Appendix 35 Myara – Carter's Freshwater Mussel Targeted Survey

Alcoa Myara – Carter's Freshwater Mussel Targeted Survey

Myara,
Huntly Mine

Alcoa of Australia Limited

181-205 Davy Street, Booragoon WA 6154

Prepared by:

SLR Consulting Australia

SLR Project No.: 675.VX5890.00002

Client Reference No.: Myara Huntly CFM Survey

04 June 2024

Revision: 01

Revision Record

Revision	Date	Prepared By	Checked/ Authorised By	Details
01	15 May 2024	JM	NN	
02	17 May 2024	JM	NN	

Basis of Report

This report has been prepared by SLR Consulting Australia (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Alcoa of Australia Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

Table of Contents

Tables in Text

Figures in Text

Photos in Text

1.0 Introduction

1.1 Background

Alcoa of Australia Limited (Alcoa) operates Huntly and Willowdale bauxite mines in the Darling Ranges located south-east of Perth, Western Australia. Alcoa committed to undertaking pre-clearance surveys for Carter's Freshwater Mussel (*Westralunio carteri*) within the Huntly Mine, Myara region as part of Alcoa's Mining and Management Program (MMP) assessment. Carter's freshwater mussel (CFM) is listed as a Vulnerable threatened species under the *Biodiversity Conservation Act 2016* (state, Western Australia), the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) and the IUCN Redlist of Threatened Species 2020 (International).

Historical records have identified the presence of CFM in the Serpentine River which is approximately 12km downstream of the survey area. A previous fauna survey of the area surrounding the serpentine dam conducted by GHD identified that the species is known to reside in Serpentine Dam, and mussels may disperse upstream during winter/spring flows as larvae (glochidia) attached to migrating fish but are unlikely to survive the extended dry summer period (GHD 2021).

A targeted survey for CFM at Myara was undertaken by SLR in October 2023. Six sites were targeted within the proposed survey area with only three sites successfully sampled and the remaining three sites being dry. Monitoring was conducted along the length and width of inundated channel areas at the site locations – employing visual observations for shells, manual hand sorting through benthic sediments, and the gentle use of mussel rakes and wire baskets where water depth allowed. These targeted survey methods for CFM followed that of Klunzinger *et al.* (2012) and the *Technical Guidance – Terrestrial vertebrate fauna surveys for environmental impact assessment* (EPA, 2020).

1.2 Scope of works

The scope of work for the Myara CFM survey of the proposed location is:

- Review previous CFM studies of this region.
- Conduct a targeted field search for Carter's Freshwater Mussel at the proposed survey location.
- Prepare a report suitable for Alcoa to:
    - amend the preliminary designs to avoid significant fauna;
    - inform translocation and construction management plans as required; and
    - assist Alcoa in preparing MMP submission to the MMPLG.
- Provide any GIS data in accordance with IBSA requirements.

2.0 Carter's freshwater mussel

Westralunio carteri, Carter's freshwater mussel (CFM; **Photo 1**), is listed as a Vulnerable threatened species under the *Biodiversity Conservation Act 2016* (state, Western Australia), the Environment Protection and *Biodiversity Conservation Act 1999* (Commonwealth) and the IUCN Redlist of Threatened Species 2020 (International). The current distribution of CFM is limited to within 50-100 km of the coast from Gingin Brook in the north, to the Kent River and Waychinicup River along the southern coast (Klunzinger & Walker 2014, Klunzinger *et al*. 2015). CFM is limited to Australia's southwest and was long considered to be the only Westralunio species in Australia. However new research confirms the existence of three evolutionary lineages of the Carter's freshwater mussel, the original *Westralunio carteri* from western coastal drainages and two significantly smaller and less elongated subspecies: *Westralunio inbisi inbisi* from southern coastal drainages, and *Westralunio inbisi meridiemus* from the southwestern corner.

