Dargues Gold Mine Aquatic Ecology Monitoring
Autumn 2023

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 autumn 2023 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 April 2023. Four groundwater monitoring bores were also sampled for stygofauna. Average rainfall resulted in normal baseflow with minimal 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'. 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. Site AE6 dropped in its classification from 'very good' to 'good' as a result of increased algal and macrophyte growth. 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 electrical conductivity, which was high at six out of eight sites, dissolved oxygen at site AE5 and turbidity at site AE8, which were outside of the Australian and New Zealand Environmental Conservation Council (ANZECC) guidelines.

Fish abundance and species diversity varied somewhat across sites, though generally increased between previous and current surveys. Mountain galaxias (*Galaxias olidus*) were the most abundant species in autumn 2023 (comprising 53 % of fish captured) and Short-finned eels were the most widespread (found at seven of eight sites surveyed). Two extra species were detected in autumn 2023 that had not been detected in previous surveys, Australian smelt and Common galaxias, at sites AE1 and AE2. Generally, fish abundance was greater in autumn 2023 when compared to previous surveys. The increase in diversity between the previous and current assessment may be attributable to lower flows and greater visibility increasing sampling efficiency.

Macroinvertebrate communities had a relatively high taxa richness, with 59 taxa collected in autumn 2023, just higher than the 58 collected in spring 2022. Taxonomic richness ranged from 16 to 30 taxa per site, and SIGNAL Scores were between 4.23 and 6.31 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.

For the second survey in a row, stygofauna have been detected with their distribution and abundance increasing in autumn 2023. This is a positive result as they are an important indicator of ecosystem health.

Ecological conditions in 2023 have improved since the 2022 spring survey in relation to the fish and macroinvertebrate communities. Macroinvertebrate community health and fish numbers and diversity have increased from spring 2022 to autumn 2023. These results are likely due to fewer disturbance events i.e. rainfall in the months preceding sampling.

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 second report since CAWS has taken over the monitoring program. This report outlines the summary findings of the aquatic ecology and stygofauna monitoring for the autumn 2023 survey.

Methods

Autumn samples were collected on the 27th – 28th April 2023. Temperatures ranged from 9 - 21°C. All sites were flowing during the survey period.

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).

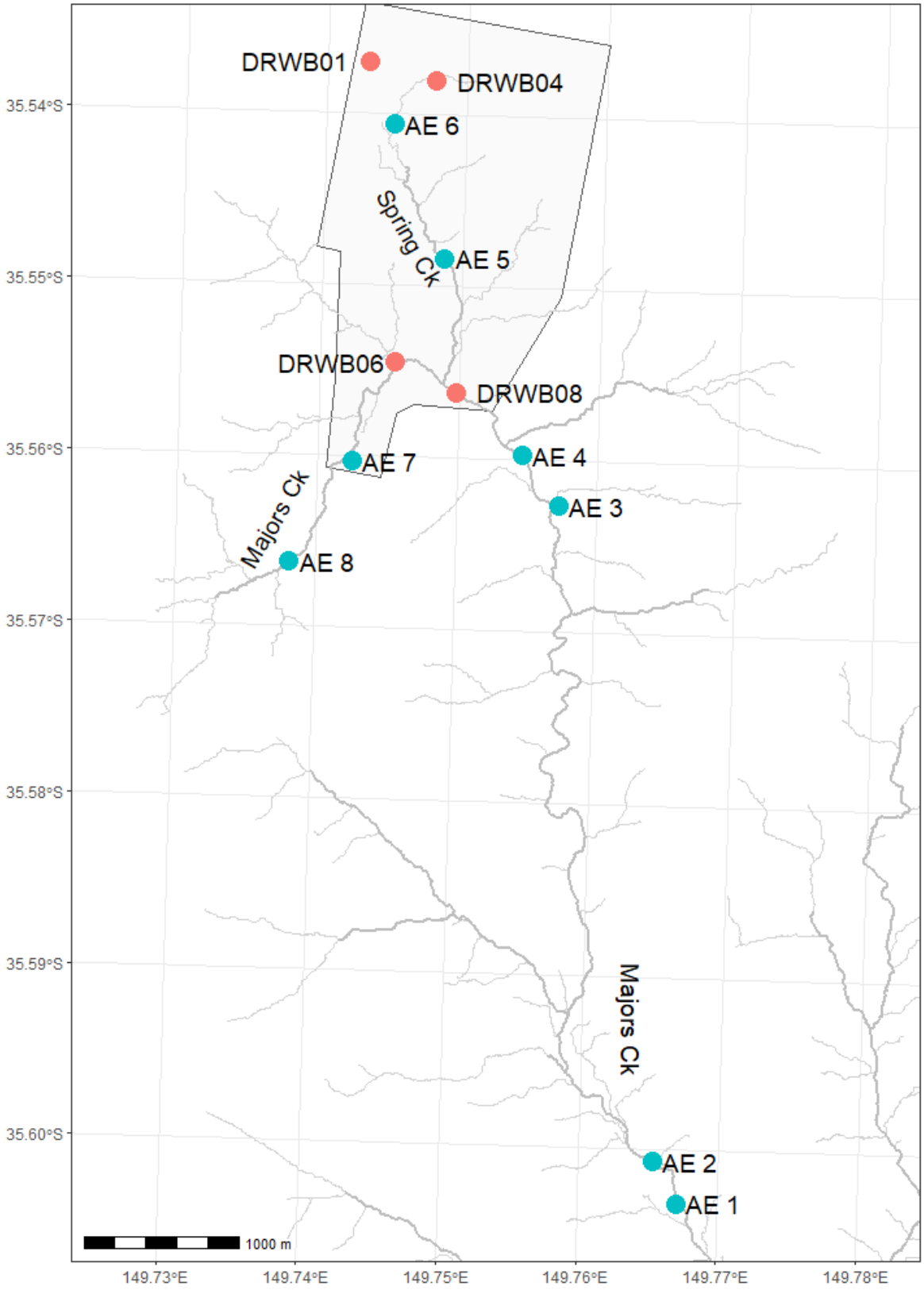

Figure 1. Map of sampling sites for the Dargues gold mine aquatic ecology monitoring program

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 295 – 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). 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 autumn 2023.

