Dargues Gold Mine Aquatic Ecology Monitoring Spring 2022

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

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Executive Summary

This report summarises the spring 2022 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 November 2022. Four groundwater monitoring bores were also sampled for stygofauna. Above average rainfall resulted in charged baseflow and large peaks in discharge in the period leading up to sampling.

Riparian condition at each of the sites was classed as either 'good', 'very good' or 'excellent'. Sites upstream of DGM had the poorest riparian condition, being located in agricultural land, with little to no riparian zone. The further downstream of DGM, the riparian condition improved with the two most downstream sites, 1 and 2, scoring in the 'excellent' range due to good instream habitat and a well-connected riparian zone with mature native forest.

Water quality varied between sites and was generally acceptable for all variables except dissolved oxygen, which was outside Australian and New Zealand Environmental Conservation Council (ANZECC) guidelines for 5 sites, and EC, which was high at 3 sites. Turbidity was outside guideline levels at sites AE1 and AE2, most likely due to increase runoff associated with a rainfall event the day prior to sampling.

Fish numbers and species diversity varied somewhat across sites, though largely increased between the previous and current surveys. Mountain galaxias (*Galaxias olidus*) was detected at an extra three sites in spring 2022 and Short-finned eels were detected at site AE6, which had no fish in spring 2021. The increase in diversity between the previous and current assessment may be attributable to sustained above average rainfall providing increased opportunities for fish passage, as well as increasing the quality of fish habitat over the longer term.

Macroinvertebrate communities had a relatively high taxa richness, with 58 taxa collected in spring 2022, higher than the 43 collected in spring 2021. Taxonomic richness ranged from 14 to 31 taxa per site, and SIGNAL Scores were between 4.34 and 5.93 and indicated moderate to mild disturbance. There was no difference between macroinvertebrate communities from upstream and downstream of the DGM, based on samples taken from edge habitats. Overall macroinvertebrate communities at sites have increased in average signal scores, taxa richness, and proportion of sensitive taxa.

Ecological conditions in 2022 have improved since the 2021 spring survey in relation to the fish and macroinvertebrate communities. Macroinvertebrate community health and fish numbers and diversity have increased from spring 2021 to 2022. These results are likely aided by the increased baseflows as a result of the above average rainfall in the preceding months.

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.

The Centre for Applied Water Science (CAWS), University of Canberra, was contracted to undertake the Aquatic ecology surveys which have occurred since 2011, with Eco Logical Australia (ELA) taking over in 2016 until autumn 2022. 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 first 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 2022 survey.

Methods

Spring samples were collected between the 4 – 10th November 2022. Air temperatures ranged from 4 – 21 °C with rain occurring on days two and three (Table 1). All sites were flowing during the survey period. All sampling methods below follow those outlined by ELA (Eco Logical Australia Pty Ltd 2021).

Table 1. Air temperature and rainfall data during the spring 2022 survey period. Data taken from Dargues weather station.

Date	Rainfall (mm)	Maximum Temp °C	Minimum Temp °C
4/11/2022	0	18.5	4
7/11/2022	5.24	20.8	10.1
8/11/2022	4.56	20.8	9.6
9/11/2022	0	21	10.1
10/11/2022	0	20.9	8.1

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).

