prior to analysis, data was grouped in factors based on habitat (riffle/edge), and location relative to mine (upstream/downstream). As riffle habitat was not available at every site, only edge data was used. Data was transformed for presence/absence and a Bray-Curtis similarity matrix developed. Nonmetric multidimensional scaling (nMDS) plots were generated to visually display data. Sites with similar communities overlap or appear close together in nMDS plots while those

with communities that have different community compositions are further apart (Clarke and Gorley 2006).

Analysis of Macroinvertebrate communities was assessed for edge samples only between treatment (upstream or downstream of the mine) using analysis of similarity (ANOSIM) with location as a fixed factor. Data was fourth-root transformed (to account for highly abundant taxa) and then a resemblance matrix was constructed using the Bray-Curtis similarity measure. The ANOSIM was run with a maximum of 9999 permutations.

### Fish sampling

Fish were collected using bait traps and backpack electrofishing. At each site 10 unbaited traps were set in sections where electrofishing could not be conducted i.e. deep pools. They were set at the arrival to a site and pulled at the conclusion of the electrofishing (1 – 2hrs).

At each site backpack electrofishing was conducted for 404 – 600 seconds of on time (Table 1) using a Smith-Root LR-24 backpack unit. Shock times varied depending on habitat, water depth and wading difficulty. Shocking times of 600 seconds (10 minutes) were achieved at all sites except AE6 and AE8 (Table 1). Site AE 6 was not able to be sampled due to lack of fishable habitat. All fish captured were measured to total length (TL) or fork length (FL), depending on species, and then released at the site.

Table 1. Backpack electrofisher settings for spring 2024.

| Site | Frequency (Hz) | Volts | Time on (sec) | Time on (min:sec) |
|---|---|---|---|---|
| AE1 | 90 | 400 | 600 | 10:00 |
| AE2 | 90 | 400 | 600 | 10:00 |
| AE3 | 90 | 400 | 600 | 10:00 |
| AE4 | 90 | 400 | 600 | 10:00 |
| AE5 | 90 | 400 | 600 | 10:00 |
| AE6 | - | - | - | - |
| AE7 | 90 | 400 | 600 | 10:00 |
| AE8 | 90 | 400 | 404 | 6:44 |

### Stygofauna sampling

A stygofauna net was lowered to the bottom of each of the four bores and drawn up slowly through the water column. The net was rinsed and the contents emptied into a 63µm sieve. After six hauls of each bore were completed the contents of the sieve were washed into a labelled sample jar and preserved with 70% ethanol.

# Results

## Hydrological context

Rainfall and subsequent discharge was relatively low in the three months leading up to sampling in October 2024 (Figure 2). Prior to this period, there were several large flood events between April – July 2024 (Figure 2).

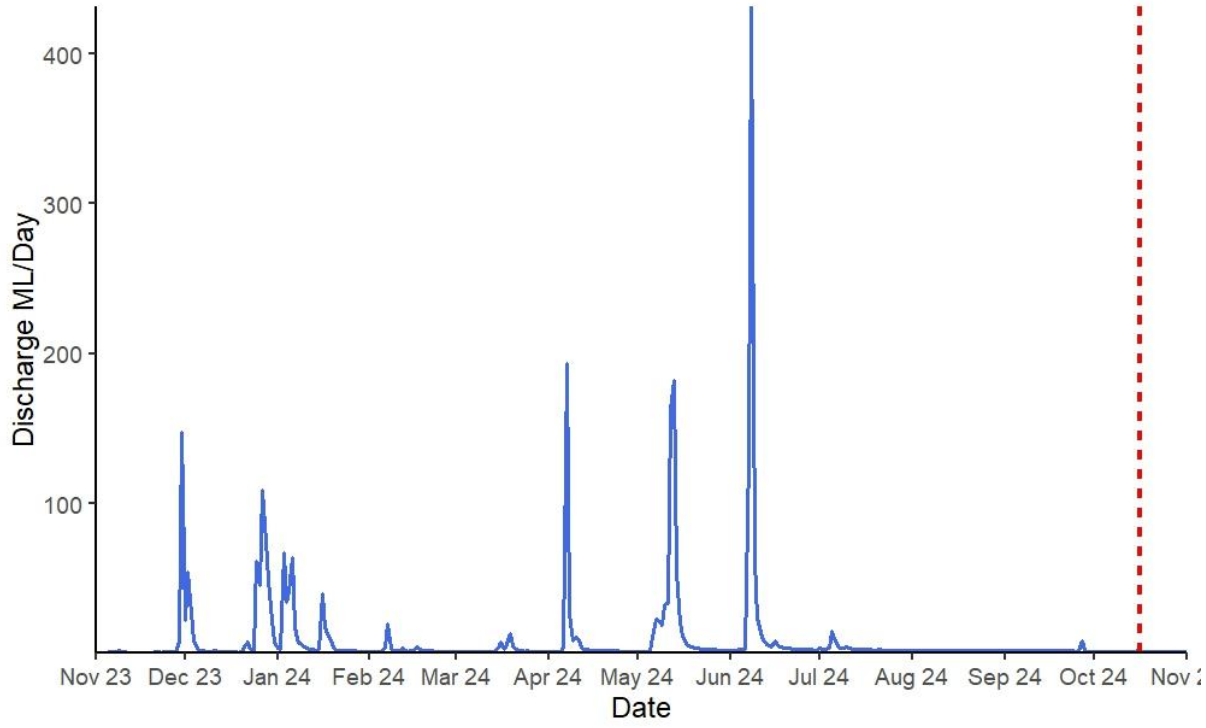


Figure 2. Discharge from Majors Creek (taken from station SW6) from Nov 2023 – Nov 2024. Red dashed lines indicate sampling dates for the spring 2024 assessment.

## Physical and chemical water quality assessment

Water temperatures in the spring 2024 survey ranged between 9.82 – 16.64°C at site AE3 and AE7, respectively (Table 2). pH ranged across sites from 7.52 – 8.07 and was within the ANZECC guideline range for all sites except one, AE2 (Table 2).

Electrical conductivity (EC) measurements on Majors Creek generally increased with distance downstream from the second most upstream site AE7 (Table 2). Five of the eight sites had EC above ANZECC guidelines (Table 2). These five sites were all downstream of site AE7 (Table 2).