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	195	3:15
AE7	90	200	600	10:00
AE8	90	200	430	7:10

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

Compared to the spring 2022 sampling, rainfall events were generally smaller and less frequent in the months leading up to the autumn 2023 sampling. This resulted in reduced base flow and much smaller peaks in discharge associated with these events (Figure 2).

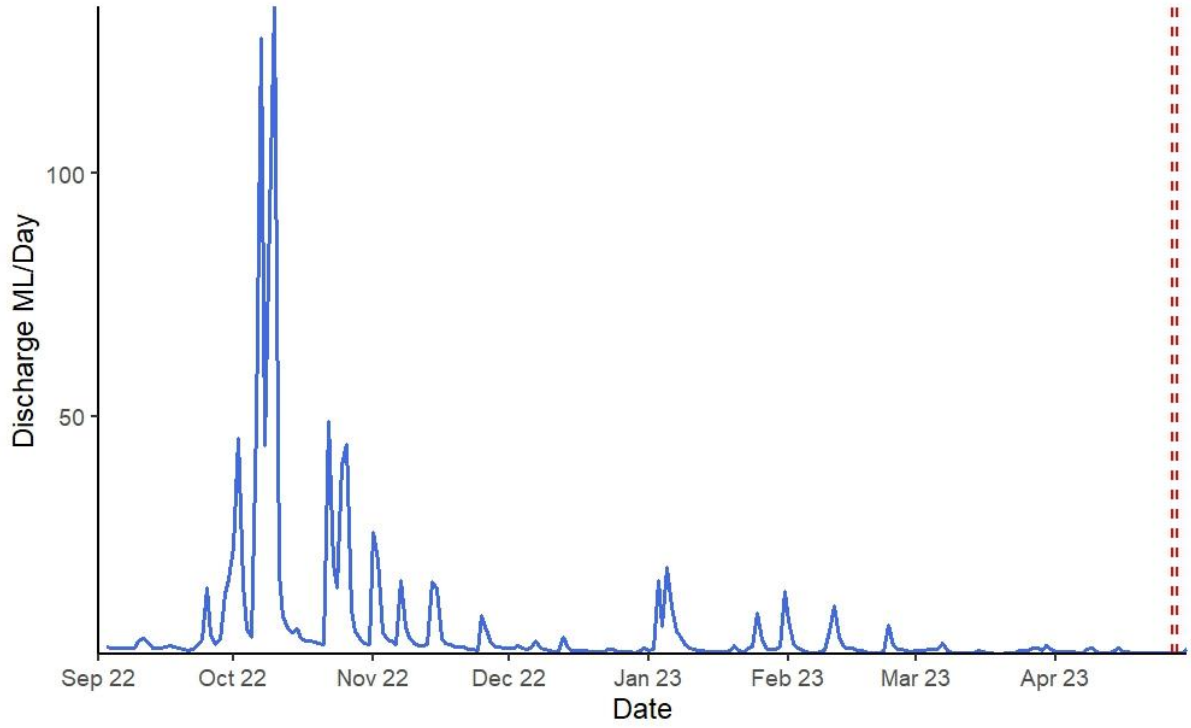

Figure 2. Discharge from Majors Creek (taken from station SW6) leading up to autumn 2023 sampling. Red lines indicate sampling dates.

Physical and chemical water quality assessment

Water temperatures ranged between 11.69 – 15.81°C at site AE5 and AE4, respectively, during the autumn 2023 survey (Table 2). The pH ranged from 6.81 – 8.13 and was within the ANZECC guideline range for all sites except AE5 which was slightly over at 8.13 (Table 2).

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 238 µS/cm which increased to 538 µS/cm at the most downstream site AE1 (Table 2). The site immediately downstream of the mine on Spring Creek (AE5) had an EC reading of 740 µS/cm, which is almost triple of the other two sites upstream of the mine (Table 2). The EC was above the ANZECC range at all sites downstream of site AE7, i.e. AE1 – AE6 (Table 2).

Table 2. Physical and chemical water quality at Dargues gold mine monitoring sites for autumn 2023.

Parameter	**ANZECC Range**	**AE1**	**AE2**	**AE3**	**AE4**	**AE5**	**AE6**	**AE7**	**AE8**
Temperature (°C)		14.31	14.73	15.25	15.81	11.69	12.85	14.42	14.45
pH	6.5 – 8.0	7.98	7.85	7.88	7.67	**8.13**	7.22	7.39	6.81
EC (µS/cm)	30 - 350	**538**	**537**	**425**	**395**	**740**	**481**	244	238
Turbidity (NTU)	2 - 25	0.9	0	1	0.9	0	1.7	2.5	**131**
Dissolved oxygen (mg/L)						11.19	9.07		
DO (% saturation)	90 - 110					**112.5**	94		
Salinity (ppt)		0.26	0.26	0.2	0.19	0.36	0.23	0.11	0.11
Alkalinity (ppm)		98	96	72	68	120	110	58	56
TDS (g/L)		0.345	0.344	0.276	0.257	0.476	0.313	0.158	0.155

Red bolded text denotes variables outside of the recommended ANZECC and ARMCANZ (2000) range. Missing DO data due to equipment malfunction.

Total dissolved solids (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 autumn 2023 except for AE8 which was well above the guideline levels (Table 2). This was likely due to an upstream influence as there had been no recent rainfall in the area. Due to equipment malfunction, DO concentrations (% saturation and mg/L) were only recorded at two sites in autumn 2023. Site AE5 was slightly above the ANZECC range (Table 2). Alkalinity ranged between 56 – 120 ppm across all sites. The highest occurring at the impact site AE5, which is immediately downstream of the mine (Table 2).

River channel environment (RCE)

River channel environment (RCE) scores varied considerably between sites, improving in condition in a downstream direction (Table 3). RCE scores ranged from 56% (AE8) at the most upstream site to 85% (AE1 and AE2) at the most downstream sites (Table 3). Two 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 autumn 2023.