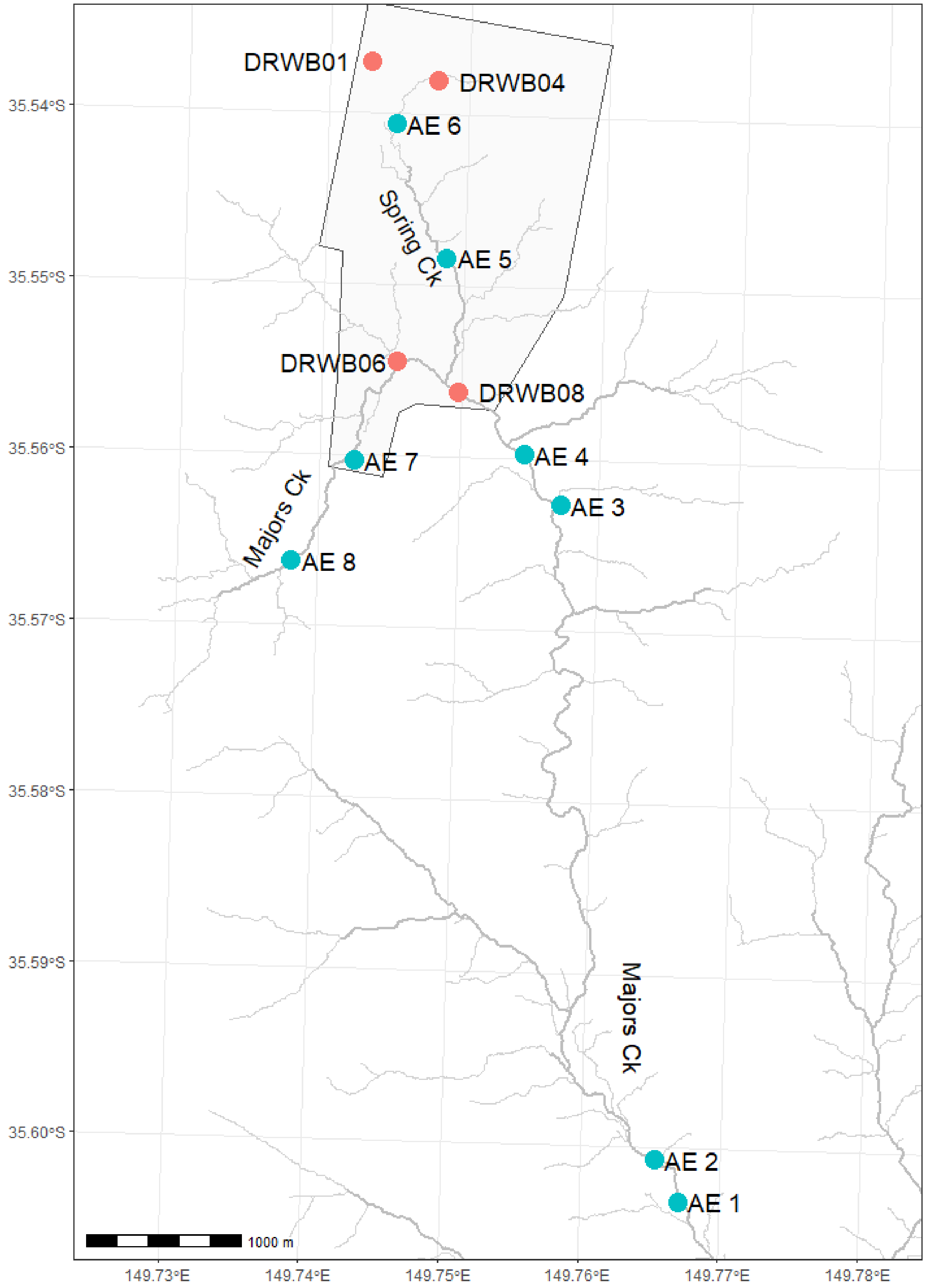

Figure 1. Map of sampling sites for the Dargues gold mine aquatic ecology monitoring program. Blue circles are stream monitoring sites and red circles are bore sampling sites.

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 295 – 600 seconds of on time (Table 2) 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 2). All fish captured were measured to total length (TL) or fork length (FL), depending on species, and then released at the site.

Table 2. Backpack electrofisher settings for spring 2022.

Site	Frequency (Hz)	Volts	Time on (sec)	Time on (min:sec)
AE1	90	200	600	10:00
AE2	90	200	600	10:00
AE3	90	200	600	10:00
AE4	90	200	600	10:00
AE5	90	200	600	10:00
AE6	90	200	295	4:55
AE7	90	200	600	10:00
AE8	90	200	425	7:05

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

Consistent rainfall across the catchment in the months leading up to sampling resulted in good base flow and several large peaks in discharge associated with larger rainfall events (notably mid and late-October) (Figure 2).

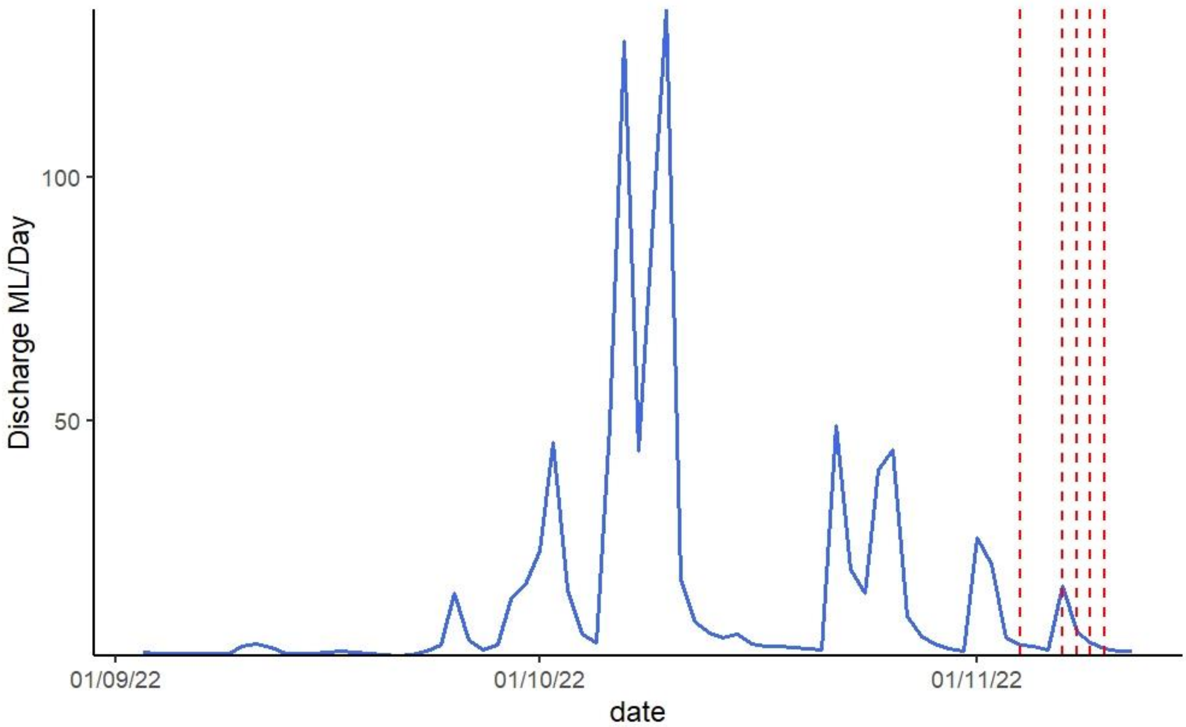

Figure 2. Discharge from Majors Creek (taken from station SW6) leading up to and including spring 2022 sampling.