Table 2. Physical and chemical water quality at Dargues gold mine monitoring sites for spring 2024.

| Parameter | ANZECC Range | AE1 | AE2 | AE3 | AE4 | AE5 | AE6 | AE7 | AE8 |
|---|---|---|---|---|---|---|---|---|---|
| Temperature (°C) | | 14.09 | 15.01 | 9.82 | 17.2 | 10.71 | 12.39 | 16.64 | 15.27 |
| pH | 6.5 – 8.0 | 7.87 | **8.07** | 7.52 | 7.61 | 7.58 | 7.76 | 7.93 | 7.61 |
| EC (µS/cm) | 30 - 350 | **418** | **436** | **362** | 313 | **646** | **415** | 223 | 228 |
| Turbidity (NTU) | 2 - 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2.8 |
| Dissolved oxygen (mg/L) | | 9.14 | 9.77 | 10.28 | 10.72 | 9.89 | 9.34 | 12.03 | 7 |
| DO (% saturation) | 90 - 110 | 91.9 | 100.2 | 96 | **121.7** | 96.9 | 96 | **133.9** | **74.8** |
| Salinity (ppt) | | 0.2 | 0.21 | 0.17 | 0.15 | 0.31 | 0.2 | 0.1 | 0.11 |
| Alkalinity (ppm) | | 80 | 80 | 60 | 60 | 95 | 100 | 65 | 60 |
| TDS (g/L) | | 0.272 | 0.284 | 0.235 | 0.204 | 0.413 | 0.269 | 0.145 | 0.148 |

Red bolded text denotes variables outside of the recommended ANZECC and ARMCANZ (2000) range.

Total dissolved solids (TDS) and salinity measurements were highest at site AE5, with readings of 0.41g/L and 0.31 ppt, respectively. Turbidity measurements were within the ANZECC range for all sites in spring 2024 (Table 2). DO concentrations (% saturation) were above the ANZECC range at sites AE4 and AE7 and below at site AE8 (Table 2). Alkalinity ranged between 60 – 100 ppm across all sites. Highest alkalinity occurred at reference site AE6, which is just upstream of the mine and within the mine site (Table 2).

### River channel environment (RCE)

River channel environment (RCE) scores varied considerably between sites, generally improving in condition in a downstream direction (Table 3). RCE scores ranged from 56% (AE7) at the second most upstream site to 87% (AE1 and AE2) at the most downstream sites (Table 3). The two most downstream sites scored in the 'Excellent' range, three sites scored in the 'Very good' range and three sites in the 'Good' range (Table 3).

Table 3. River channel environment (RCE) scores for sites in spring 2024.

| | AE1 | AE2 | AE3 | AE4 | AE5 | AE6 | AE7 | AE8 |
|---|---|---|---|---|---|---|---|---|
| Land-use pattern beyond the immediate riparian zone | 3 | 3 | 4 | 3 | 2 | 2 | 2 | 3 |
| Width of riparian of woody vegetation | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 2 |
| Completeness of riparian strip of woody vegetation | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 2 |
| Vegetation of riparian zone within 10 m of channel | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 |
| Stream bank structure | 4 | 4 | 3 | 2 | 3 | 3 | 3 | 3 |
| Bank undercutting | 4 | 4 | 2 | 2 | 2 | 3 | 2 | 3 |
| Channel form | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 |
| Riffle/pool sequence | 4 | 4 | 4 | 3 | 4 | 2 | 3 | 2 |
| Retention devices in stream | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 3 |
| Channel sediment accumulations | 3 | 3 | 2 | 2 | 2 | 3 | 2 | 2 |
| Stream bottom | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 1 |
| Stream detritus | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 3 |
| Aquatic vegetation | 4 | 4 | 3 | 3 | 1 | 1 | 1 | 2 |
| **RCE Score** | **45** | **45** | **39** | **35** | **34** | **30** | **29** | **31** |
| **RCE Score %** | **86.5** | **86.5** | **75.0** | **67.3** | **65.4** | **57.7** | **55.8** | **59.6** |
| **Condition rating** | **Excellent** | **Excellent** | **Very Good** | **Very Good** | **Very Good** | **Good** | **Good** | **Good** |

Site AE7, the second most upstream site on Majors Creek, and AE6 on Spring Creek had the lowest scores of 56 and 58%, respectively, placing them in the 'Good' range. Both sites were heavily silted with little instream features. Site AE7 had no riparian woody vegetation and undercut banks with mixed native and exotic vegetation. Site AE6 remained in the 'Good' condition in its RCE score the same as the previous assessment as there had been no improvement at this site (Table 3). This is due to the increased algal and macrophyte growth at the site.

Sites AE1 and AE2 scored 'Excellent' in their condition rating in spring 2024 increasing from 'Very good' in autumn 2024. This was due to the increased stream detritus and less sand present at these sites.

### Macroinvertebrate communities

A total of 1962 invertebrates were collected in spring 2024 survey, comprising 52 taxa . Macroinvertebrate samples were collected from five edge habitats and four riffle habitats (Table 5). Four families occurred at all sites sampled in spring 2024, which included Leptophlebiidae*, Baetidae, Orthocladiinae and Oligochaeta from highest to lowest relative abundance (Table 4). During this period, edge habitats had between 22 and 25 taxa at impacted sites (AE3 – AE5) while reference sites (AE7 – AE8) had 21 and 23 taxa, respectively (Table 5). No edge samples were taken at the recovery sites (AE1 – AE2) in spring 2024, but the riffle habitats had between 21 and 23 taxa present (Table 5). Leptophlebiidae has one of the highest SIGNAL scores (indicating they are sensitive to degradation) of eight and were found at all sites (Table 4). Site AE6 was not sampled in spring 2024 as there was no suitable edge habitat because of low flows in Spring Creek.

*control-left click to be taken to webpage containing information about this taxa.

