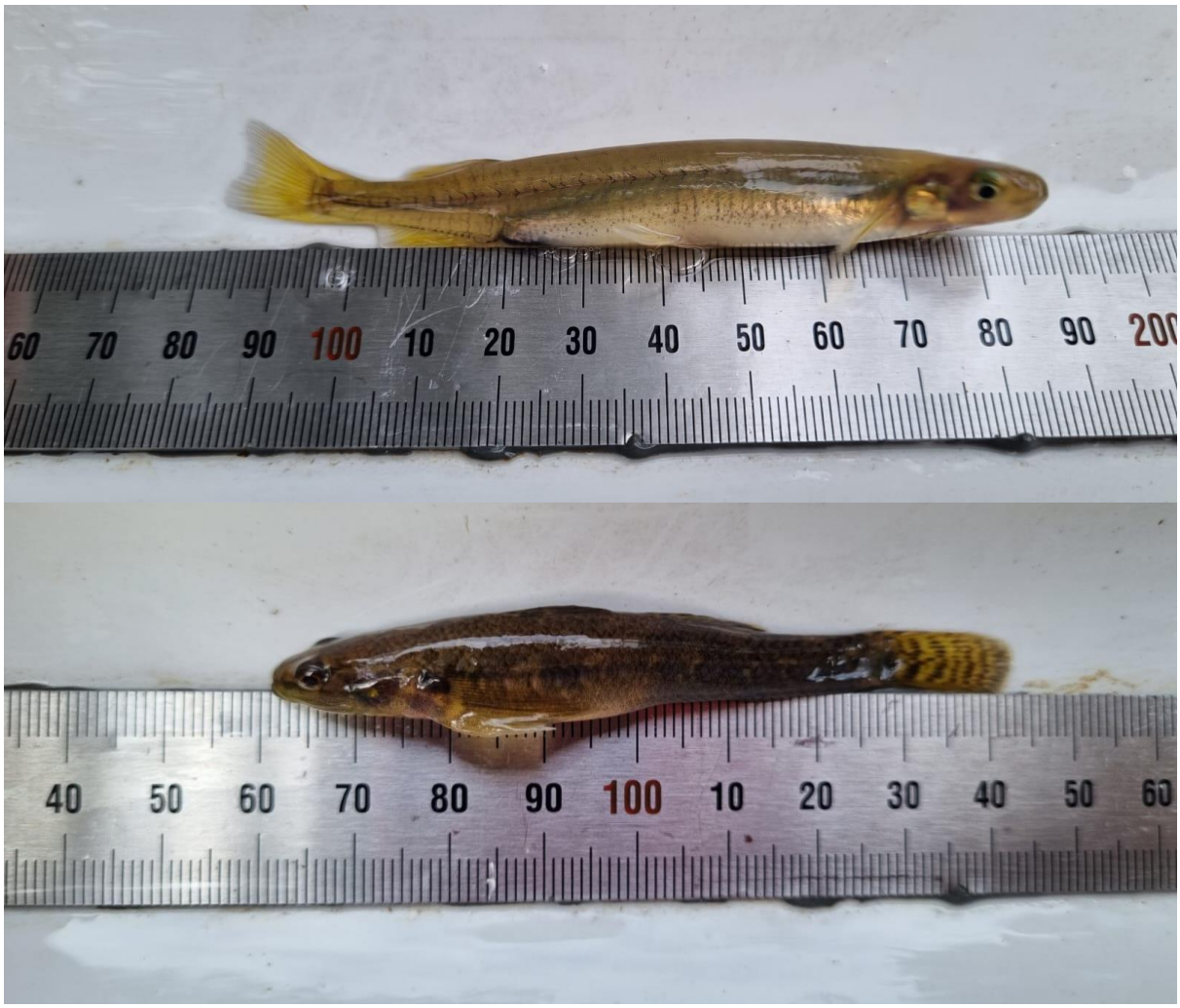
Dargues Gold Mine Aquatic Ecology Monitoring
Autumn 2024



Final report to the Aurelia Metals Ltd
Centre for Applied Water Science
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Executive Summary

This report summarises the autumn 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 April 2024. Four groundwater monitoring bores were also sampled for stygofauna. There was an increase in rainfall events over the summer period and subsequent higher flows. There was also a rainfall event which caused a rapid rise and fall in flow just before sampling.

Riparian condition at each of the sites was classed as either 'good' or 'very 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 'Excellent' to 'Very good' and this was due to the large amounts of sand present, filling in the interstitial spaces, from recent rainfall and large flows. For the third 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 six out of eight sites and dissolved oxygen (% saturation) at one site and pH at one site. These were outside of the Australian and New Zealand Environmental Conservation Council (ANZECC) guidelines.

Fish relative abundance increased slightly between previous and current surveys, with species diversity also increasing. Mountain galaxias (*Galaxias olidus*) were the most abundant species in autumn 2024 (comprising 66 % 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 autumn 2024. Two species not detected in spring 2023 (Australian smelt and Long-finned eel) were again detected in autumn 2024. The increase in abundance and diversity between the previous and current assessment may be attributable to an increase in rainfall and subsequent flows allowing for greater movement of fish within the creeks.

Macroinvertebrate communities had a relatively high taxa richness, with 53 taxa collected in autumn 2024, slightly less than spring 2023. Taxonomic richness ranged from 19 to 37 taxa per site, and SIGNAL Scores were between 4.37 and 6.33 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. Two sites improved in 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 spring 2023. Overall, macroinvertebrate community health had improved between spring 2023 and autumn 2024.

Stygofauna have been detected again in autumn 2024, there were less individuals, but more species captured when compared to spring 2023. This is still a positive result as they are an important indicator of ecosystem health.

Ecological conditions in autumn 2024 have improved since the spring 2023 survey in relation to the fish and macroinvertebrate communities. Macroinvertebrate community health and fish numbers and diversity have increased since spring 2023. These results are likely due to increased rainfall

events in the months preceding sampling resulting in higher flows and greater connectivity in the creeks.

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 third 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 2024 survey.

Methods

Autumn samples were collected on the 18th – 19th April 2024. Temperatures ranged from 6.2 – 19°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).