	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	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	4	4	2	2	2	3	2	1
Stream detritus	1	1	3	3	2	3	2	2
Aquatic vegetation	4	4	3	3	1	1	2	1
RCE Score	**44**	**44**	**40**	**37**	**34**	**32**	**30**	**29**
RCE Score %	**84.6**	**84.6**	**76.9**	**71.2**	**65.4**	**61.5**	**57.7**	**55.8**
Condition rating	**Excellent**	**Excellent**	**Very Good**	**Very Good**	**Very Good**	**Good**	**Good**	**Good**

Sites AE7 and AE8, the most upstream sites on Majors Creek, had the lowest scores of 58 and 56%, 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 AE8 had a narrow riparian zone with mostly exotic trees (willows) and shrubs (blackberries) and a channel with no riffle/pool sequence. Site AE6 dropped its RCE score in autumn 2023 from 'very good' to 'good' (Table 3). This was due to the increased algal and macrophyte growth between sampling events.

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 2340 invertebrates were collected in autumn 2023 survey, comprising 59 different taxa (Table 5). Macroinvertebrate samples were collected from five edge habitats and four riffle habitats (Table 5). Two families occurred at all sites sampled in autumn 2023, which included Leptophlebiidae* and Orthocladiinae in ascending order (Table 5). During this period, edge habitats had between 23 and 30 taxa at impacted sites (AE3 – AE5) while reference sites (AE6 – AE8) had between 24 and 27 taxa (Table 5). No edge samples were taken at the recovery sites (AE1 – AE2) but the riffle habitats had between 16 and 20 taxa present (Table 5). Leptophlebiidae have one of the highest SIGNAL scores of eight and were found at all sites (Table 4). Site AE6 was not sampled in autumn 2023 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 autumn 2023.

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							Not sampled due to lack of suitable edge habitat		
Lymnaeidae	1					2		2					
Planorbidae	4							1	3	16		2	3
Physidae	1					6		10		2		2	5
Sphaeriidae	5				1			1					4
OLIGOCHAETA	2				1	10	2	5		4		5	7
ACARINA	6		2		1								1
Coleoptera													
Chrysomelidae	2							1					
Saldidae	1						2		1				
Dytiscidae	2					16		2		23		13	19
Elmidae (Adult)	7					1	1						
Elmidae (Larvae)	7		1		1								
Hydrophilidae	2							1				8	
Hydrochidae	4											6	9
Scirtidae	6							1				1	1
Psephenidae	6				1	1	1		2				
Gyrinidae	4							1				1	
Hygrobiidae	4							1					
Diptera													
Tipulidae	5		2				2	2	2	7		4	
Ceratopogonidae	4											8	1
Culicidae	1		1										
Simuliidae	5		116		129		46	1	27			2	
Tanyderidae	6							1					
Stratiomyidae	2							7				2	3
Dolichopodidae	3									10			
Tanypodinae	4					3	2	2		3			2
Orthocladiinae	4		13		4	22	33	32	14	10		37	4
Chironominae	3				1	10	12	9	6	1		2	86
Ephemeroptera													
Baetidae	5		68		5	12	8	4	45	90			1
Leptophlebiidae	8		46		43	57	73	18	60	35		13	7
Caenidae	4				5	15		7		83		29	
Hemiptera													
Veliidae	3					3		9		1		2	4
Notonectidae	1					9		2					4
Mesoveliidae	2									1			
Micronectidae	2					4				11			
Corixidae	2					2				6		1	
Hebridae	3							2					1
Mecoptera													
Nannochoristidae	9												1
Megaloptera													
Corydalidae	7		1		2		4		9				
Odonata													
Aeshnidae	4									2			
Gomphidae	5											1	
Argiolestidae	NA												6
Platycnemididae	NA									24			
Synlestidae	7					8		19				1	1
Telephlebiidae	9									1		1	
Corduliidae	5									2			
Plecoptera													
Gripopterygidae	8		6		6	2			5	2		10	4
Trichoptera													
Hydrobiosidae	8		6		10		5	2	12	11			
Calamoceratidae	7				2	1				2			1
Hydroptilidae	4					1				5			
Philopotamidae	8		4		7	1	23	1	11				
Philorheithridae	8								1				
Hydropsychidae	6		5		7		2					2	
Polycentropodidae	7						8		4				
Ecnomidae	4					23	12	16				35	1
Conoesucidae	8		5		8		2	2	2			1	
Calocidae	9											3	
Odontoceridae	7		1										
Leptoceridae	6				1	11		81		38		42	92
Tasimiidae	8		9		13		4		5				
No. of individuals			286		248	220	242	243	209	390		234	268
No. of taxa			16		20	23	19	30	17	25		27	25
% of sub-sample			100		100	100	100	100	100	100		100	100
Whole sample estimate			**286**		**248**	**220**	**242**	**243**	**209**	**390**		**234**	**268**

Table 5. Macroinvertebrate community indices for autumn 2023.

Result	AE1	AE2	AE3		AE4		AE5	AE6	AE7	AE8
	Riffle	Riffle	Edge	Riffle	Edge	Riffle	Edge	Edge	Edge	Edge
Total taxa	16	20	23	19	30	17	24	*	27	24
Average SIGNAL score	6.31 (0.49)	6.05 (0.41)	4.30 (0.50)	5.58 (0.50)	4.23 (0.40)	6.06 (0.52)	4.38 (0.46)		4.70 (0.45)	4.50 (0.46)
Proportion of sensitive taxa	92.0	94.7	73.2	73.7	73.2	87.9	93.7		75.4	51.7
Site SIGNAL score	6.4	6.5	4.2	5.7	4.4	6.1	4.5		4.7	4.2

*Site AE6 not sampled as there was no available edge habitat.

The average SIGNAL scores for each site ranged from 4.23 at AE4 to 6.31 at AE1 in autumn 2023 (Table 5). AE4 had the lowest SIGNAL score and AE8 had the lowest proportion of sensitive taxa (Table 5). For edge communities, SIGNAL scores at reference sites were 4.50 – 4.70, indicating moderate pollution. For the impacted sites (AE3 – AE5) the average SIGNAL was between 4.23 – 4.38 for edge communities, indicating moderate pollution. Riffle habitats had higher SIGNAL averages than edge habitats with scores ranging from 5.58 – 6.31 (Table 5). All sites where edge samples were collected had similar site SIGNAL scores, although they 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 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 = 0.1667, p = 0.500) (Figure 4).