Table 4. Macroinvertebrate taxa, number of taxa collected and estimated total macroinvertebrate abundance in sub-samples from Majors Creek and Spring Creek in spring 2024.

| CLASS<br>Order<br>Family<br>*Sub-family* | Signal 2 Grade | AE1 Edge | AE1 Riffle | AE2 Edge | AE2 Riffle | AE3 Edge | AE3 Riffle | AE4 Edge | AE4 Riffle | AE5 Edge | AE6 Edge | AE7 Edge | AE8 Edge |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gastropoda** | | Not sampled due to lack of suitable edge habitat | | Not sampled due to lack of suitable edge habitat | | | | | | | Not sampled due to lack of suitable edge habitat | | |
| Lymnaeidae | 1 | | | | | | | | | 1 | | 5 | |
| Planorbidae | 4 | | | | | | | | | | | | 1 |
| Physidae | 1 | | | | | | | | | 1 | | | 3 |
| **Decapod** | | | | | | | | | | | | | |
| Atyidae | 3 | | | | | | 2 | 2 | | 5 | | | |
| **OLIGOCHAETA** | 2 | | 20 | | 16 | 4 | 31 | 8 | 5 | 4 | | 16 | |
| **ACARINA** | 6 | | 4 | | | | 1 | | | 1 | | | 1 |
| **Coleoptera** | | | | | | | | | | | | | |
| Carabidae | 3 | | | | | | | | | | | 1 | |
| Dytiscidae | 2 | | | | 1 | 3 | | 9 | 3 | 26 | | 4 | 18 |
| Elmidae (Adult) | 7 | | 1 | | 2 | | | | | | | | |
| Hydrophilidae | 2 | | | | | 1 | | 2 | | 1 | | 10 | |
| Hydrochidae | 4 | | | | | | | 1 | 5 | 2 | | | |
| Scirtidae | 6 | | | | | | | 2 | | | | | |
| Psephenidae | 6 | | 5 | | 1 | | | | 1 | | | | |
| Gyrinidae | 4 | | | | | | | | | | | 2 | |
| Hygrobiidae | 4 | | | | | | | | | | | | 2 |
| **Diptera** | | | | | | | | | | | | | |
| Tipulidae | 5 | | | | | | | | | 1 | | | 1 |
| Ceratopogonidae | 4 | | 4 | | 5 | | | | 5 | 1 | | 1 | |
| Simuliidae | 5 | | 18 | | 48 | 3 | 6 | | 1 | | | 1 | |
| Stratiomyidae | 2 | | | | | | | | | 1 | | | |
| Dixidae | 7 | | 1 | | 2 | 16 | | 11 | | 6 | | | 1 |
| Ephyridae | 2 | | | | | | 1 | | | | | | |
| Sciomyzidae | 2 | | | | | | | | | | | | 1 |
| Dolichopodidae | 3 | | | | 2 | | | | | | | | |
| *Podonominae* | **6** | | | | | 1 | | | | | | | |
| *Tanypodinae* | **4** | | | | | 2 | 4 | 2 | 1 | 2 | | 2 | 12 |
| *Orthocladiinae* | **4** | | 6 | | 25 | 57 | 18 | 54 | 34 | 21 | | 45 | 13 |
| *Chironominae* | **3** | | 23 | | 23 | 18 | 53 | 10 | 33 | 2 | | 6 | 45 |
| **Ephemeroptera** | | | | | | | | | | | | | |
| Baetidae | 5 | | 32 | | 11 | 4 | 11 | 13 | 8 | | | | 5 |
| Leptophlebiidae | 8 | | 52 | | 31 | 45 | 73 | 23 | 59 | 70 | | 36 | 17 |
| Caenidae | 4 | | | | 1 | 2 | | 28 | 6 | 28 | | 25 | 4 |
| **Hemiptera** | | | | | | | | | | | | | |
| Veliidae | 3 | | | | | 10 | | 4 | | 6 | | 1 | 4 |
| Notonectidae | 3 | | | | | 2 | | 3 | | 7 | | | |
| Micronectidae | 2 | | | | | | | 9 | | | | | 4 |
| Corixidae | 2 | | | | | 1 | | | | 4 | | | 3 |
| **Megaloptera** | | | | | | | | | | | | | |
| Corydalidae | 7 | | 7 | | 5 | 2 | 1 | | 6 | | | | |
| **Odonata** | | | | | | | | | | | | | |
| Platycnemididae | NA | | | | | | | | | | | | 1 |
| Gomphidae | 5 | | 2 | | 1 | | | | 2 | | | 1 | |
| Coenagrionidae | 2 | | | | | | | | | | | | |
| Argiolestidae | 5 | | | | | | | | | 2 | | 1 | |
| Synlestidae | 7 | | | | | 2 | | | | 6 | | 5 | |
| Telephlebiidae | 9 | | 1 | | | 1 | | | | 1 | | 1 | |
| Austropetaliidae | NA | | | | | | | | | | | 2 | |
| **Plecoptera** | | | | | | | | | | | | | |
| Gripopterygidae | 8 | | 30 | | 7 | 1 | 43 | 3 | 28 | | | 9 | 1 |
| **Trichoptera** | | | | | | | | | | | | | |
| Hydrobiosidae | 8 | | 35 | | 29 | 2 | 35 | 3 | 33 | | | | |
| Hydroptilidae | 4 | | 1 | | 1 | | | | | | | | |
| Philopotamidae | 8 | | | | 2 | | | 9 | | | | | |
| Hydropsychidae | 6 | | 5 | | 13 | | | | 4 | | | | |
| Ecnomidae | 4 | | | | 3 | | | 2 | | 5 | | 7 | 1 |
| Conoesucidae | 8 | | 1 | | 1 | | | 1 | 1 | | | | |
| Calocidae | 9 | | | | | 2 | | 2 | | | | 12 | |
| Leptoceridae | 6 | | 1 | | | 1 | | 13 | | 19 | | 7 | 11 |
| Tasimiidae | 8 | | 2 | | 1 | | | | | | | | |
| **No. of individuals** | | | **251** | | **231** | **180** | **279** | **214** | **235** | **223** | | **200** | **149** |
| **No. of taxa** | | | **21** | | **23** | **22** | **13** | **23** | **18** | **25** | | **23** | **21** |
| **% of sub-sample** | | | 100 | | 100 | 100 | 100 | 100 | 100 | 100 | | 100 | 100 |
| **Whole sample estimate** | | | **251** | | **231** | **180** | **279** | **214** | **235** | **223** | | **200** | **149** |

Table 5. Macroinvertebrate community indices for spring 2024.

| Result | AE1 | AE2 | AE3 | | AE4 | | AE5 | AE6* | AE7 | AE8 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Riffle | Riffle | Edge | Riffle | Edge | Riffle | Edge | | Edge | Edge |
| Total taxa | 21 | 23 | 22 | 13 | 23 | 18 | 25 | - | 23 | 21 |
| Average SIGNAL score | 6.00 ± (0.41) | 5.48 ± (0.43) | 5.18 ± (0.52) | 5.00 ± (0.62) | 4.91 ± (0.49) | 5.17 ± (0.47) | 4.04 ± (0.43) | - | 4.64 ± (0.49) | 4.20 ± (0.45) |
| Proportion of sensitive taxa | 76.4 | 61.0 | 41.0 | 60.4 | 56.7 | 65.6 | 80.8 | - | 58.2 | 35.8 |
| Site SIGNAL score | 6.10 | 5.66 | 5.20 | 5.72 | 5.11 | 5.60 | 4.38 | - | 5.04 | 4.07 |

*Site AE6 not sampled as there was no suitable edge or riffle habitat.