Physical and chemical water quality assessment

Water temperatures ranged between 14.48 – 20.8°C at site AE1 and AE7, respectively, during the spring 2022 survey (Table 3). The pH ranged from 7.43 – 8.04 and was within the ANZECC guideline range for all sites except AE6 which was slightly over at 8.04 (Table 3).

Electrical conductivity (EC) measurements tended to increase with distance downstream from the most upstream site AE8 on Majors creek. At site AE8 the EC was 189 µS/cm which increased to 299 µS/cm at the most downstream site AE1 (Table 3). The site immediately downstream of the mine on Spring Creek (AE5) had an EC reading of 734 µS/cm, which is almost double of one site and triple of the other two sites upstream of the mine (Table 3). The EC was still slightly above the ANZECC range at site AE4 because of the inflows from site AE5 but decreased at the downstream sites AE1-AE3 (Table 3). These sites may have had lower EC readings because of rainfall having a dilution effect (Table 1).

Table 3. Physical and chemical water quality at Dargues gold mine monitoring sites.

Parameter	**ANZECC Range**	**AE1**	**AE2**	**AE3**	**AE4**	**AE5**	**AE6**	**AE7**	**AE8**
Temperature (°C)		14.48	15.94	19.26	20.63	17.05	19.77	20.8	15.68
pH	6.5 – 8.0	7.76	7.57	7.66	7.43	7.71	8.04	7.45	7.47
EC (µS/cm)	30 - 350	299	308	287	374	734	446	191	189
Turbidity (NTU)	2 - 25	44.9	30.4	21.3	2.5	0	0	0	5.84
Dissolved oxygen (mg/L)		10.33	9.82	9.29	9.34	10.58	10.82	11.55	6.31
DO (% saturation)	90 - 110	104.5	103	108.3	114.2	119	129	138.6	67.9
Salinity (ppt)		0.14	0.15	0.14	0.18	0.36	0.21	0.09	0.09
Alkalinity (ppm)		78	70	54	64	83	76	53	50
TDS (g/L)		0.194	0.2	0.186	0.243	0.47	0.29	0.124	0.124

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

TDS and salinity measurements also increased at site AE5, with readings of 0.47 g/L and 0.36 ppt respectively. Turbidity measurements were within the ANZECC range for all sites in spring 2022 except for AE1 and AE2 (Table 3). This was likely due to significant rainfall the previous night and subsequent runoff into Majors Creek (Table 1). Sites AE1 - AE3 were within the ANZECC range for DO concentrations (% saturation) in spring 2022. However, sites AE4 – AE7 were above the ANZECC range and site AE8 was below the range. Site AE8 recorded the lowest DO% saturation of 67.9% (Table 3). Alkalinity ranged between 50 – 83 ppm across all sites. The highest occurring at the impact site AE5, which is immediately downstream of the mine (Table 3).

River channel environment (RCE)

RCE scores ranged from 60% (AE7, AE8) to 85% (AE1) (Table 4). Two sites scored in the 'excellent' range, four sites scored in the 'very good' range and two sites in the 'good' range.

Table 4. RCE Scores for sites in spring 2022

	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	3	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	4	2
Retention devices in stream	4	4	4	4	4	2	3	3
Channel sediment accumulations	3	2	2	2	2	3	2	2
Stream bottom	4	4	2	1	3	3	2	2
Stream detritus	1	1	2	2	2	3	2	2
Aquatic vegetation	4	4	4	4	4	3	2	2
RCE Score	**44**	**43**	**40**	**36**	**38**	**34**	**31**	**31**
RCE Score %	**84.6**	**82.7**	**76.9**	**69.2**	**73.1**	**65.4**	**59.6**	**59.6**
Condition rating	**Excellent**	**Excellent**	**Very Good**	**Very Good**	**Very Good**	**Very Good**	**Good**	**Good**

Sites AE7 and AE8, the most upstream sites on Majors Creek, had the lowest scores of 60% 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 AE8 had a narrow riparian zone with mostly exotic trees and shrubs and a channel with no riffle/pool sequence.

Sites AE1 and AE2 scored in the 'excellent' range. These sites had banks stabilised by trees with no bank undercutting and frequent alternation of riffles and pools. The riparian zone at these sites was well connected with mature native forests. The stream bottom was stable with retention devices, including boulders and contained clean stones with obvious interstices.

Macroinvertebrate communities

A total of 2889 invertebrates were collected in spring 2022 comprising 58 different taxa (Table 8). They were collected from six edge habitats and four riffle habitats. Five families occurred at all sites sampled in spring 2022, which included Leptophlebiidae, Orthocladiinae, Hydrobiosidae, Gripopterygidae and Chironominae in ascending order. During this period, edge habitats had between 24 and 29 taxa at impacted sites (AE3 – AE5) while reference sites (AE6 – AE8) had between 23 and 31 taxa. No edge samples were taken at the recovery sites (AE1 – AE2) but the riffle habitats had between 14 and 20 taxa present (Table 5). Leptophlebiidae, Hydrobiosidae, Gripopterygidae all had one of the highest SIGNAL scores of eight and were found at all sites.