CFM occurs in greatest abundance in slower flowing permanent/semi-permanent stream and riverine habitats with stable sediments and low salinity, living two thirds to almost fully buried in sand and finer sediment (Klunzinger *et al.* 2010, Klunzinger 2012). Klunzinger (2012) only found CFM in perennial (permanent/semi-permanent) stream and riverine habitats, and dehydration exposure experiments demonstrated CFM cannot survive prolonged drying (i.e., 76% mortality occurring under experimental conditions, within five days of exposure to dry conditions in sand filled bath tubs) (Lymbery *et al.* 2021). CFM also occurs in lentic (still water) waters including large water supply dams and on-stream farm dams (Klunzinger *et al*. 2015, DWER 2022). CFM require perennial streams or shallow pools or damp mud to retreat to during low water levels and drought. However, they may survive in seasonally-flowing creeks if the period of zero flow is sufficiently short, and/or there are residual pools or low lying areas that remain damp/wet.

Freshwater mussels (Bivalvia: Unionoida) are a keystone species in freshwater ecosystems due to their filter-feeding ability, the important role they play in nutrient cycling and bio-deposition, as well as the structural habitat and the food source they provide for other organisms (Klunzinger *et al.* 2014, Vaughn and Hakenkamp 2001, Spooner and Vaughn 2008). Freshwater mussel species are endangered throughout the world with a multitude of threats influencing their persistence and survival.

Photo 1. *Westralunio carteri* Carter's freshwater mussel. Photo by B. Clark, SLR Consulting.

The CFM lifecycle involves an obligate parasitic 'larval' stage, known as glochidia, which attach to host fish for several weeks to months to complete their development (Bauer and Wächtler 2001, Strayer 2008, Klunzinger *et al*. 2012). The glochidia aids with the distribution of this species, with individuals being dispersed by migrating fish. CFM is a long-lived species, becoming sexually mature within six years at approximately 27 mm shell length, and living for at least 50 years (Klunzinger *et al.* 2014; Figure 1). Despite this known information, there is a distinct knowledge gap with respect to the ecology of CFM, thereby confounding conservation efforts and status of the species, whilst emphasising the protection of any known/new populations of the species (Klunzinger *et al.* 2015).

CFM is currently under threat across south-western Australia due to secondary salinisation, loss of suitable host species, nutrient pollution, habitat loss, water extraction, as well as sedimentation resulting in increased turbidity. Reservoir dewatering and declining rainfall also appear to have had a negative effect on populations (Klunzinger *et al*. 2012). Secondary threats are trampling by cattle, changes in water quality and possible loss of suitable host fishes for larval stages (glochidia). Confirmed native host species for glochidia are freshwater cobbler, western minnows, western pygmy perch, nightfish, Swan River goby and southwestern goby, and the exotic species gambusia and one-spot livebearer (Klunzinger *et al.* 2012, 2015).

Barriers to upstream movement of fish may therefore also restrict gene flow between mussel populations, limit upstream-downstream recruitment of CFM, restrict distributions and prevent recolonisation. As well as weirs and dams, barriers include low flow regimes that make natural barriers (waterfalls, riffle zones) impassable for fish. CFM are filter feeders and are vulnerable to water pollutants and sedimentation. Burial by deep loose sands and silts will also kill CFM. CFM also appear intolerant of average salinity levels > 1,500 mg/L (~3,000 μS/cm; Klunzinger *et al*. 2012). Klunzinger *et al*. (2015) speculated that the species extent of occurrence (EOO) had declined by 49% in less than 50 years, due primarily to secondary salination, and emphasised the importance of habitat protection where the species persists. The former range for this species extended from Moore River in the north to King George Sound in the south and inland to the Avon River (Klunzinger & Walker 2014, Klunzinger *et al*. 2015).