The average SIGNAL scores for each site ranged from 4.04 at AE5 to 6.00 at AE1 in spring 2024 (Table 5). AE8 had the lowest site SIGNAL score had lowest proportion of sensitive taxa in spring 2024 (Table 5). For edge communities, site SIGNAL scores at reference sites were 4.07 – 5.20, indicating moderate pollution to mild pollution, respectively. For the impacted sites (AE3 – AE5) the site SIGNAL scores ranged between 4.38 – 5.20 for edge communities, indicating moderate to mild pollution. Riffle habitats had higher site SIGNAL scores than edge habitats with scores ranging from 5.6 – 6.1 (Table 5). All sites where edge samples were collected were assessed as being in condition quadrant 2 (high salinity or nutrient levels) for the spring 2024 assessment (Figure 3). Site AE8 changed in condition quadrant from quadrant 4 (urban, industrial or agricultural pollution) in autumn 2024 to quadrant 2 in the spring 2024 assessment (Figure 3). All other sites remained in quadrant 2 between autumn 2024 and spring 2024 assessments (Figure 3). Site AE3, AE4 and AE7 were very close to being assessed as quadrant 1 (favourable habitat and chemically dilute waters) in spring 2024 (Figure 3). There was no significant difference in the macroinvertebrate communities between sites upstream of the mine and sites downstream of the mine, based on samples collected from edge habitats (Global R = 0.25, $p$ = 0.300) (Figure 4).

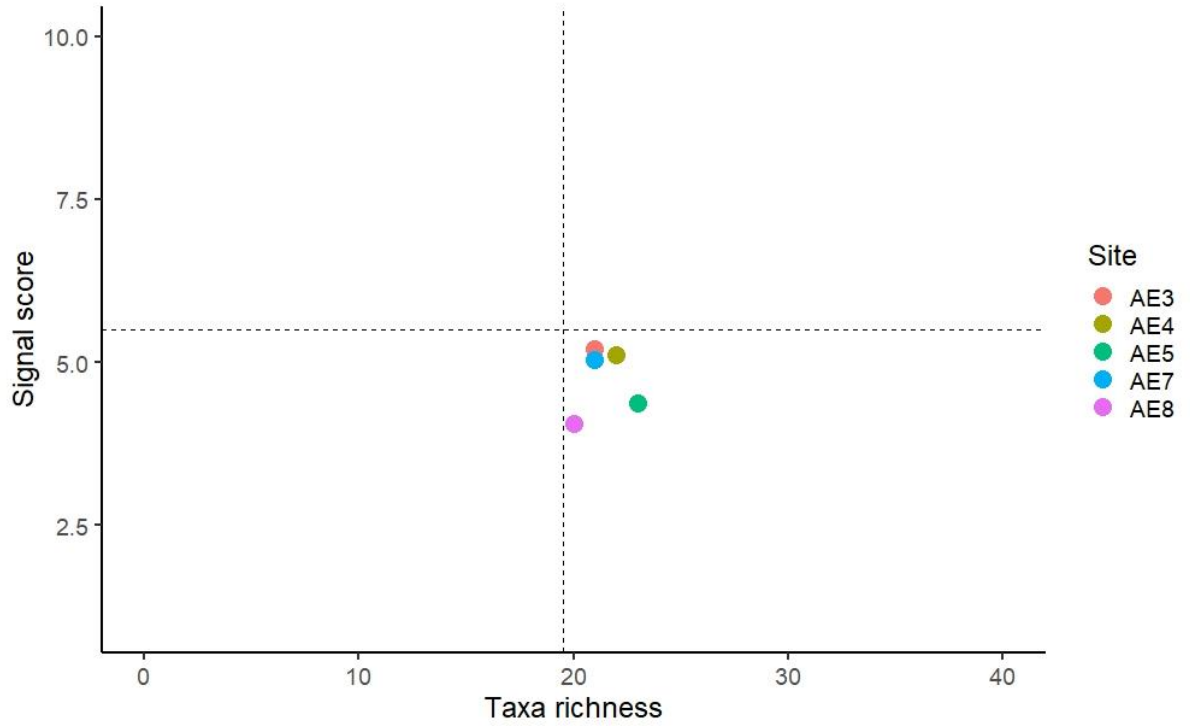


Figure 3. Biplot of macroinvertebrate communities collected from edge samples in spring 2024. Dotted lines indicate the location of quadrants for interpretation of site SIGNAL results (from Chessman 2001).

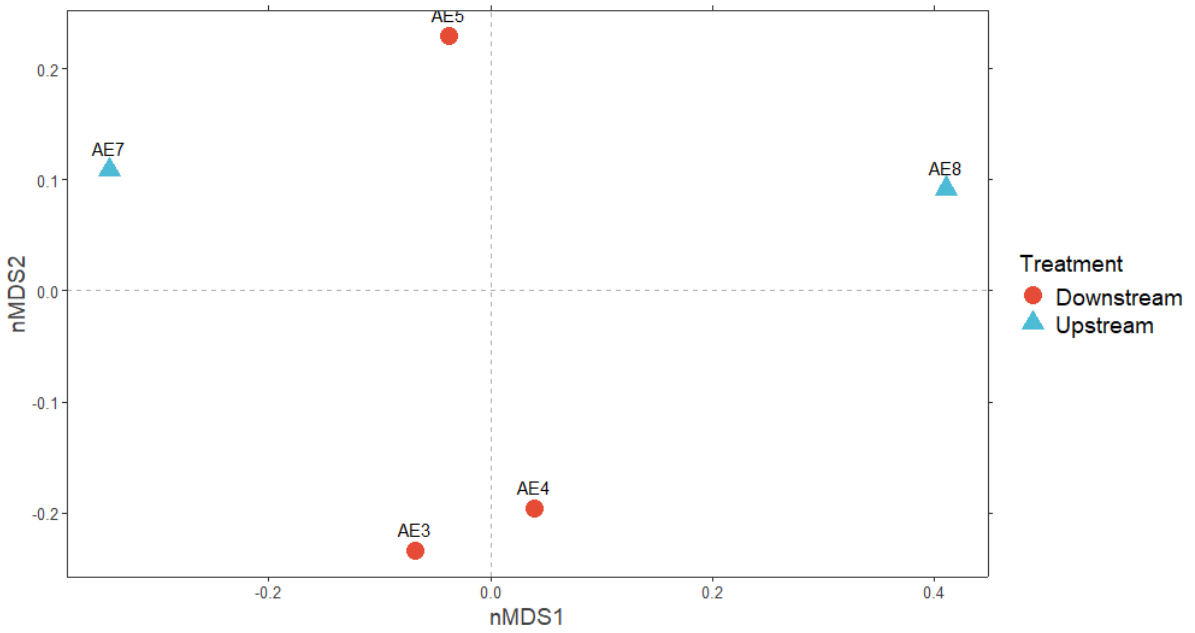


Figure 4. nMDS comparison of macroinvertebrate communities at edge habitats upstream (red) and downstream (blue) of Dargues Gold Mine for spring 2024.