Table 5. Macroinvertebrate indices for spring 2022

Result	AE1	AE2	AE3		AE4		AE5	AE6	AE7	AE8
	Riffle	**Riffle**	**Edge**	**Riffle**	**Edge**	**Riffle**	**Edge**	**Edge**	**Edge**	**Edge**
Total taxa	14	20	29	20	27	17	24	31	30	23
Average SIGNAL score	5.93 (0.59)	5.63 (0.45)	4.66 (0.44)	5.20 (0.46)	4.56 (0.42)	5.06 (0.52)	4.65 (0.53)	4.52 (0.51)	4.34 (0.42)	4.70 (0.48)
Proportion of sensitive taxa	74.7	77.7	85.6	67.0	62.4	52.1	58.4	77.9	30.9	76.3
Site SIGNAL score	6.2	5.9	4.6	5.4	4.6	5.5	4.8	4.6	4.8	4.8

The average SIGNAL scores for each site ranged from 4.34 at AE7 to 5.93 at AE1 in spring 2022 (Table 5). AE7 had the lowest SIGNAL score and the lowest proportion of sensitive taxa (Table 5). For edge communities, SIGNAL scores at reference sites were 4.34 – 4.70, indicating moderate pollution. For the impacted sites (AE3 – AE5) the average SIGNAL was between 4.56 – 4.66 for edge communities, indicating moderate pollution. Riffle habitats had higher SIGNAL averages than edge habitats with scores ranging from 5.06 – 5.93 (Table 5).

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 = -0.2593, p = 0.80) (Figure 3).

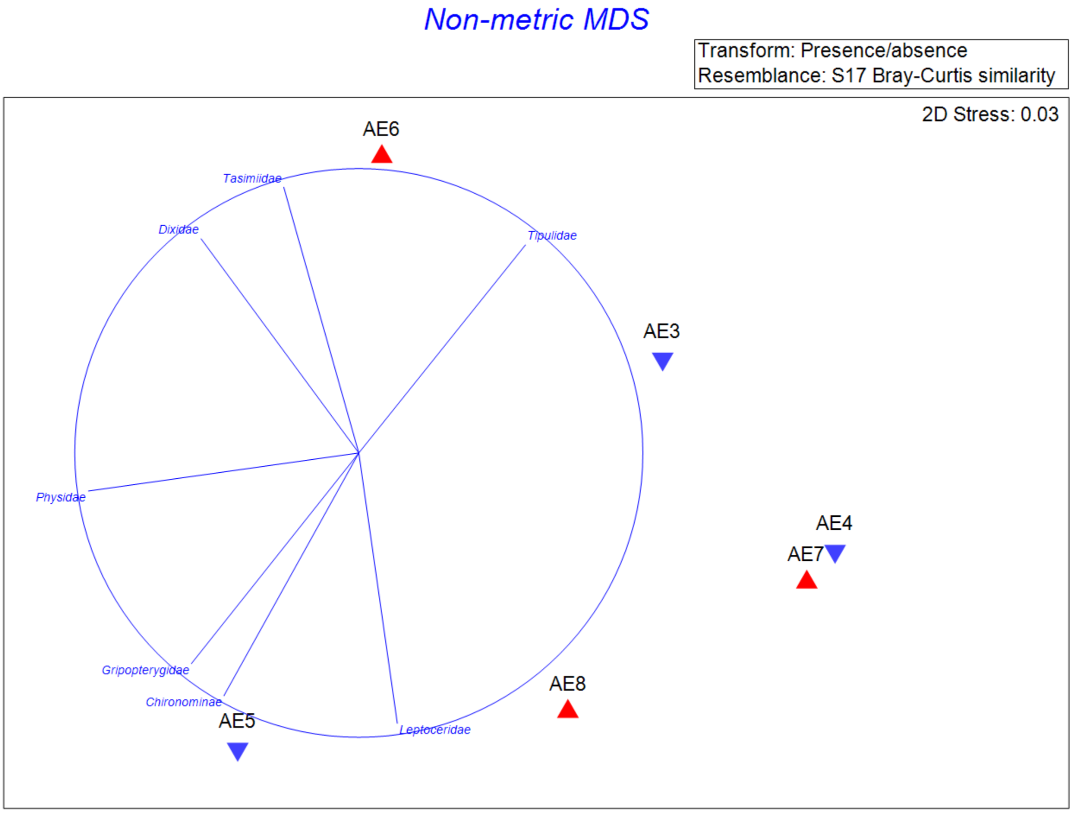

Figure 3. nMDS comparison of macroinvertebrate communities at edge habitats upstream (red) and downstream (blue) of Dargues Gold Mine.

All sites where edge samples were collected, had similar site SIGNAL scores, and although varied a little in the number of taxa, were all assessed as being in the same condition quadrant (Quadrant 2: community impairment, often caused by high salinity or nutrient levels) (Figure 4).