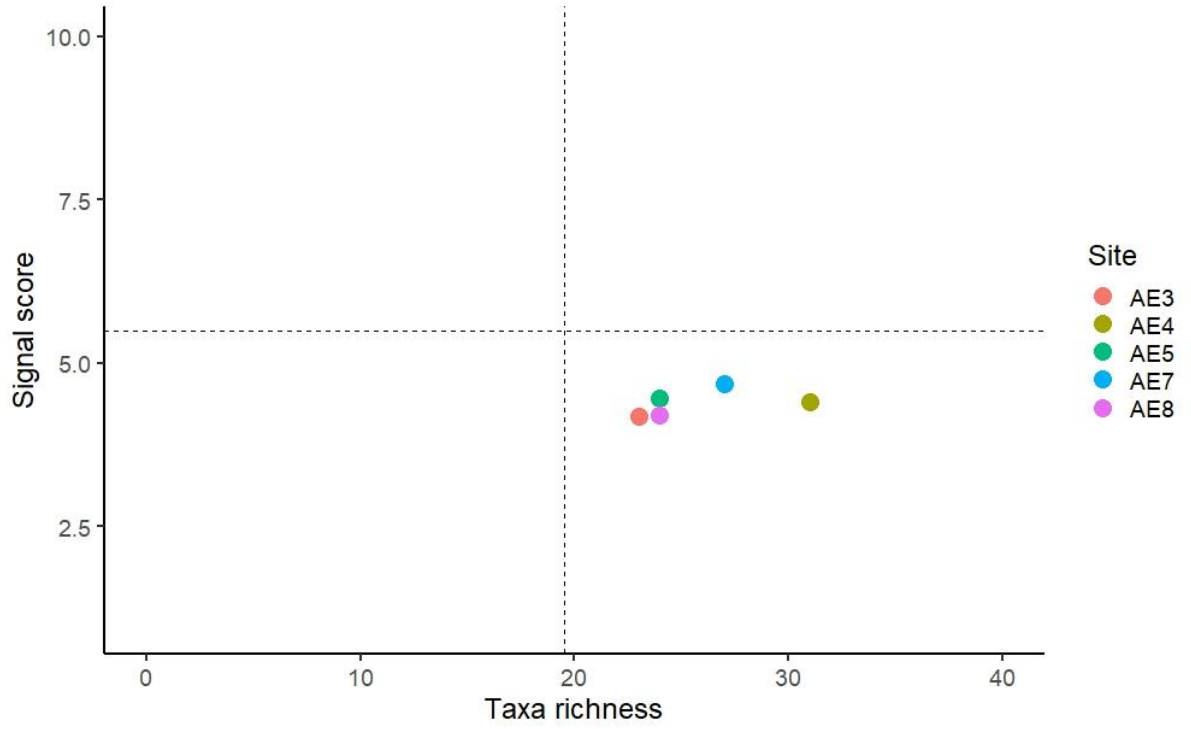

Figure 3. Biplot of macroinvertebrate communities collected from edge samples. Dotted lines indicate the location of quadrants for interpretation of site SIGNAL results (from Chessman 2001).

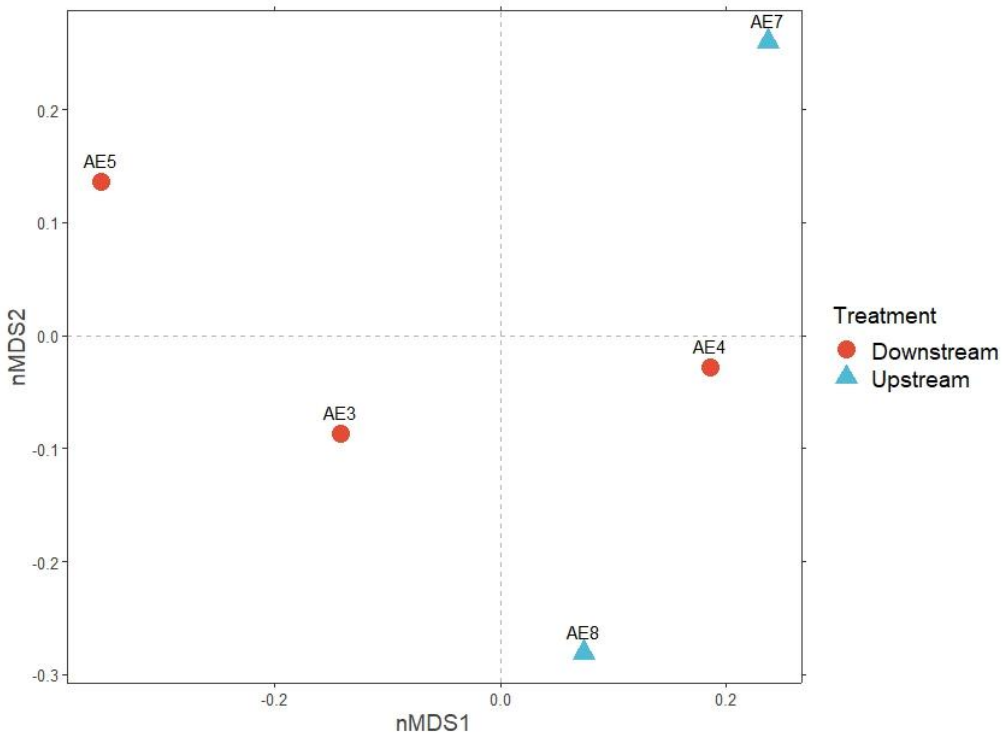

Figure 4. nMDS comparison of macroinvertebrate communities at edge habitats upstream (red) and downstream (blue) of Dargues Gold Mine.

Stygofauna communities

Four bores were sampled (1, 4, 6 and 8) in autumn 2023. All bores had stygofauna present with bores 1 and 4 having two species present and bores 6 and 8 having the one species. There was a total of 16 individuals captured across the four bores (Table 6).