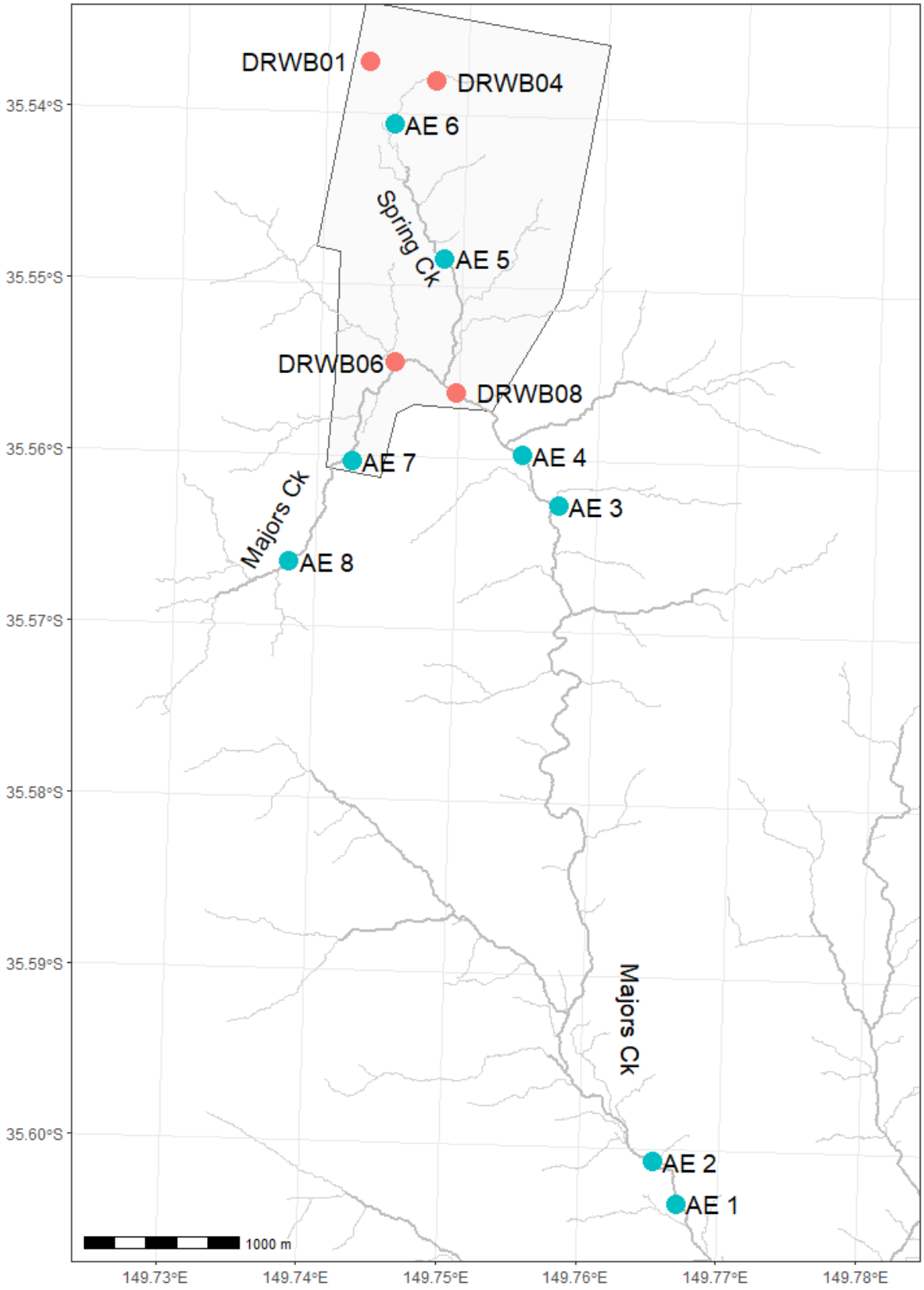

Figure 1. Map of sampling sites for the Dargues gold mine aquatic ecology monitoring program

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). 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 autumn 2024.

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	-	-	-	-
AE7	90	200	600	10:00
AE8	90	200	490	8:10

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 2023, there was an increase in rainfall events over the summer period and subsequent higher flows. There was also a rainfall event which caused a rapid rise and fall in flow just before sampling in April 2024 (Figure 2).

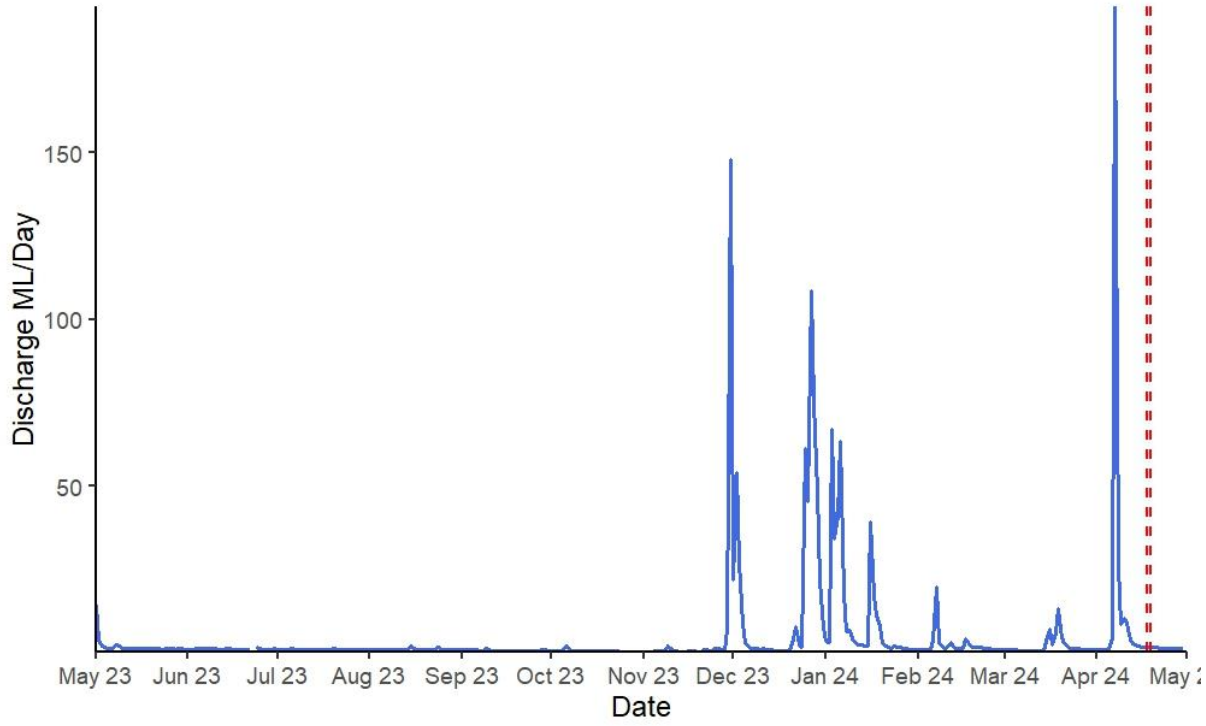

Figure 2. Discharge from Majors Creek (taken from station SW6) from May 2023 – May 2024. Red dashed lines indicate sampling dates for the autumn 2024 assessment.