### Stygofauna communities

Four bores were sampled (1, 4, 6 and 8) in spring 2024. One bore (DRW04) had stygofauna with two species present. There was a total of six individuals captured from the one bore (Table 6).

Table 6. Total abundance of each species of stygofauna per site for spring 2024.

| Site | Taxa | Total |
|---|---|---|
| DRWB04 | Parabathynellidae | 3 |
| DRWB04 | Astigmata | 3 |

*Taxa identified to lowest taxonomic level.

### Fish communities

Six species of fish were captured in spring 2024; Mountain galaxias* (*Galaxias olidus*), Cox's gudgeon (*Gobiomorphus coxii*), Short-finned eel (*Anguilla australis*), Australian smelt (*Retropinna semoni* ), Common galaxias (*Galaxias maculatus*) and Long-finned eel (*Anguilla reinhardtii*). All sites sampled had 2 – 3 species present except for AE6, where no sampling occurred in spring 2024 due to low flows and no suitable habitat to sample (Table 7).

*Control-left click to be taken to webpage containing information about this taxa.

Table 7. Total abundance of each species per site for spring 2024.

| Species | AE1 | AE2 | AE3 | AE4 | AE5 | AE6 | AE7 | AE8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Australian smelt | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |
| Common galaxias | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Cox's gudgeon | 31 | 31 | 0 | 0 | 0 | 0 | 0 | 0 | **62** |
| Long-finned eel | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Short-finned eel | 0 | 1 | 1 | 6 | 4 | 0 | 4 | 2 | **18** |
| Mountain galaxias | 0 | 0 | 15 | 16 | 11 | 0 | 17 | 10 | **69** |
| **Total** | **34** | **33** | **16** | **22** | **15** | **0** | **21** | **12** | **153** |

The most widespread species were Short-finned eels captured at six out of eight sites (Table 7). Eighteen Short-finned eels were captured ranging in size from 100 – 800 mm total length (TL) (Table 7 and Figure 5). Mountain galaxias were the most abundant species with 69 individuals (comprising 45 % of total number of fish captured) captured across five sites ranging in size from 45 – 110 mm fork length (FL) (Table 7 and Figure 6). A total of 62 Cox's gudgeon were caught at sites AE1 and AE2 and ranged in size from 42 – 98 mm (TL) and comprised 40% of total number of fish captured (Table 7 and Figure 7). Two Australian smelt total were captured at site AE1 and were 66 and 67 mm (FL). A single Common galaxias was captured at site AE1 and measured 98 mm (FL). A single Long-finned eel was captured at site AE2 and measured 200 mm (TL). Young- of -year Mountain galaxias were observed in the tens to thousands at sites AE4, AE5, AE7 and AE8.

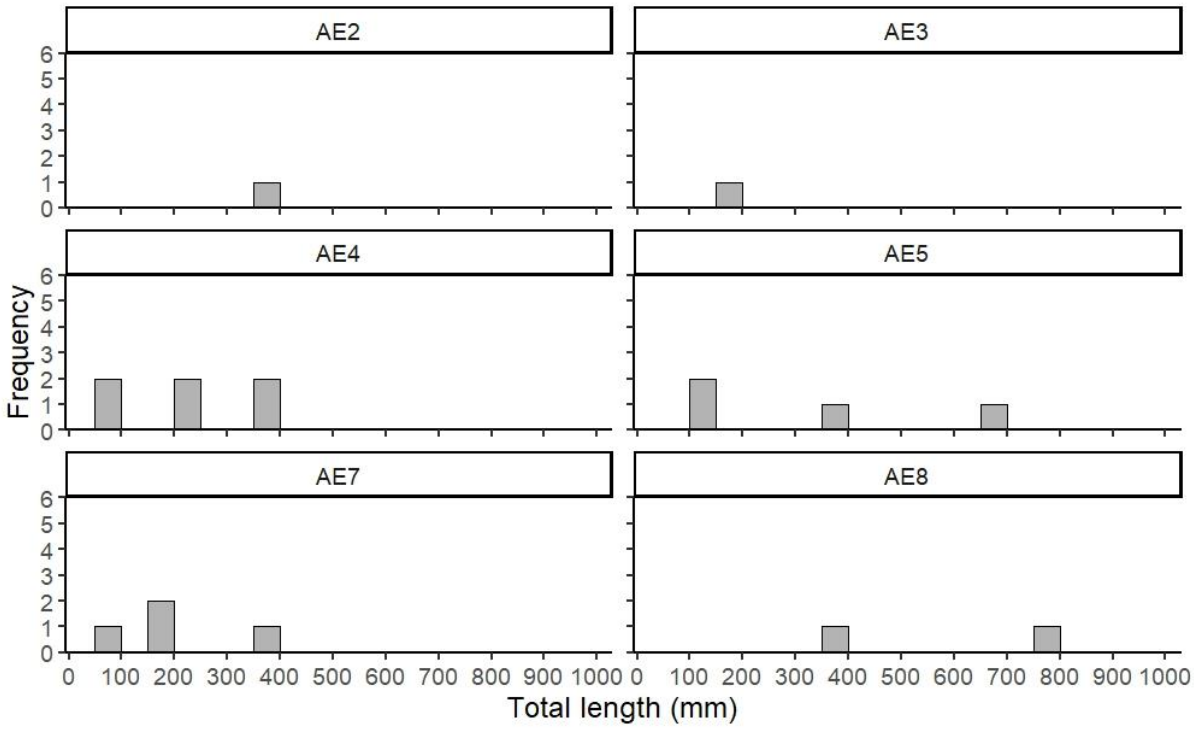


Figure 5. Length frequency of Short-finned eel captured by backpack electrofishing at six sites in spring 2024.