Table 6. Total abundance of each species of stygofauna per site for autumn 2023.

Site	Taxa	Total
DRWB01	Isotomidae	3
DRWB01	Naididae	3
DRWB04	Chydoridae	2
DRWB04	Parabathynellidae	4
DRWB06	Astigmata	2
DRWB08	Isotomidae	2

*Taxa identified to lowest taxonomic level.

Fish communities

Six species of fish were captured in autumn 2023 which included Mountain galaxias* (*Galaxias olidus*), Cox's gudgeon (*Gobiomorphus coxii*), Short-finned eel (*Anguilla australis*), Long-finned eel (*Anguilla reinhardtii*), Common galaxias (*Galaxias maculatus*) and Australian smelt (*Retropinna semoni*). All sites sampled had 2 – 5 species present except for AE6, where no fish were captured in autumn 2023 (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 autumn 2023.

Species	AE1	AE2	AE3	AE4	AE5	AE6	AE7	AE8	Total
Australian smelt	16	58	0	0	0	0	0	0	**74**
Common galaxias	10	5	0	0	0	0	0	0	**15**
Cox's gudgeon	39	55	0	0	0	0	0	0	**94**
Long-finned eel	1	1	0	0	0	0	0	0	**2**
Short-finned eel	1	3	6	13	1	0	1	2	**27**
Mountain galaxias	0	0	34	54	7	0	91	57	**243**
Total	**67**	**122**	**40**	**67**	**8**	**0**	**92**	**59**	**455**

The most widespread species was Short-finned eels with 27 individuals captured across all sites, except AE6, and ranging in size from 100 – 600 mm total length (TL) (Table 7 and Figure 5). Two Long-finned eels were captured, one at each site AE1 and AE2, measuring 500 and 335 mm (TL), respectively (Table 7). Mountain galaxias were the most abundant species with 243 individuals (comprising 53 % of total number of fish captured) captured across five sites ranging in size from 34 – 94 mm fork length (FL) (Table 7 and Figure 6). Of this total 30 fish were caught in bait traps at site AE7 and one individual at AE8. A total of 94 Cox's gudgeon were caught at sites AE1 and AE2 and ranged in size from 37 – 116 mm (TL) (Table 7 and Figure 7). A total of 74 Australian smelt were

captured at sites AE1 and AE2 and ranged in size from 49 – 67 mm (FL) (Table 7 and Figure 8). This species was undetected in the spring 2022 survey. A total of 15 Common galaxias were captured at sites AE1 and AE2 and ranged in size from 79 – 152 mm (FL) (Figure 9). This species was also undetected in the spring 2022 survey.

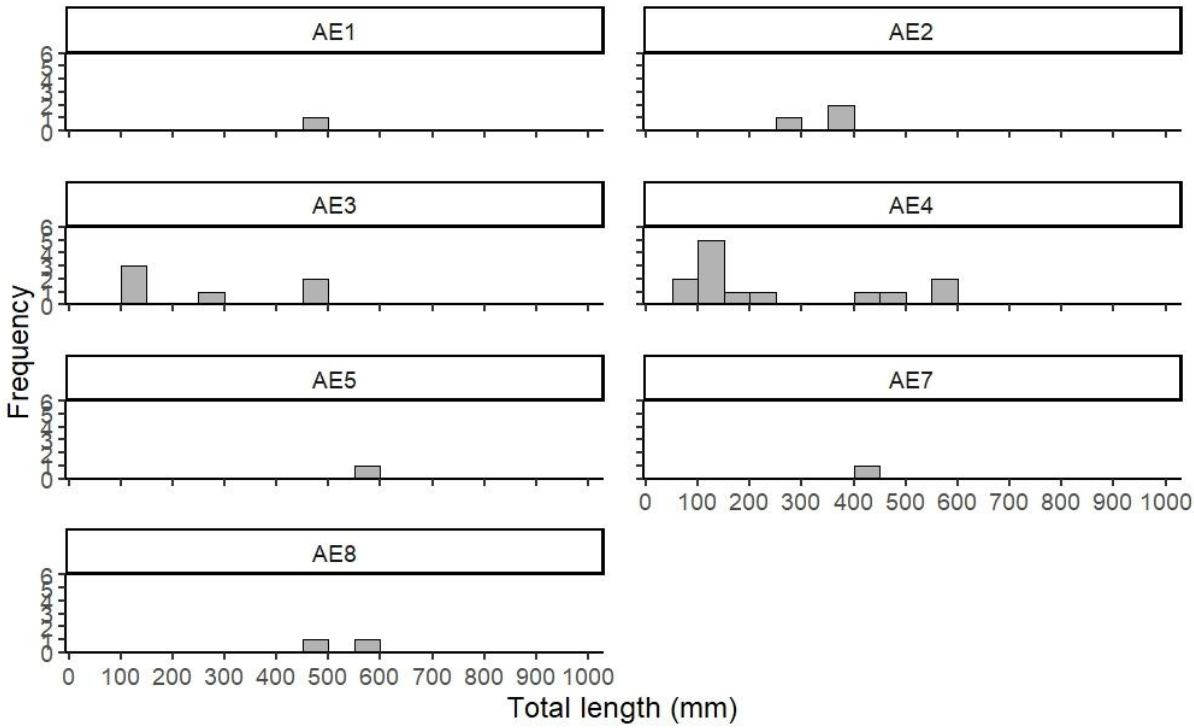

Figure 5. Length frequency of Short-finned eel captured by backpack electrofishing at all sites in autumn 2023.