Physical and chemical water quality assessment

Water temperatures ranged between 12.8 – 16.21°C at site AE8 and AE4, respectively, during the autumn 2024 survey (Table 2). The pH ranged from 6.11 – 8.31 and was within the ANZECC guideline range for all sites except one, AE2 (Table 2).

Electrical conductivity (EC) measurements tended to increase with distance downstream from the second most upstream site AE7 on Majors creek. At site AE7 the EC was 214 µS/cm which increased to 439 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 786 µS/cm, which is over three times higher than the 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 2024.

Parameter	ANZECC Range	AE1	AE2	AE3	AE4	AE5	AE6	AE7	AE8
Temperature (°C)		14.31	14.4	14.66	16.21	13.61	14	15.9	12.8
pH	6.5 – 8.0	7.94	**8.31**	7.9	7.53	7.73	7.78	7.39	6.11
EC (µS/cm)	30 - 350	**439**	**436**	**439**	**360**	**786**	**455**	214	218
Turbidity (NTU)	2 - 25	0	0	0.4	1.8	0.5	1.9	1.4	4.6
Dissolved oxygen (mg/L)		9.93	10.15	9.52	9.61	9.14	7.7	10.7	6.4
DO (% saturation)	90 - 110	99.5	102.4	101.9	106.3	96.2	82	**112.6**	66
Salinity (ppt)		0.21	0.21	0.21	0.17	0.38	0.22	0.1	0.1
Alkalinity (ppm)		65	65	60	60	85	92	55	40
TDS (g/L)		0.285	0.283	0.285	0.234	0.503	0.296	0.139	0.149

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

Total dissolved solids (TDS) and salinity measurements also increased at site AE5, with readings of 0.50 g/L and 0.38 ppt, respectively. Turbidity measurements were within the ANZECC range for all sites in autumn 2024 (Table 2). DO concentrations (% saturation) were slightly above the ANZECC range at site AE7 (Table 2). Alkalinity ranged between 40 – 92 ppm across all sites. The highest occurring at the 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 54% (AE7) at the second most upstream site to 81% (AE1 and AE2) at the most downstream sites (Table 3). No sites scored in the 'Excellent' range, five 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 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	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	2	2	2	2	2	3	2	2
Stream bottom	3	3	2	2	2	2	2	1
Stream detritus	1	1	2	2	2	2	1	2
Aquatic vegetation	4	4	3	3	1	1	1	1
RCE Score	**42**	**42**	**39**	**36**	**34**	**30**	**28**	**29**
RCE Score %	**80.8**	**80.8**	**75.0**	**69.2**	**65.4**	**57.7**	**53.8**	**55.8**
Condition rating	**Very Good**	**Very Good**	**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 54 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 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 'Very good' in their condition rating in autumn 2024 dropping from 'Excellent' in spring 2023. This was due to the increased amount of sand and lack of stream detritus present at these sites.

Macroinvertebrate communities

A total of 2000 invertebrates were collected in autumn 2024 survey, comprising 53 taxa (Table 4). Macroinvertebrate samples were collected from five edge habitats and four riffle habitats (Table 5). Four families occurred at all sites sampled in autumn 2024, which included Leptophlebiidae*, Baetidae, Orthocladiinae and Oligochaeta from highest to lowest relative abundance (Table 4). During this period, edge habitats had between 23 and 28 taxa at impacted sites (AE3 – AE5) while reference sites (AE6 – AE8) had between 19 and 37 taxa (Table 5). No edge samples were taken at the recovery sites (AE1 – AE2) but the riffle habitats had between 21 and 28 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 autumn 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 autumn 2024.

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
Lymnaeidae	1	Not sampled due to lack of suitable edge habitat		Not sampled due to lack of suitable edge habitat				2			Not sampled due to lack of suitable edge habitat	7	4
Planorbidae	4		1				2					1	17
Physidae	1					1		6		10		14	
Pelecypoda													
Sphaeriidae	5									1			
Oligochaeta	2		5		2	1	24	4	6	4		2	15
Acarina	6		1				1					3	
Coleoptera													
Dytiscidae	2					28				13		5	
Elmidae (Adult)	7		3		2			1				11	
Elmidae (Larvae)	7				2	1	2						
Hydrophilidae	2		2			6		1		1		1	8
Hydraenidae	3											1	
Scirtidae	6		1					1					
Psephenidae	6		5		3	1	4		10			1	
Gyrinidae	4											1	
Hygrobiidae	4									2			
Diptera													
Tipulidae	5		2		4		1		4			1	4
Ceratopogonidae	4							1				2	
Simuliidae	5		3		26	1	2		27				
Dixidae	7		3					4		2		4	
Stratiomyidae	2		1					5		4		3	2
Tanypodinae	**4**		2			1		5		1		1	1
Orthocladiinae	**4**		7		2	10	10	15	10	7		15	6
Chironominae	**3**		4		1	1		2	2	1		2	11
Ephemeroptera													
Baetidae	5		46		29	10	9	15	56	12		2	2
Leptophlebiidae	8		65		49	43	83	37	31	23		3	3
Caenidae	4		2			15	5	11	3	59		27	2
Hemiptera													
Gerridae	4					2							
Veliidae	3					7	1		6	3		11	11
Notonectidae	3							2		22		3	
Micronectidae	2					15	7	4	4	4			10
Corixidae	2					24							8
Hydrometridae	3									1		1	
Megaloptera													
Corydalidae	7		8		14		27		17				
Odonata													
Aeshnidae	4									11			
Gomphidae	5		4		3	2	4		3			1	
Coenagrionidae	2									14			
Argiolestidae	5											1	
Synlestidae	7					5		5		5		6	
Telephlebiidae	9				1	1				1		2	1
Plecoptera													
Gripopterygidae	8		17		19	1	10		2			4	
Trichoptera													
Hydrobiosidae	8		10		13	1	12		16			2	
Calamoceratidae	7		1			3	1					1	
Helicopsychidae	8		1				4					1	
Hydroptilidae	4									1		4	
Philopotamidae	8		12		25		30	1	20				
Philorheithridae	8							1					
Hydropsychidae	6		4		17				5	1			
Polycentropodidae	7				2		8		12				
Ecnomidae	4		1						1	2		3	
Conoesucidae	8		3		2			1	1	4		4	1
Calocidae	9		5		6	3		8		2		8	12
Leptoceridae	6				2	23	1	75	1	43		44	82
Tasimiidae	8						1						
No. of individuals			219		224	206	249	207	237	254		203	200
No. of taxa			28		21	25	23	23	21	28		37	19
% of sub-sample			100		100	100	100	100	100	100		100	100
Whole sample estimate			**219**		**224**	**206**	**249**	**207**	**237**	**254**		**203**	**200**