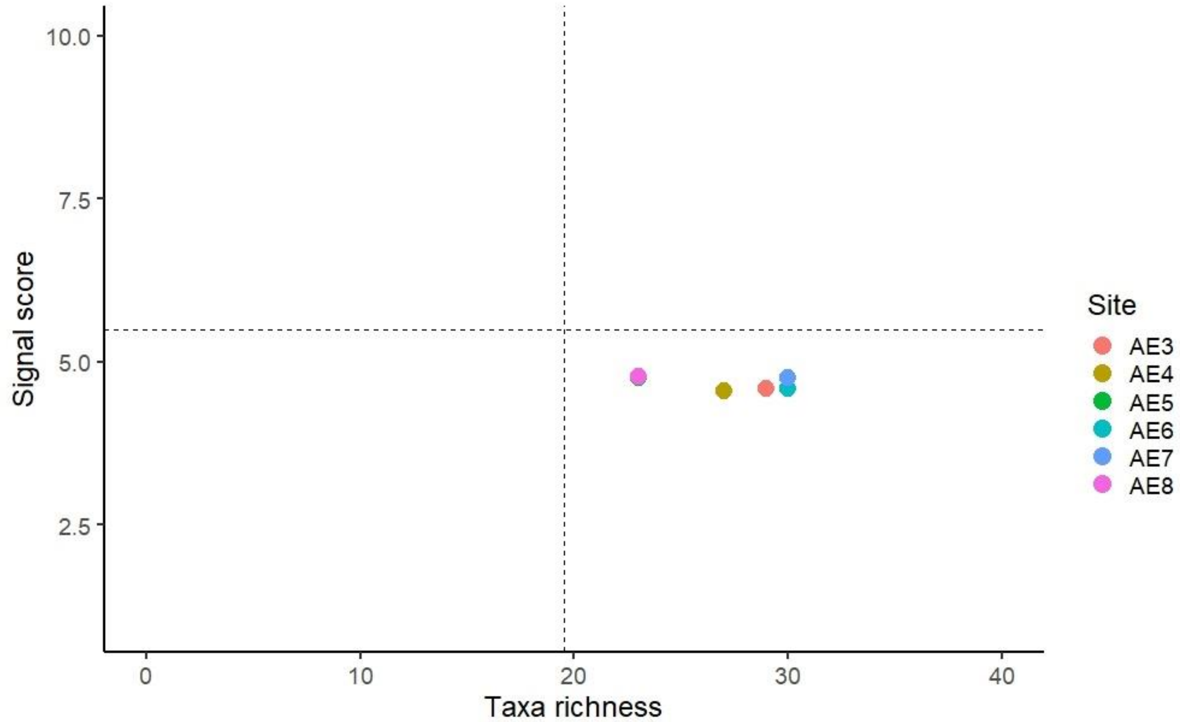

Figure 4. Biplot of macroinvertebrate communities collected from edge samples. Dotted lines indicate the location of quadrants for interpretation of site SIGNAL results (from Chessman 2001).

Stygofauna communities

Four bores were sampled (1, 4, 6 and 8) in spring 2022. Bore 1 was the only one to have stygofauna present which included two individuals identified to family level. One was a *Cyclopidae* and the other a *Sminthuridae*.

Fish communities

Four species of fish were captured in spring 2022 which included Mountain galaxias (*Galaxias olidus*), Cox's gudgeon (*Gobiomorphus coxii*), Short-finned eel (*Anguilla australis*) and Long-finned eel (*Anguilla reinhardtii*). All sites sampled had 2 – 3 species present except for AE6 which only had one, a single Short-finned eel (Table 6).

Table 6. Total abundance of each species per site for spring 2022.

Species	AE1	AE2	AE3	AE4	AE5	AE6	AE7	AE8	Total
Cox's gudgeon	16	18	0	0	0	0	0	0	**34**
Long-finned eel	1	0	0	0	0	0	0	0	**1**
Short-finned eel	3	2	5	7	5	1	6	2	**31**
Mountain galaxias	0	2	3	34	13	0	143	11	**206**
Yabby	0	0	0	1	0	0	0	0	**1**
Total	**20**	**22**	**8**	**42**	**18**	**1**	**149**	**13**	**273**

The most widespread species was Short-finned eels with 31 individuals captured across all sites and ranging in size from 65 – 780 mm total length (TL) (Table 6 and Figure 5). A single Long-finned eel was captured at site AE1 and measured 245 mm (TL) (Table 6).