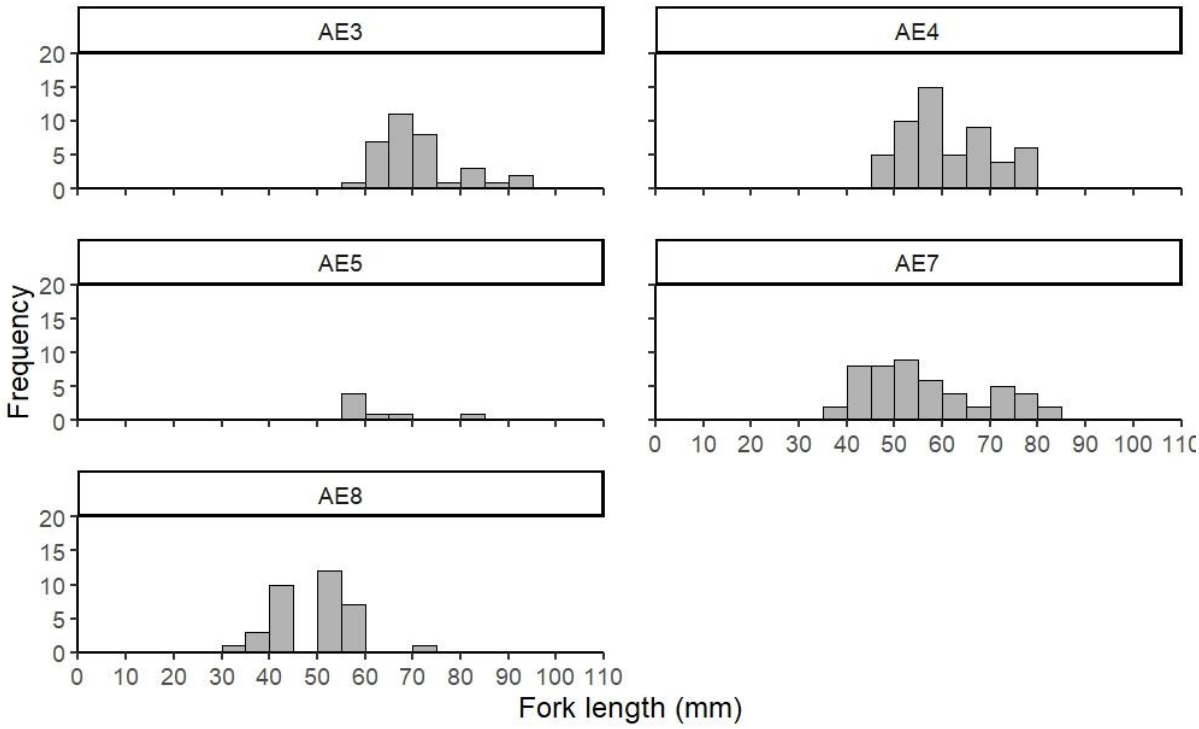

Figure 6. Length frequency of Mountain galaxias captured by backpack electrofishing at five sites in autumn 2023.

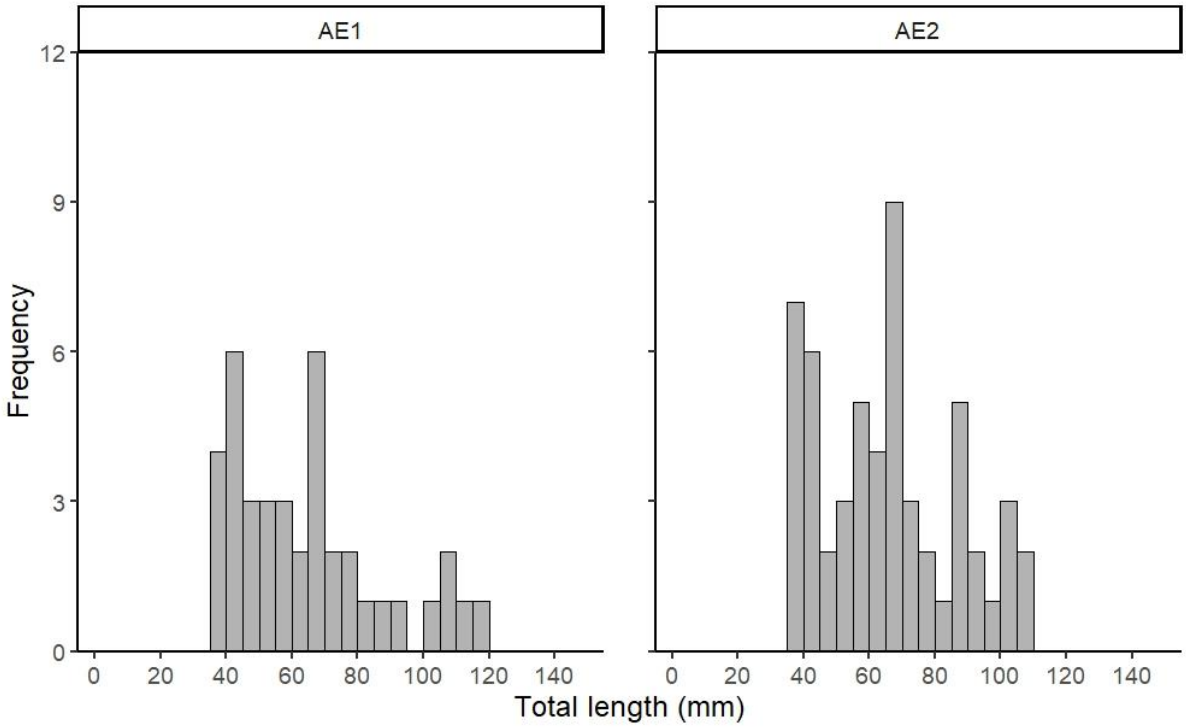

Figure 7. Length frequency of Cox's gudgeon captured by backpack electrofishing at two sites in autumn 2023.