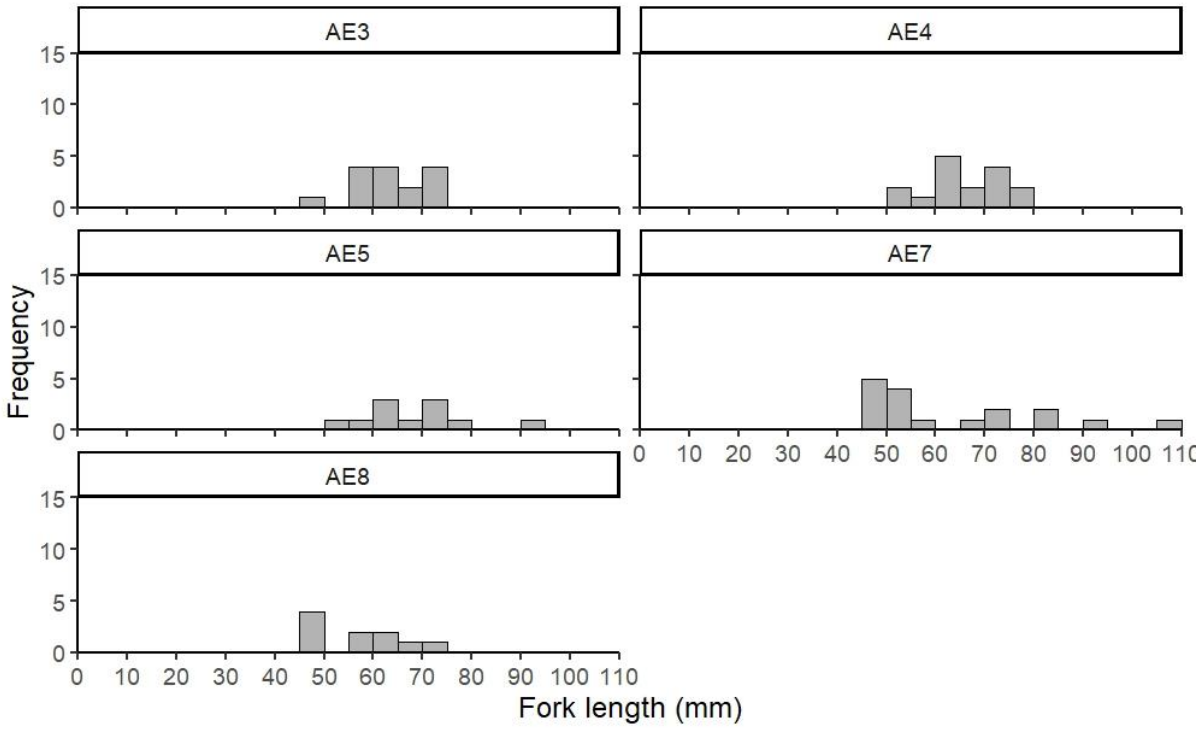


Figure 6. Length frequency of Mountain galaxias captured by backpack electrofishing at five sites in spring 2024.

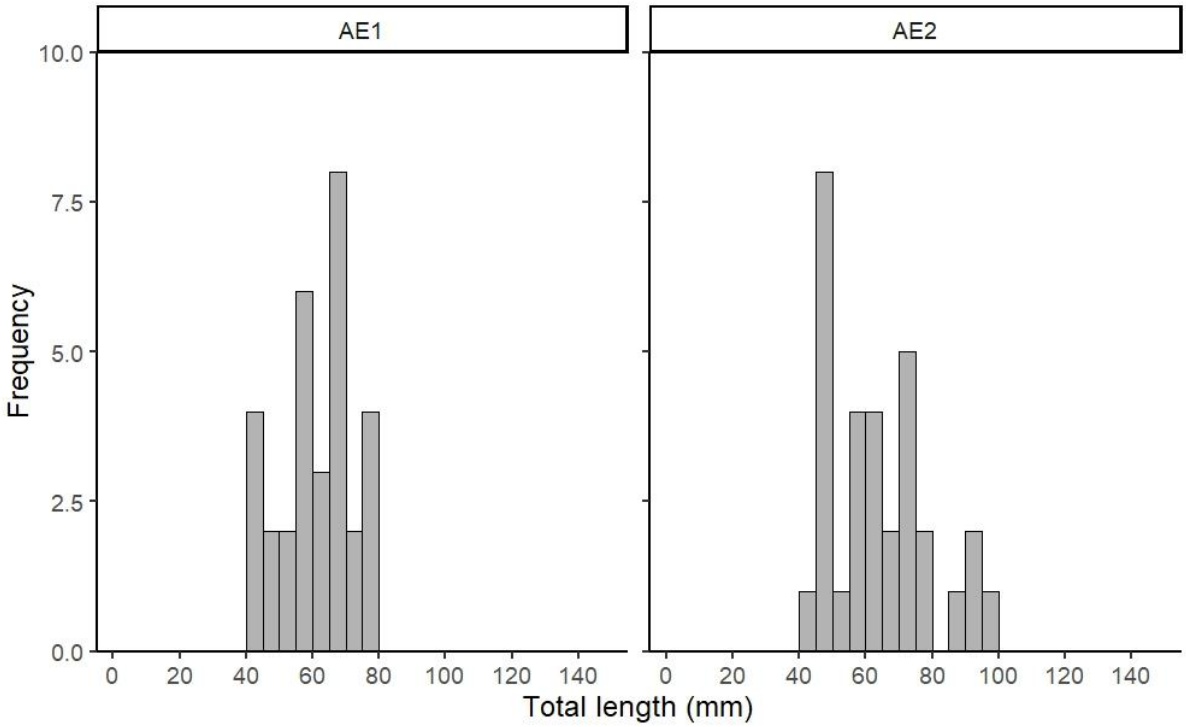


Figure 7. Length frequency of Cox's gudgeon captured by backpack electrofishing at two sites in spring 2024.

The highest catch rate for Short-finned eels occurred at site AE4 with 36 fish per hour (Table 8). Catch rates for Mountain galaxias were the highest at site AE7 with 102 fish caught per hour followed by AE4 with 96 fish caught per hour (Table 8). The most common size range was between 50 – 80 mm (FL) (Figure 6). Sites AE1 and AE2 had the same catch rate for Cox's gudgeon with 186 fish caught per hour (Table 8 and Figure 7). The most common size range was between 50 – 80 mm (TL) (Figure 7).