Table 5. Macroinvertebrate community indices for autumn 2024.

Result	AE1	AE2	AE3		AE4		AE5	AE6*	AE7	AE8
	Riffle	Riffle	Edge	Riffle	Edge	Riffle	Edge		Edge	Edge
Total taxa	28	21	25	24	23	21	28	-	37	19
Average SIGNAL score	5.64 ± (0.39)	6.33 ± (0.42)	4.92 ± (0.49)	5.58 ± (0.44)	4.83 ± (0.54)	5.43 ± (0.44)	4.39 ± (0.43)	-	4.89 ± (0.38)	4.37 ± (0.58)
Proportion of sensitive taxa	76.3	73.2	48.1	65.6	72.0	62.4	57.9	-	50.7	51.0
Site SIGNAL score	6.10	6.63	4.64	5.89	5.00	5.80	4.28	-	4.93	4.27

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

The average SIGNAL scores for each site ranged from 4.37 at AE8 to 6.33 at AE2 in autumn 2024 (Table 5). AE8 had the lowest site SIGNAL score and AE3 (edge) had lowest proportion of sensitive taxa (Table 5). For edge communities, site SIGNAL scores at reference sites were 4.27 – 4.93, indicating moderate pollution to mild pollution, respectively. For the impacted sites (AE3 – AE5) the site SIGNAL scores ranged between 4.28 – 5.0 for edge communities, indicating moderate pollution. Riffle habitats had higher site SIGNAL scores than edge habitats with scores ranging from 5.8 – 6.63 (Table 5). All sites where edge samples were collected had site SIGNAL scores ranging from 4.27 – 5.0 (Table 5). Two sites, AE3 and AE7, were assessed as being in the same condition quadrant (Quadrant 2: community impairment, often caused by high salinity or nutrient levels) as they were in the spring 2023 sampling (Figure 3). Site AE4, AE5 increased in condition from Quadrant 4 (urban, industrial, or agricultural pollution, or downstream effects of dams) in spring 2023 to Quadrant 2 in autumn 2024. AE8 remained in Quadrant 4 (urban, industrial, or agricultural pollution, or downstream effects of dams) for the autumn 2024 assessment (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 = 0.700) (Figure 4).

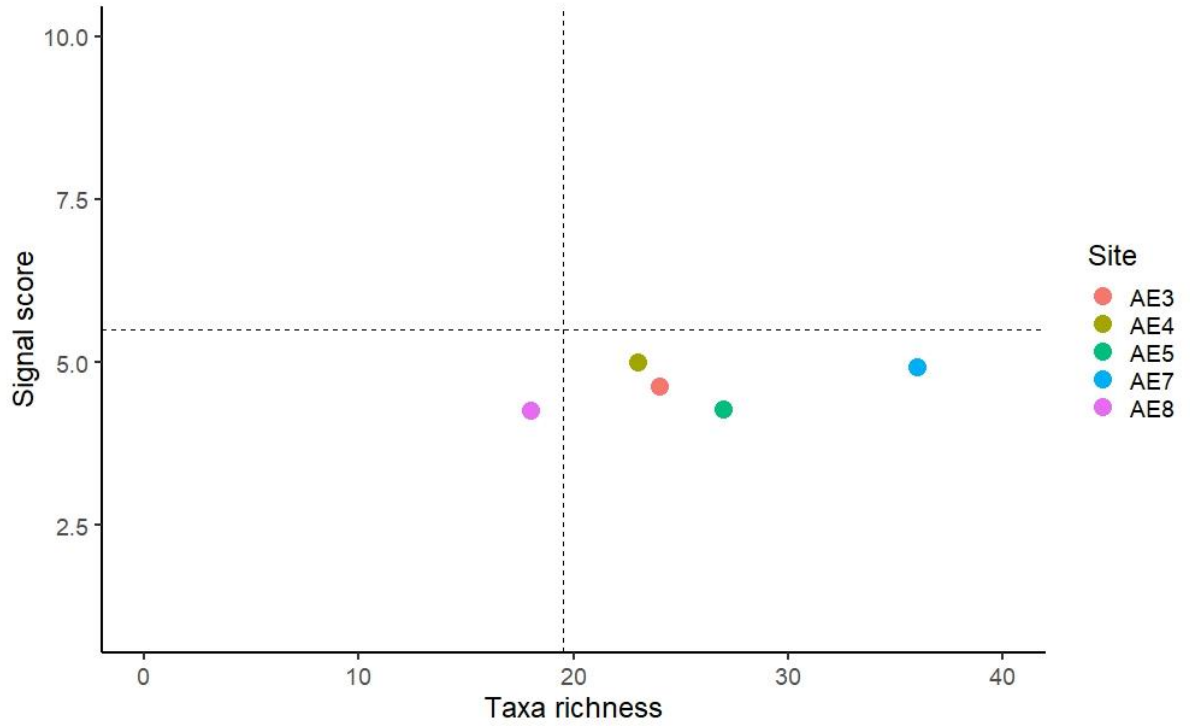

Figure 3. Biplot of macroinvertebrate communities collected from edge samples in autumn 2024. Dotted lines indicate the location of quadrants for interpretation of site SIGNAL results (from Chessman 2001).