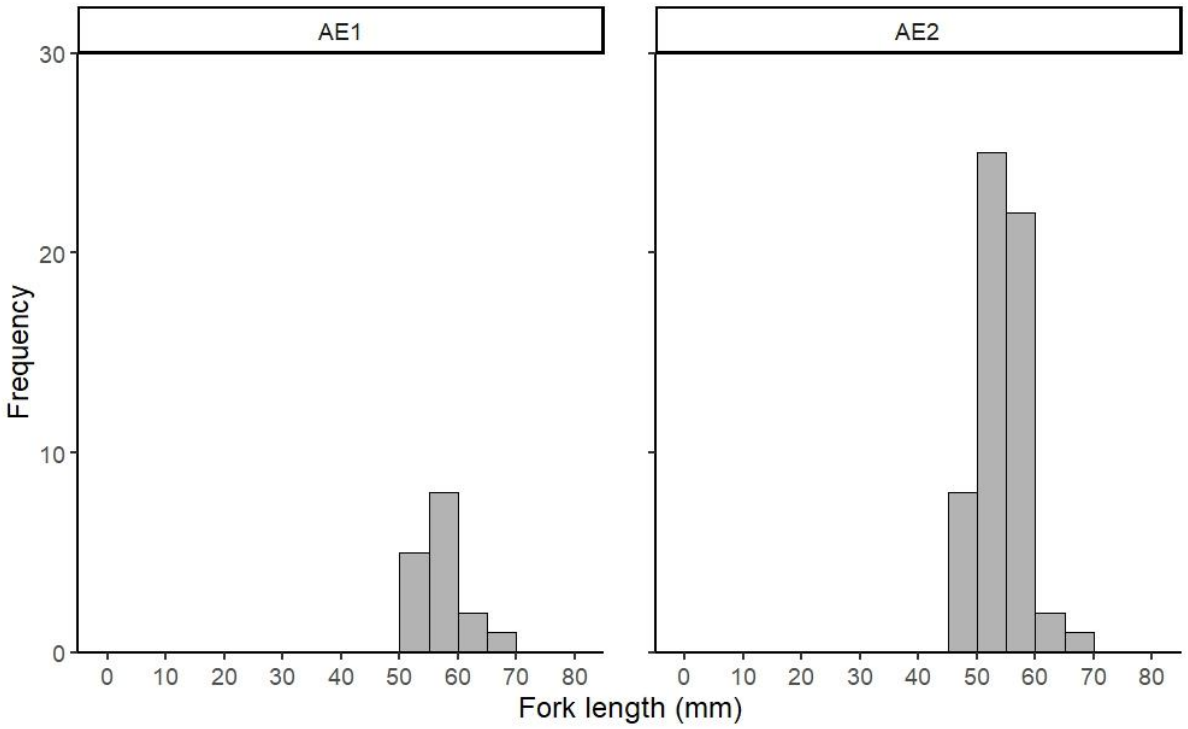

Figure 8. Length frequency of Australian smelt captured by backpack electrofishing at two sites in autumn 2023.

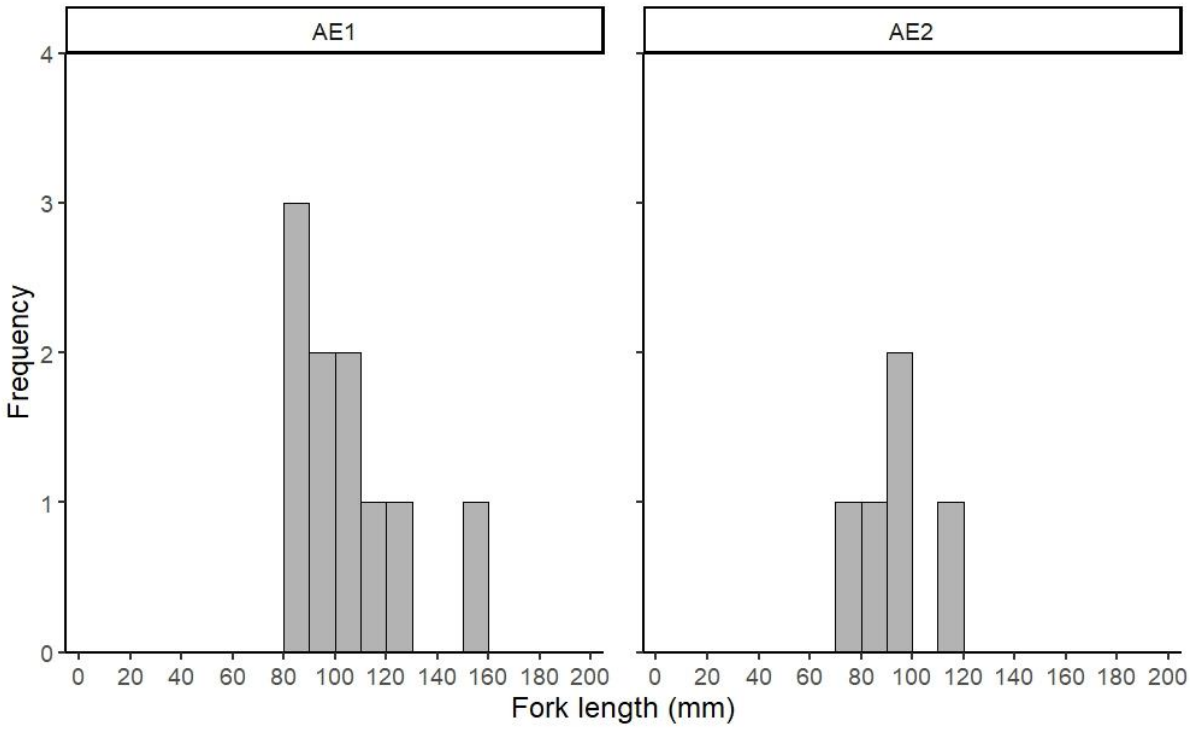

Figure 9. Length frequency of Common galaxias captured by backpack electrofishing at two sites in autumn 2023.

The highest catch rate for Short-finned eels occurred at site AE4 with 78 fish per hour (Table 8). Catch rates for Mountain galaxias were the highest at site AE8 with 469 fish caught per hour followed by AE7 with 366 fish caught per hour (Table 8). The most common size range was between 50 – 70 mm (FL) (Figure 6). Site AE2 had the highest catch rate for Cox's gudgeon and Australian smelt with 330 and 348 fish caught per hour, respectively (Table 8, Figure 7 and Figure 8). The most common size range was between 40 – 70 mm (TL) for Cox's gudgeon and 50 – 60 mm for Australian smelt (Figure 7 and Figure 8).

Table 8. Catch per hour of fish collected in autumn 2023.