Table 8. Catch per hour of fish collected in spring 2024.

| Species | AE1 | AE2 | AE3 | AE4 | AE5 | AE6 | AE7 | AE8 |
|---|---|---|---|---|---|---|---|---|
| Australian smelt | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Common galaxias | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cox's gudgeon | 186 | 186 | 0 | 0 | 0 | 0 | 0 | 0 |
| Long-finned eel | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Short-finned eel | 0 | 6 | 6 | 36 | 24 | 0 | 24 | 17.82 |
| Mountain galaxias | 0 | 0 | 90 | 96 | 66 | 0 | 102 | 89.11 |

The recovery sites AE1 and AE2 both had the most fish caught with 34 and 33 each out of 153 fish captured and comprised three species each, respectively, in spring 2024 (Table 7). This catch was Cox's gudgeon, Australian smelt and Common galaxias at AE1 with a total catch per hour of 204 fish for the site and Cox's gudgeon, Short-finned and Long-finned eel caught at AE2 and the total catch per hour for the site was 198 fish (Table 8). The total catch per hour across all sites for spring 2024 was 953 fish.

## Conclusion

In contrast to autumn 2024, there were fewer rainfall events and subsequent low flows in the three months leading to the spring 2024 sampling. Based on the results of this assessment, there were no clear indications that the DGM is having a significant impact on the aquatic ecology of Spring Creek or Majors Creek. Elevated EC downstream of the mine at AE5 and continuing downstream to AE1 does not appear to be having a significant impact on the macroinvertebrate or fish communities in spring 2024.

Macroinvertebrate communities did not significantly differ above and below the DGM. All five edge habitat communities collected were assessed as being in condition quadrant (Quadrant 2) which showed some impairment, and grouped out as sites that are often impaired by salinity or nutrient levels (Chessman 2001). Site AE8 increased in condition from Quadrant 4 (urban, industrial, or agricultural pollution, or downstream effects of dams) in autumn 2024 to Quadrant 2 in spring 2024. Site AE3, AE4 and AE7 were very close to being assessed as quadrant 1 (favourable habitat and chemically dilute waters) in spring 2024. Overall, macroinvertebrate community health was very similar between autumn 2024 and spring 2024. Total number of taxa decreased, taxa richness from edge samples decreased at three of five sites and the percentage of sensitive taxa also decreased at three sites when compared to autumn 2024. These differences were all minimal (Clear *et al.* 2024).

Fish communities in spring 2024 declined in overall abundance, but number of species remained the same compared to the autumn 2024 survey. Fish diversity decreased at sites AE1 and AE2, however the species not detected at AE1 were detected at AE2 and vice versa. There was an increase of 113% of Cox's gudgeon captured and a decrease of 41% of Mountain galaxias captured when compared to autumn 2024 (Clear *et al.* 2024). At four sites (AE4, AE5, AE7 and AE8) young-of-year Mountain galaxias were observed in the tens to thousands, indicating favourable conditions for spawning to occur this season. Overall, there were 21 less fish captured in spring 2024 when compared to autumn 2024 (Clear *et al.* 2024).

In spring 2024, two different stygofauna taxa were detected from one of the four bore sites. There was one less species detected but more individuals when compared to autumn 2024 (Clear *et al.* 2024). One of the species detected was the same and one different to those found in autumn 2024. Stygofauna are an important indicator of ecosystem health (Saccò *et al.* 2022) and also very sensitive to environmental characteristics of the water (Serov *et al.* 2012). Future surveys will help determine if there have been any positive or negative impacts on the stygofauna communities.

River channel environment (RCE) condition ratings changed for the two most downstream sites (AE1 and AE2) when compared to autumn 2024 (Clear *et al.* 2024). The condition rating went from 'Very good' to 'Excellent' for these sites and this was due to a decrease in sand present and an increase in detritus. The condition ratings and RCE scores remained the same for the other six sites when compared to autumn 2024 (Clear *et al.* 2024). There was noticeably more damage to the riverbank at site AE4 as electric fences have been removed and livestock allowed to access the river, this site is on private land. The low flow and overgrowth of submerged and emergent macrophytes at AE6 in spring 2024 meant backpack electrofishing was unable to be conducted, and no macroinvertebrate sample was able to be taken. Site AE5 had the same RCE score as it has for the last three sampling events, for the same reasons, more algal and macrophyte growth plus more sediment on the stream bottom. Like the previous three assessments the low flow resulted in less fishable water at this site. Both these sites are on Spring Creek.

Other than the high EC continuing downstream from AE5 – AE1 there were no other longitudinal trends downstream of DGM, indicating that mining operations are not having a significant impact on aquatic ecology. Instead, the main overriding impact on aquatic ecology present at the sites appears to be current and historic agricultural and historic mining activities and current hydrological regime.

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# Appendix A – Site Photos

## Site AE1

AE1 upstream

AE1 downstream

This site is 5 km downstream of Dargues gold mine near Araluen. It is sparsely vegetated with both native and exotic species.

The channel bed consists of cobbles and boulders embedded in sand and gravel. The water was clear and low at the time of sampling. Riffles were present linking the pools. There was sand present but less than the previous sampling event and there was detritus present in the form of casuarina needles/leaves.

The trees and shrubs in the riparian corridor along the stream were mostly native with casuarina being the dominant species.

## Site AE2

AE2 upstream

AE2 downstream

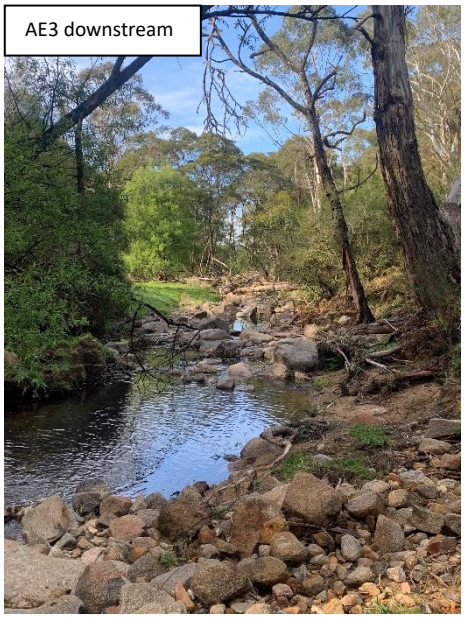
This site is 400m upstream of AE1 and downstream of Dargues gold mine. The surrounding land and vegetation are the same as AE1.