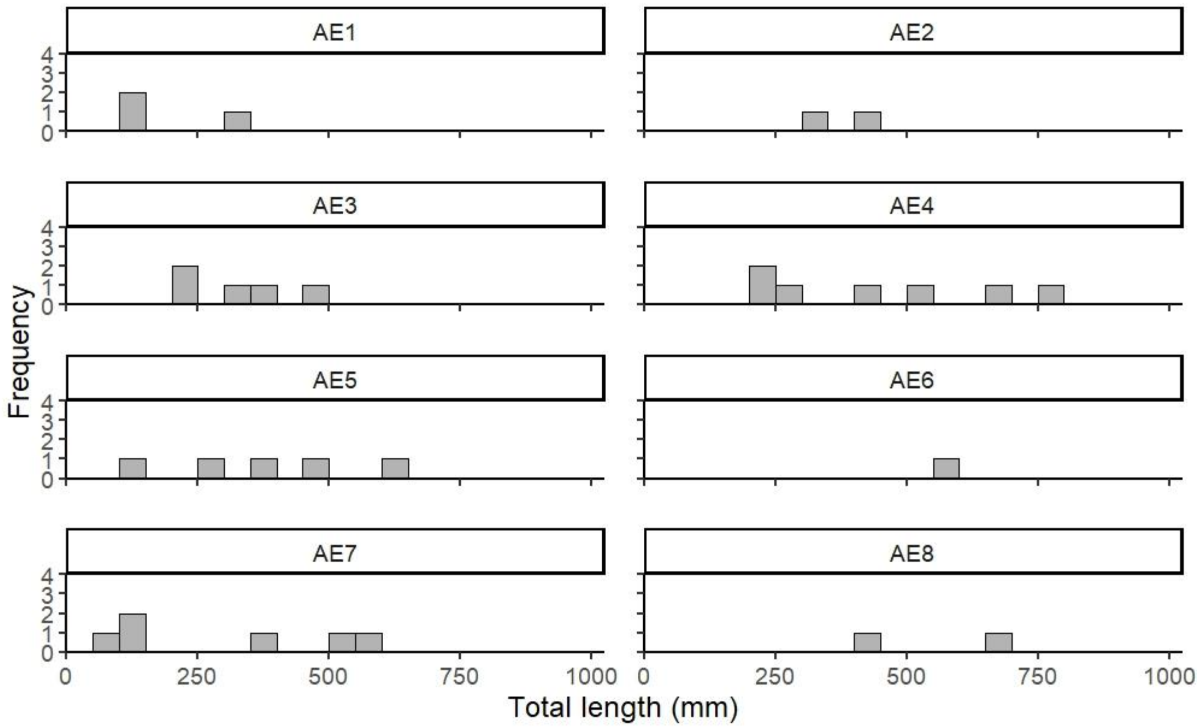

Figure 5. Length frequency of Short-finned eel captured by backpack electrofishing at all sites in spring 2022.

Mountain galaxias were the most abundant species with 206 individuals captured across six sites ranging in size from 25 – 119 mm fork length (FL) (Table 6 and Figure 6).

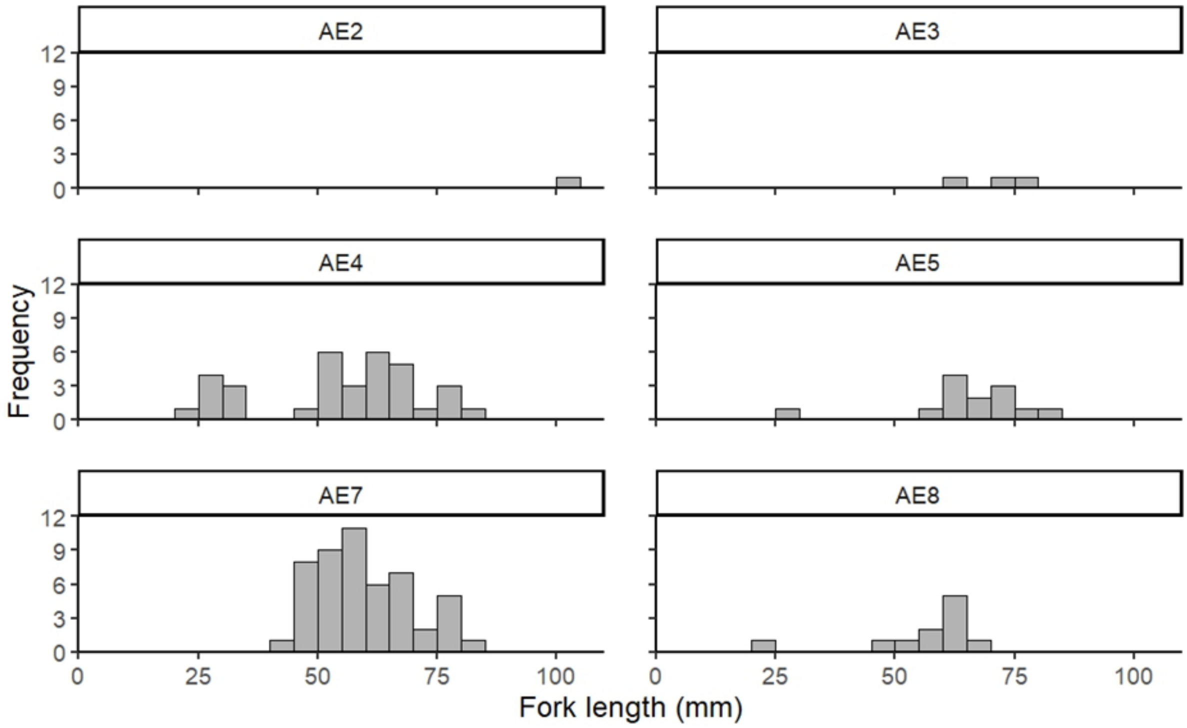

Figure 6. Length frequency of Mountain galaxias captured by backpack electrofishing at six sites in spring 2022.

A total of 34 Cox’s gudgeon were caught at sites AE1 and AE2 and ranged in size from 45 – 102 mm (TL) (Table 6 and Figure 7).