Species	AE1	AE2	AE3	AE4	AE5	AE6	AE7	AE8
Australian smelt	96	348	0	0	0	0	0	0
Common galaxias	60	30	0	0	0	0	0	0
Cox's gudgeon	234	330	0	0	0	0	0	0
Long-finned eel	6	6	0	0	0	0	0	0
Short-finned eel	6	18	36	78	6	0	6	16.74
Mountain galaxias	0	0	204	324	42	0	366	468.84

The recovery site AE2 had the most fish caught with 122 out of 455 fish captured and comprised five of the six species detected in autumn 2023 (Table 7). This catch was primarily Australian smelt and Cox's gudgeon and the total catch per hour for the site was 732 fish per hour (Table 8). The total catch per hour across all sites for autumn 2023 was 2682 fish.

Conclusion

Few and generally small rainfall events in the months preceding the autumn 2023 sampling resulted in low baseflow interspersed with small peaks in discharge. 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 autumn 2023.

Macroinvertebrate communities did not significantly differ above and below the DGM. Edge habitat communities collected at the five 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 was similar between spring 2022 and autumn 2023. Total number of taxa increased slightly and the percentage of sensitive taxa increased at six of the seven sites sampled in autumn 2023, compared to the previous survey in 2022 (Clear *et al.* 2023).

Fish communities in autumn 2023 remained in relatively good condition. Two additional species of fish were detected in the autumn 2023 (Australian smelt and Common galaxias) at sites AE1 and AE2, compared to previous surveys (Eco Logical Australia Pty Ltd 2021, Clear *et al.* 2023). Fish diversity increased at sites AE1 - AE2 with the addition of the two extra species and remained the same at the other sites, except AE6 where no fish were caught, when compared to spring 2022 (Clear *et al.* 2023). Overall, an extra 182 fish were captured in autumn 2023 when compared to spring 2022. This increase is likely due to the streams being back at baseflows and with greater visibility, making it easier to wade through the water while backpack electrofishing and catch fish.

In autumn 2023, five different stygofauna taxa were detected across the four bore sites. This is a positive result as only two individuals were detected from one site in spring 2022 and none from the previous five years of sampling. 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) scores remained similar between autumn 2023 and spring 2022 (Clear *et al.* 2023). The only site to change its classification was AE6 which went from ‘very good’ in spring 2022 to ‘good’ in autumn 2023. This was due to the increased algal and macrophyte growth. The flow at AE6 was significantly less in autumn 2023 which made it harder to backpack electrofish resulting in no fish captured and no macroinvertebrate sample was able to be taken. Site AE5 also dropped in its RCE score for the same reasons above, more algal and macrophyte growth plus more sediment on the stream bottom. Less fish were also caught at this site compared to spring 2022 due to the low flow resulting in less fishable water. 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 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

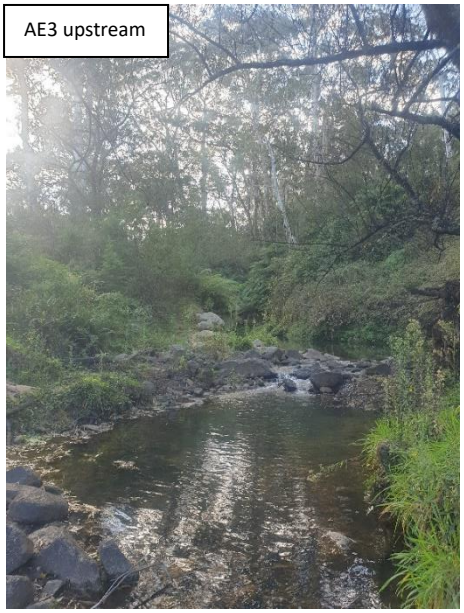
AE2 upstream

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

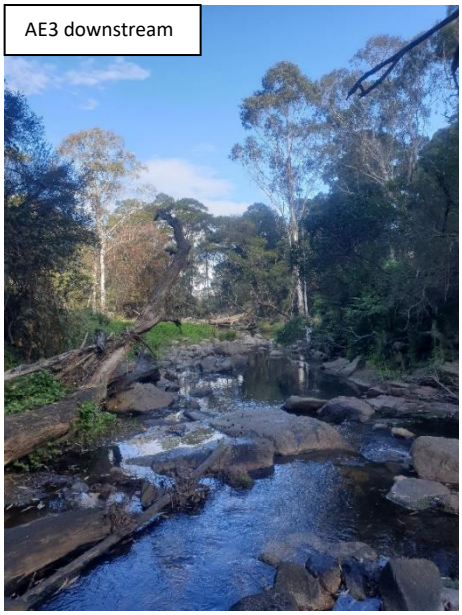
The channel bed consists of cobbles and boulders embedded in sand and gravel. The water was slightly turbid at the time of sampling due to rainfall the previous night. Riffles were present linking the pools. The banks had undercutting due to the floods from the previous two years which exposed the roots 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.

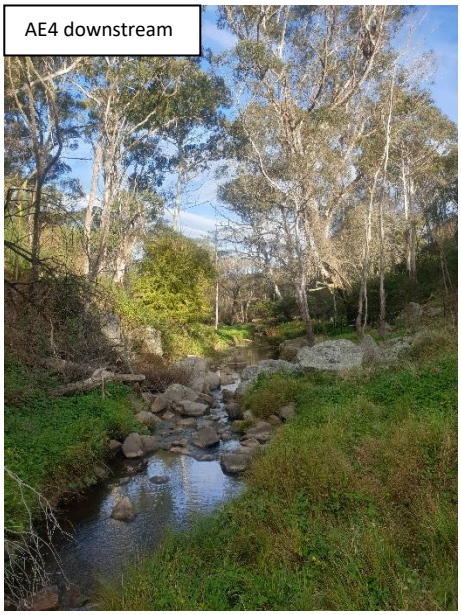
The channel frequently alternated between riffles and pools and consisted of bedrock with cobbles and boulders. Bars of sand and silt were common, and the bottom was heavily silted. Bank undercutting was frequent along the stream and the banks were mainly held by ferns and grasses.

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

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 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

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.

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.