The channel bed consists of cobbles and boulders embedded in sand and gravel. The water was clear and low at the time of sampling. Riffles were present linking the pools. There was sand present but less than the previous sampling event and there was detritus present in the form of casuarina needles/leaves. The banks had undercutting due to the floods from the previous two years which exposed the roots of large trees making them unstable. Dead trees were common with several falling into the river or along the banks.

## Site AE3

AE3 upstream

AE3 downstream



This site is on Majors Creek, 300 m from the top of Majors Creek Falls and 900 m downstream from the mine. The riparian zone consisted of a mix of native and exotic species while the broader area outside of this was mostly undisturbed native vegetation.

The channel frequently alternated between riffles and pools and consisted of bedrock with cobbles and boulders. Bars of sand and silt were common covering the stream bottom in the pools and slower flowing areas. Bank undercutting was frequent along the stream and the banks were mainly held by ferns and grasses.

The water was clear and low flowing at the time of sampling. No macrophytes was present at the time of sampling.

## Site AE4

AE4 upstream

AE4 downstream

This site is 400m downstream of Majors Creek Road. The riparian zone consisted of mixed native and exotic trees and shrubs while the broader area consisted mixed native vegetation, pastures and exotics.

The channel consisted of long pools and runs with infrequent riffles. Many large boulders were present and bars of sand and silt were common covering the stream bottom in the majority of this reach. Bank undercutting was frequent along the stream the banks were held by grasses and sedges. There was increased amount of damage to the banks from livestock at the time of sampling.

The water was clear and low flowing at the time of sampling. No macrophytes were present at the time of sampling.

## Site AE5

AE5 upstream

AE5 downstream

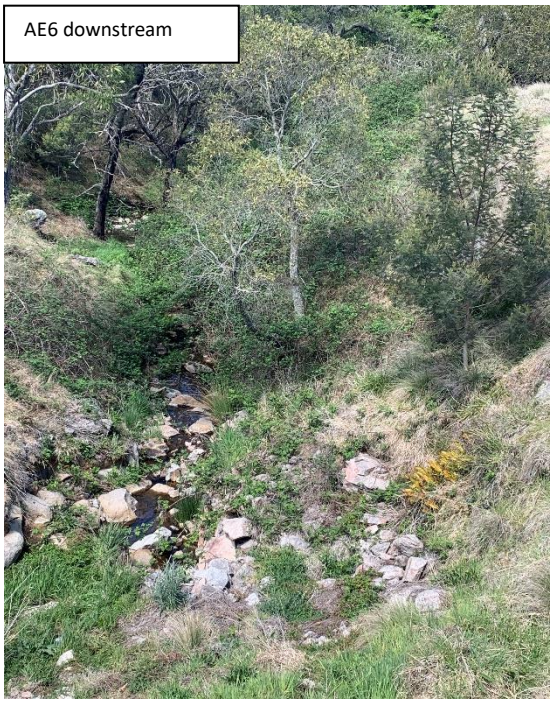
This site is on Spring Creek and downstream of Dargues goldmine project area. The riparian zone is made of mostly grasses and herbs (exotic and native) which supported both banks. The broader area consisted of mainly pasture with scattered trees.

The channel consists of narrow runs and occasional pools. The creek bed consists of cobbles and boulders with bars of sand and silt common. Bank undercutting was frequent along all parts of the creek.

The water at the time of sampling was clear and very low flowing. Submerged and emergent macrophytes were present within the reach and covered the creek in parts making it impossible to sample some sections.

## Site AE6

AE6 downstream



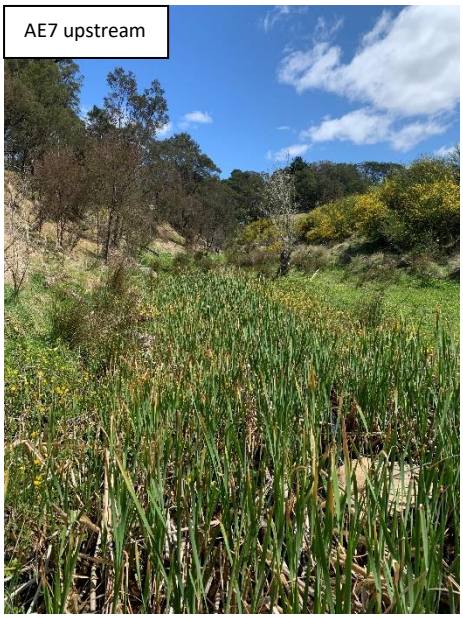
This site is on Spring Creek upstream of Dargues gold mine and approximately 700m upstream of AE4. The survey area is immediately downstream of the haul road crossing. The riparian zone consisted of pasture grasses and with minimal trees and was overgrown with blackberries.

The channel consists of narrow runs and occasional pools. Cobbles and boulders were present with the benthic composition being sand and silt.

The water at the time of sampling was clear and extremely low. Submerged and emergent macrophytes along with algae dominated the reach at the time of sampling. This with the low flow made it impossible to sample.

## Site AE7

AE7 upstream



AE7 downstream

This site is on Majors Creek approximately 1 km upstream from the confluence with Spring Creek. As it is upstream of the gold mine it acts as a reference site as there are no potential influences from the mine. The riparian zone consisted of shrubs and grasses that overhung the water on both banks with no mature trees present. The vegetation in the broader area was similar to the riparian zone.

The channel consisted of runs and pools with no riffles. The creek bed consisted of sand with boulders and shallow bedrock and was heavily silted at the time of sampling.

The water was clear and low flowing at the time of sampling. Woody debris was common throughout the reach and the pool upstream of the weir was dominated by emergent macrophytes. There was little to no algal growth at the time of sampling.

## Site AE8

AE8 upstream

AE8 downstream

This site is on Majors Creek, north of the Majors Creek village and is divided by a road causeway. Like AE7 it acts as a reference site as its upstream of any potential impacts from the mine. The riparian zone was dominated by exotic trees and shrubs in particular willows and blackberries. The broader area has been cleared and consisted mostly of grasses.

The channel consisted of a pool upstream of the causeway and shallow runs downstream. The creek bed consisted of soft sediment and some woody debris consisting of fallen willow and willow roots. There was a considerable amount of detritus in the form of dead macrophytes washed down from the pool upstream from previous heavy flows.

The water was slightly turbid and iron flocs occurred on the edges of the creek. The pool upstream had considerably less emergent macrophytes when compared to the autumn 2024 sampling. Downstream was choked with juvenile willow trees. The deposits of sand and gravel appeared to be caused from runoff from the road crossing.