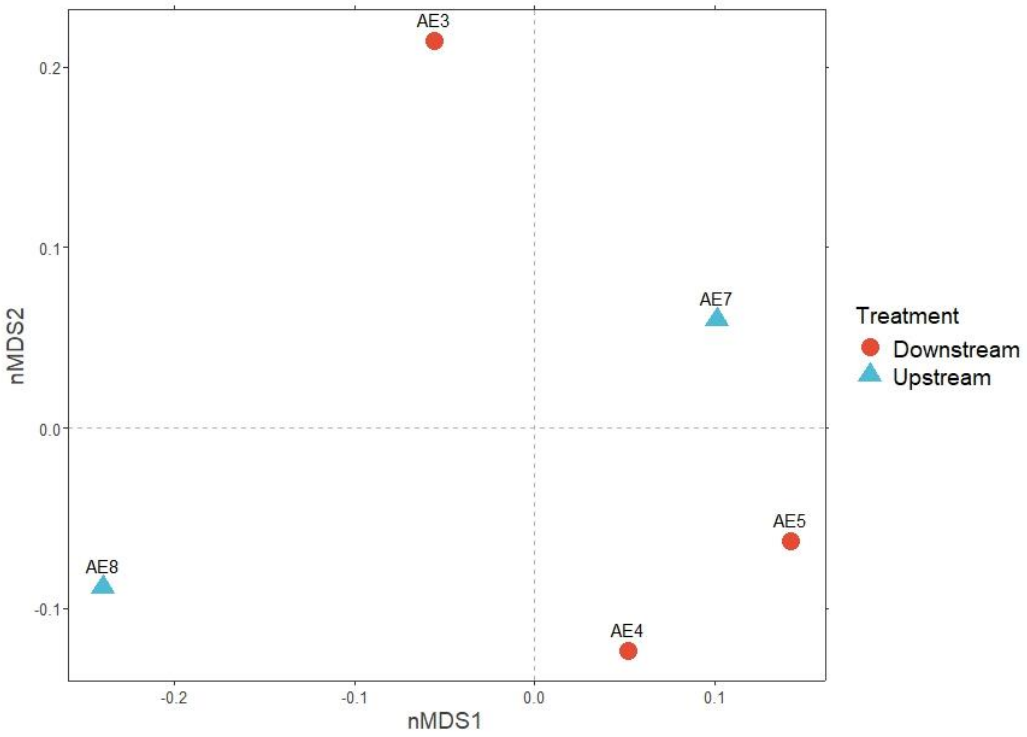

Figure 4. nMDS comparison of macroinvertebrate communities at edge habitats upstream (red) and downstream (blue) of Dargues Gold Mine for autumn 2024.

Stygofauna communities

Four bores were sampled (1, 4, 6 and 8) in autumn 2024. Two bores had stygofauna present with bore 4 having two species present and bore 6 having one species. There was a total of three individuals captured across the two bores (Table 6).

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

Site	Taxa	Total
DRWB04	Parabathynellidae	1
DRWB04	Isotomidae	1
DRWB06	Naididae	1

*Taxa identified to lowest taxonomic level.

Fish communities

Six species of fish were captured in autumn 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 1 – 5 species present except for AE6, where no sampling occurred in autumn 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 autumn 2024.

Species	AE1	AE2	AE3	AE4	AE5	AE6	AE7	AE8	Total
Australian smelt	1	5	0	0	0	0	0	0	**6**
Common galaxias	1	1	0	0	0	0	0	0	**2**
Cox's gudgeon	15	14	0	0	0	0	0	0	**29**
Long-finned eel	1	1	0	0	0	0	0	0	**2**
Short-finned eel	1	1	0	11	2	0	2	2	**19**
Mountain galaxias	0	0	20	27	16	0	43	10	**116**
Total	**19**	**22**	**20**	**38**	**18**	**0**	**45**	**12**	**174**

The most widespread species were Short-finned eels captured at six out of eight sites (Table 7). Nineteen Short-finned eels were captured ranging in size from 100 – 600 mm total length (TL) (Table 7 and Figure 5). Mountain galaxias were the most abundant species with 116 individuals (comprising 67 % of total number of fish captured) captured across five sites ranging in size from 38 – 86 mm fork length (FL) (Table 7 and Figure 6). A total of 29 Cox's gudgeon were caught at sites AE1 and AE2 and ranged in size from 41 – 81 mm (TL) (Table 7 and Figure 7). Six Australian smelt total were captured at sites AE1 and AE2 and ranged in size from 54 – 61 mm (FL) (Figure 8). A total of two Common galaxias were captured at sites AE1 and AE2 and ranged in size from 100 – 107 mm (FL). Two Long-finned eels total were captured at sites AE1 and AE2 and ranged in size from 400 – 600 mm (TL). This species and Australian smelt were undetected in the spring 2023 survey.