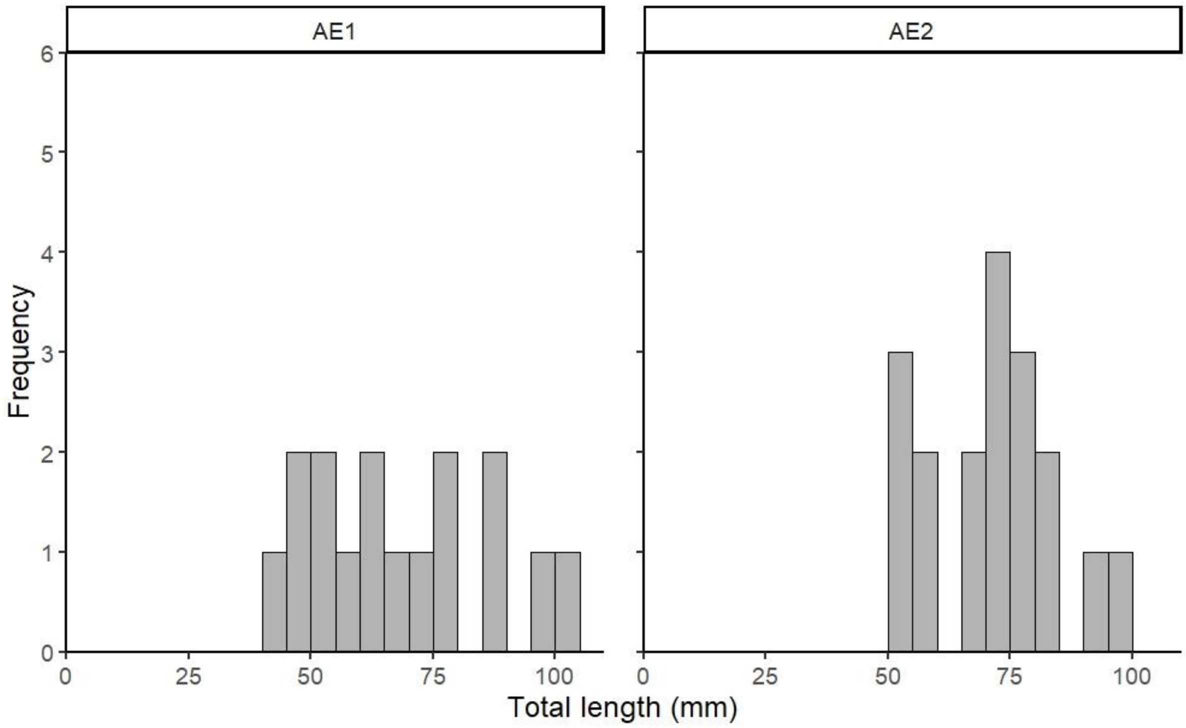

Figure 7. Length frequency of Cox’s gudgeon captured by backpack electrofishing at two sites in spring 2022.

The highest catch rate for Short-finned eel occurred at site AE4 with 40 fish per hour (Table 7). Catch rates for Mountain galaxias were the highest at site AE7 with 858 fish caught per hour, this being over four times higher than the next site, AE4, with 204 fish caught per hour (Table 7). The most common size range was between 60 – 80 mm (FL) (Figure 6). Site AE2 had the highest catch rate for Cox’s gudgeon with 108 fish caught per hour with the most common size range between 60 – 80 mm (TL) (Table 7 and Figure 7).

Table 7. Catch per hour of fish collected in spring 2022.

Species	AE1	AE2	AE3	AE4	AE5	AE6	AE7	AE8
Cox's gudgeon	96	108	0	0	0	0	0	0
Long-finned eel	6	0	0	0	0	0	0	0
Short-finned eel	18	12	30	42	30	12.20	36	16.94
Mountain galaxias	0	12	18	204	78	0	858	93.18
Yabby	0	0	0	6	0	0	0	0

The reference site AE7, upstream of the mine, had the most fish caught with 149 out of 273 fish captured in spring 2022 (Table 6). This catch was primarily Mountain galaxias and the total catch per hour for the site was 894 fish per hour (Table 7). The total catch per hour across all sites for spring 2022 was 1670 fish.

Conclusion

Above average rainfall continued through 2022 which resulted in regular fluctuations in stream levels. 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. Exceedingly high EC downstream of the mine at AE5 does not appear to be having a significant impact on the macroinvertebrate or fish communities in spring 2022.

Macroinvertebrate communities did not significantly differ above and below the DGM. Edge habitat communities collected at the six most upstream sites showed some impairment, and grouped out as sites that are often impaired by salinity or nutrient levels (Chessman 2001). Overall, macroinvertebrate community health has increased between spring 2021 and spring 2022. Total number of taxa and average SIGNAL score was higher for each site and habitat in spring 2022, compared to the previous survey in 2021 (Eco Logical Australia Pty Ltd 2021). In addition, percentage of sensitive taxa has increased in 2022, ranging from 1.08 – 6 times the percentages found in 2021 (Eco Logical Australia Pty Ltd 2021). This is likely a result of above average rainfall resulting in increased stream baseflow over the preceding months diluting any potential pollution impacts of the land use (e.g. salinity).

Fish communities at all sites remain in relatively good condition. In fact, an additional species of fish was detected in the spring 2022 (Long-finned eel at site AE1) compared to previous surveys (Eco Logical Australia Pty Ltd 2021). Fish diversity either remained the same or improved in spring 2022, with sites AE2, AE5 and AE8 having Mountain galaxias present, compared to spring 2020 and 2021 when they were absent from these sites (Eco Logical Australia Pty Ltd 2021). It is likely that increased baseflow and flushing flow peaks have improved opportunity for fish passage and improved fish habitat over the past couple of years.

Two types of stygofauna (a copepod and a spring tail) was detected in the sample at a single site. This is an interesting result, given that no stygofauna had been detected in the previous five years of monitoring. Future surveys will determine whether this was an anomaly or there has been a longer-term change in the stygofauna.

There were no obvious 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 historic agricultural and 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 slightly turbid at the time of sampling due to rainfall the previous night. Riffles were present linking the pools. The pools seemed to be shallow due to flood events washing in sand and gravel.

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 slightly turbid at the time of sampling due to rainfall the previous night. Riffles were present linking the pools.

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, and the bottom was heavily silted. Bank undercutting was frequent along the stream and the banks were mainly held by ferns and grasses.