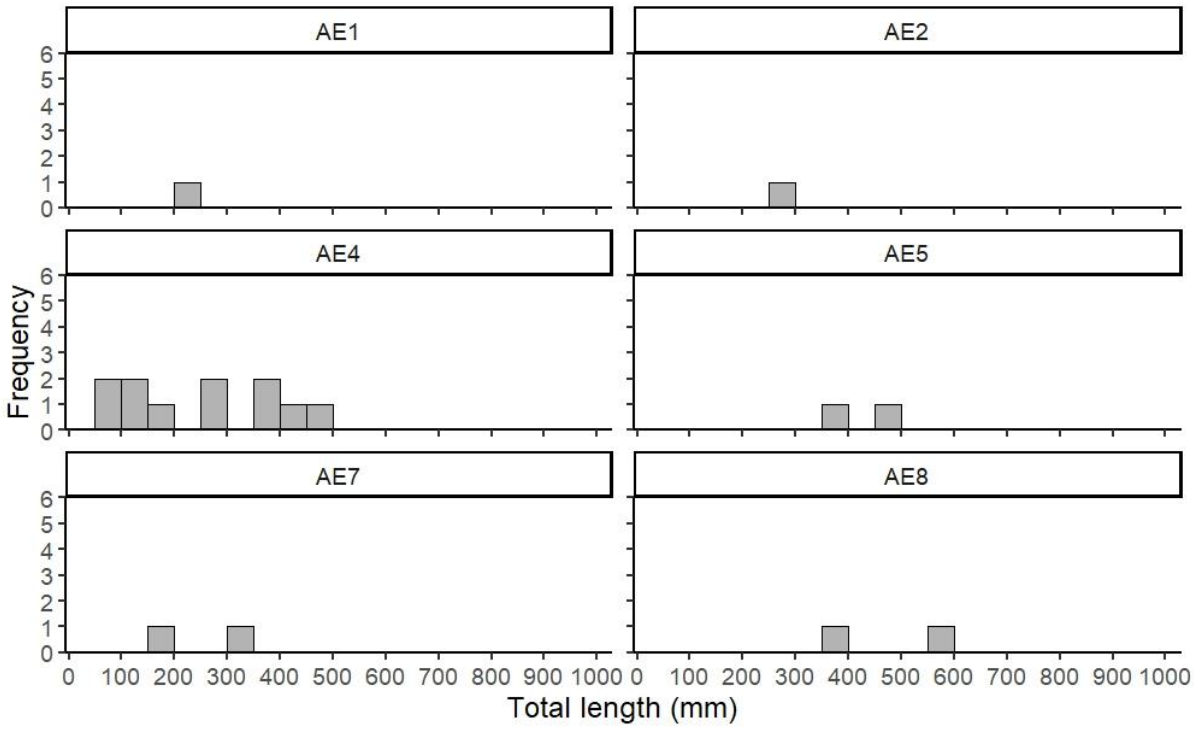

Figure 5. Length frequency of Short-finned eel captured by backpack electrofishing at six sites in autumn 2024.

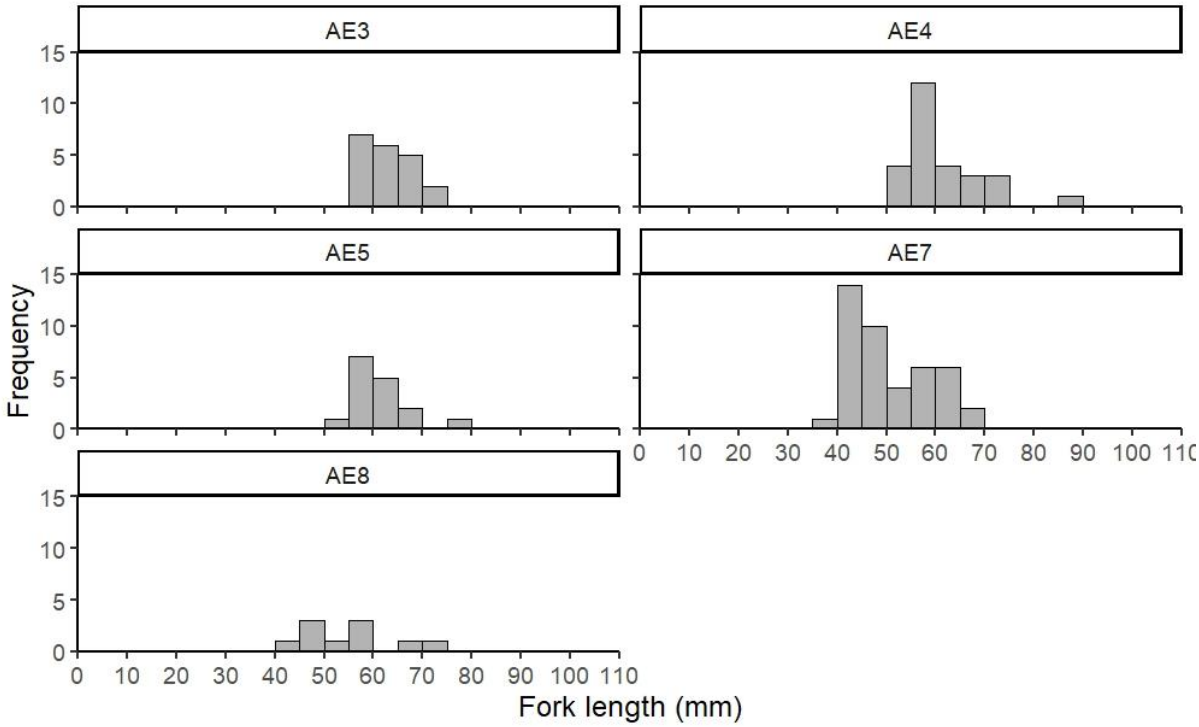

Figure 6. Length frequency of Mountain galaxias captured by backpack electrofishing at five sites in autumn 2024.

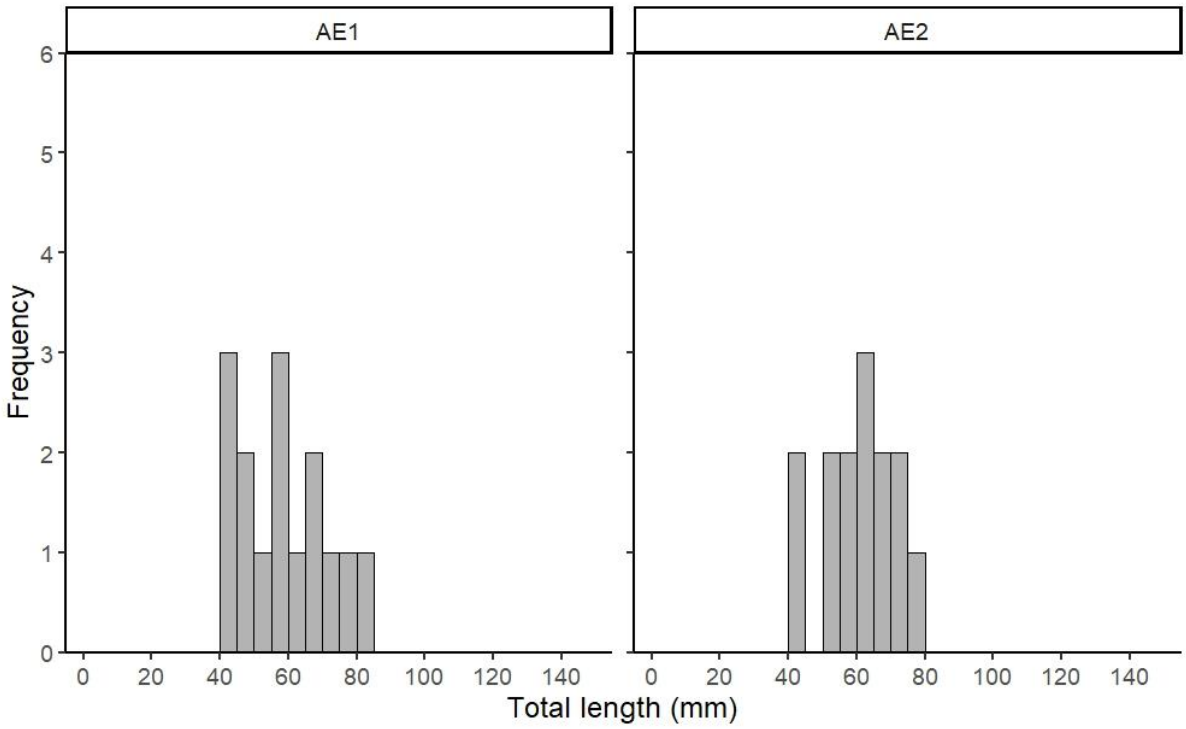

Figure 7. Length frequency of Cox's gudgeon captured by backpack electrofishing at two sites in autumn 2024.

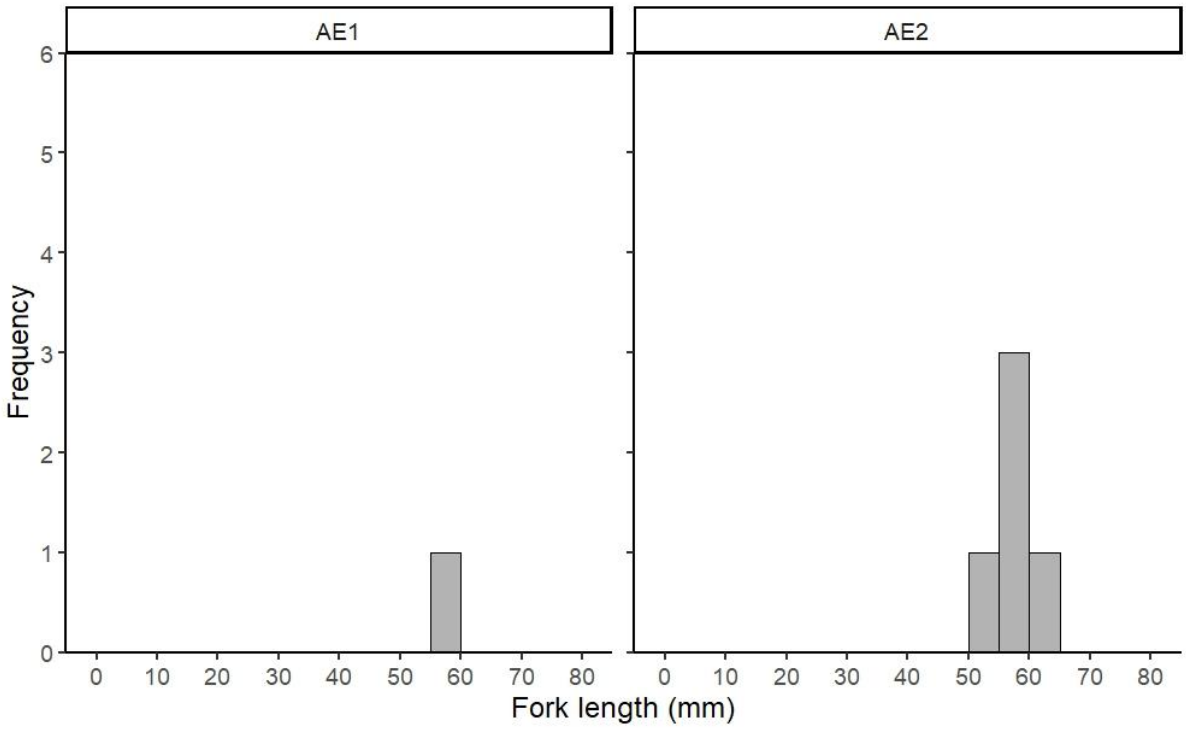

Figure 8. Length frequency of Australian smelt captured by backpack electrofishing at two sites in autumn 2024.

The highest catch rate for Short-finned eels occurred at site AE4 with 66 fish per hour (Table 8). Catch rates for Mountain galaxias were the highest at site AE7 with 258 fish caught per hour followed by AE4 with 162 fish caught per hour (Table 8). The most common size range was between 50 – 70 mm (FL) (Figure 6). Site AE1 had the highest catch rate for Cox's gudgeon with 90 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 autumn 2024.

Species	AE1	AE2	AE3	AE4	AE5	AE6	AE7	AE8
Australian smelt	6	30	0	0	0	0	0	0
Common galaxias	6	6	0	0	0	0	0	0
Cox's gudgeon	90	84	0	0	0	0	0	0
Long-finned eel	6	6	0	0	0	0	0	0
Short-finned eel	6	6	0	66	12	0	12	14.69
Mountain galaxias	0	0	120	162	96	0	258	73.47

The reference site AE7 and impact site AE4 both had the most fish caught with 45 and 38 each out of 174 fish captured and comprised two species each, respectively, in autumn 2024 (Table 7). This catch was Short-finned eels and Mountain galaxias at AE7 with a total catch per hour of 270 fish for the site and the same two species at AE4 and the total catch per hour for the site was 228 fish (Table 8). The total catch per hour across all sites for autumn 2024 was 1060 fish.

Conclusion

In contrast to spring 2023, there was an increase in rainfall events over the summer period and as result produced higher flows and a number of high flow peaks. A large flow event occurred just prior to the current survey. 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 2024.