The water was turbid at the time of sampling due to recent rainfall. No macrophytes or algae 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 and the bottom was mainly loose with fine detritus mixed with sediment. Bank undercutting was frequent along the stream the banks were held by grasses and sedges.

The water was turbid at the time of sampling due to recent rainfall. No macrophytes or algae was present at the time of sampling.

Site AE5


AE5 upstream


AE5 downstream

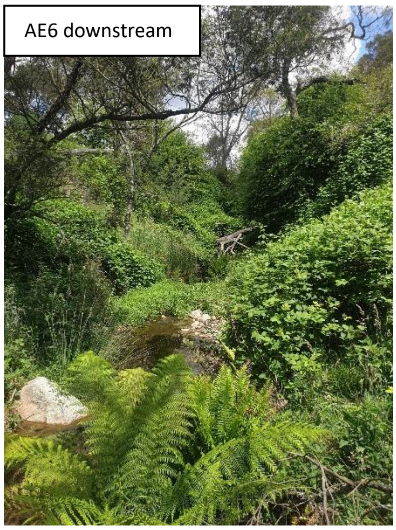
This site is on Spring Creek and downstream of Dargues goldmine project area. The riparian zone is made of mostly grasses and herbs (exotic and native) which supported both banks. The broader area consisted of mainly pasture with scattered trees.

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. Submerged and emergent macrophytes were present within the reach with some algae present also.

Site AE6


AE6 upstream


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. Submerged and emergent macrophytes were present within the reach with some algae present also.

Site AE7

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 and silt with boulders and shallow bedrock.

The water was clear at the time of sampling. Woody debris was common throughout the reach and the pool upstream of the weir was dominated by emergent macrophytes.

Site AE8

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.

The water was turbid and iron flocs occurred on the edges of the creek. The pool upstream was heavily lined with emergent macrophytes and downstream was choked with juvenile willow trees. The deposits of sand and gravel appeared to be caused from runoff from the road crossing.

Table 8. Macroinvertebrate taxa, number of taxa collected and estimated total macroinvertebrate abundance in sub-samples from Majors Creek and Spring Creek in Spring 2022.

CLASS **Order** Family *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									
Lymnaeidae	1					3		3			1	1	
Planorbidae	4							1		1	1		
Physidae	1					1				4	3		3
OLIGOCHAETA	2				2		5	2	10	10	6	9	11
ACARINA	6				1	2	1			2			1
Coleoptera													
Carabidae	3							1	3	2			
Chrysomelidae	2					6					1		
Dytiscidae	2					34	11	50	3	47	17	7	2
Elmidae (Adult)	7		2		1	1							1
Elmidae (Larvae)	7						1		4				
Noteridae	4					1							
Hydrophilidae	2					1			1	1	1	1	
Hydraenidae	3											2	
Heteroceridae	1											1	
Scirtidae	6					8		1				3	2
Psephenidae	6				1		2	1	2				
Hydrochidae	4					1					1	4	
Hygrobiidae	4					8		11			10	1	7
Diptera													
Tipulidae	5		5		2	1	14	1	6		1	1	
Ceratopogonidae	4						2	1					
Simuliidae	5		37		71	1	4	4	7			1	
Athericidae	8					1	1						
Dixidae	7					5		1		3	6		1
Tanyderidae	6												1
Muscidae	1		1							1			
Tanypodinae	4				1	5		6			7	8	11
Orthocladiinae	4		67		49	14	63	35	90	94	17	184	14
Chironominae	3		1		5	7	2	7	4	25	1	7	20
Ephemeroptera													
Baetidae	5		29		28	5	3	2	3	2		7	5
Leptophlebiidae	8		122		116	110	65	24	40	117	84	25	139
Caenidae	4					23	1	41		27	9	24	5
Hemiptera													
Gelastocoridae	5										2		
Veliidae	3				1	3				1		1	2
Notonectidae	1					5		1			4		
Mesoveliidae	2					6	2	5			1	6	
Corixidae	2							3		2	2	1	1
Pleidae	2											1	1
Lepidoptera													
Crambidae	NA				1								
Mecoptera													
Nannochoristidae	9										1		
Megaloptera													
Corydalidae	7		1		1		2		3				
Odonata													
Aeshnidae	4						1						
Gomphidae	5								1			1	
Lestidae	1										3		
Platycnemididae	NA									5	1		
Synlestidae	7					20		7		15	18	23	
Synthemistidae	2										1	1	2
Telephlebiidae	9									1			
Plecoptera													
Gripopterygidae	8		8		13	6	4	3	18	19	5	10	14
Notonemouridae	6										3		
Trichoptera													
Hydrobiosidae	8		22		30	2	56	3	35	2	1	2	1
Glossosomatidae	9										1		
Philopotamidae	8									1			
Hydropsychidae	6		6		7		13		17				
Ecnomidae	4				1			1		1		1	
Conoesucidae	8		9		2			1				11	1
Helicopsychidae	8										1		
Leptoceridae	6					6		8		12		12	15
Tasimiidae	8		5		2	2					5	1	
No. of individuals			315		335	288	253	224	247	395	215	357	260
No. of taxa			14		20	29	20	27	17	24	31	30	23
% of sub-sample			100		100	100	100	100	100	100	100	100	100
Whole sample estimate			**315**		**335**	**288**	**253**	**224**	**247**	**395**	**215**	**357**	**260**