Macroinvertebrate communities did not significantly differ above and below the DGM. Two of the five edge habitat communities collected remained in the same condition quadrant (Quadrant 2) as they were in spring 2023 (AE3 and AE7) which showed some impairment, and grouped out as sites that are often impaired by salinity or nutrient levels (Chessman 2001). Site AE4 and AE5 increased in condition from Quadrant 4 (urban, industrial, or agricultural pollution, or downstream effects of dams) in spring 2023 to Quadrant 2 in autumn 2024. AE8 remained in Quadrant 4 (urban, industrial, or agricultural pollution, or downstream effects of dams) for the autumn 2024 assessment (Chessman 2001). Overall, macroinvertebrate community health had improved between spring 2023 and autumn 2024. Although total number of taxa decreased, taxa richness from edge samples increased at three of five sites and the percentage of sensitive taxa also increased at three sites ranging from 24 – 33% increase when compared to spring 2023 (Clear *et al.* 2023).

Fish communities in autumn 2024 improved in abundance and number of species compared to the spring 2023 survey. Two species of fish that were not detected in spring 2023 (Australian smelt and Long-finned eel) were again captured in the autumn 2024 survey (Clear *et al.* 2023). Fish diversity increased at sites AE1, AE2, AE5 and AE8 and remained the same at sites AE4 and AE7, and decreased at site AE3 with no Short-finned eels detected, when compared to spring 2023 (Clear *et al.* 2023). Overall, there was an increase of 39 fish captured in autumn 2024 when compared to spring 2023.

In autumn 2024, three different stygofauna taxa were detected from two of the four bore sites. There was one more species detected but less individuals when compared to spring 2023 (Clear *et al.* 2023). The three species detected were different to those found in spring 2023. 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 spring 2023 (Clear *et al.* 2023). The condition rating went from 'Excellent' to 'Very good' for these sites and this was due to the large amounts of sand present, filling in the interstitial spaces, from recent rainfall and large flows. The condition ratings and RCE scores remained the same for the other six sites when compared to spring 2023 (Clear *et al.* 2023). The low flow and overgrowth of submerged and emergent macrophytes at AE6 in autumn 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 the autumn 2023 and spring 2023 sampling, for the same reasons, more algal and macrophyte growth plus more sediment on the stream bottom. More fish and an extra species (Short-finned eel) were caught at this site compared to spring 2023 (Clear *et al.* 2023). Like the previous two 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 historic agricultural and mining activities and current hydrological regime.

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Appendix A – Site Photos

Site AE1

AE1 upstream

AE1 downstream

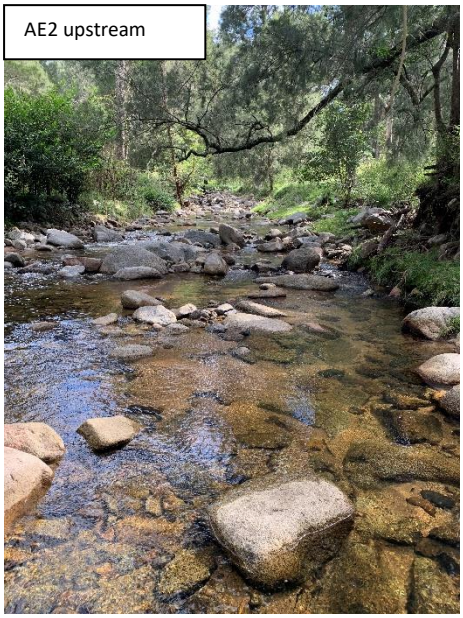
This site is 5 km downstream of Dargues gold mine near Araluen. It is sparsely vegetated with both native and exotic species.

The channel bed consists of cobbles and boulders embedded in sand and gravel. The water was clear and low at the time of sampling. Riffles were present linking the pools. There was a large amount of sand present filling in the interstitial spaces as a result from recent heavy rains and subsequent high flows. There was little to no detritus present.

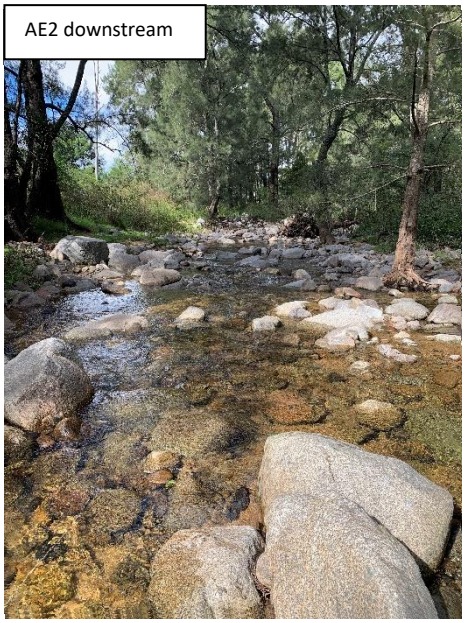
The trees and shrubs in the riparian corridor along the stream were mostly native with casuarina being the dominant species.

Site AE2

AE2 upstream



AE2 downstream

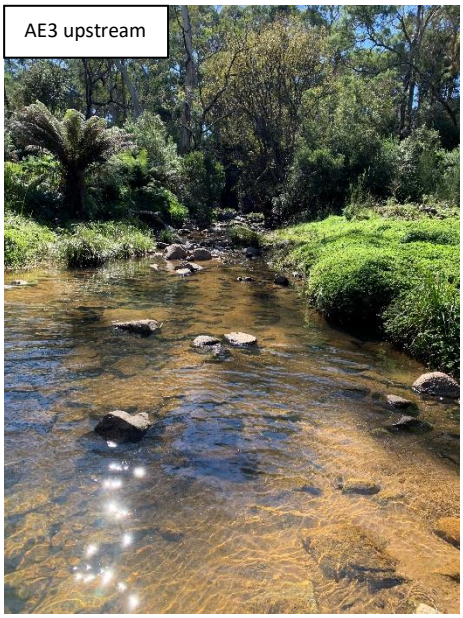


This site is 400m upstream of AE1 and downstream of Dargues gold mine. The surrounding land and vegetation are the same as AE1.

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 a large amount of sand present filling in the interstitial spaces as a result from recent heavy rains and subsequent high flows. There was little to no detritus present. 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 and covered in sand from recent high flows. 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 and the bottom was mainly covered with sand from recent high flows. Bank undercutting was frequent along the stream the banks were held by grasses and sedges.

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 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 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. 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.

The water was slightly 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.