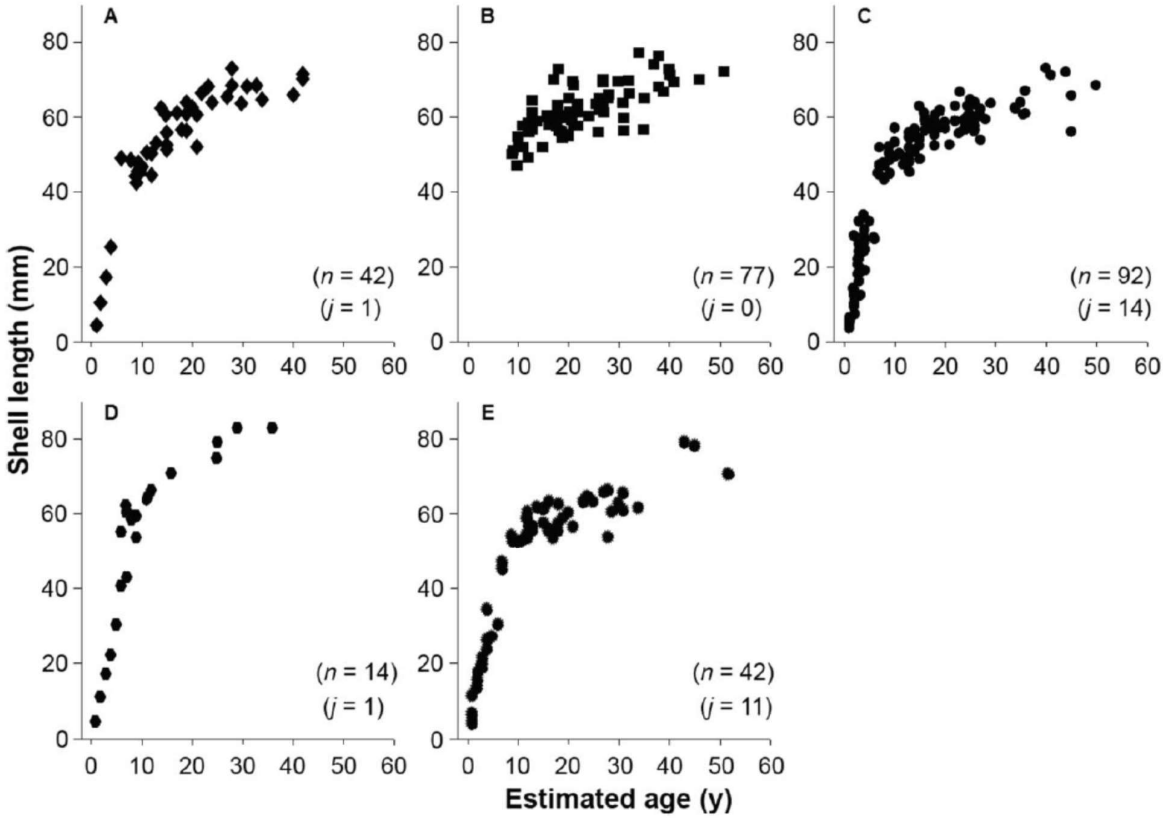


Figure 1. Figure 1 from Klunzinger et al. (2014); age-at-length measurements for CFM at Bennett Brook (A), Brunswick River (B), Collie River (C), Serpentine River at Dog Hill (D), and Serpentine River at Horse Drink (E).

2.1 Past surveys for CFM in the study area region

Past aquatic and relevant CFM survey reports were sourced and reviewed as part of the desktop assessment. This included, but was not limited to, relevant scientific reports and studies that have been undertaken on a local and regional scale, together with published and grey literature (Table 1). Locations of CFM records are shown in Figure 2. The Department of Water and Environmental Regulation Healthy Rivers database (DWER 2022) was also searched for CFM records within 50 km of the current study area.

In 2022 SLR conducted a targeted survey for CFMs in the Myara North area of the Huntly Mine. Upstream and downstream of a stream crossing and an associated tributary were surveyed in full for CFM but no evidence was present of living or dead individuals.

The CFM record closest to the study area was made by Klunzinger et al. (2012), in the Serpentine River approximately 12 km downstream of the current study area (Figure 2). CFM is also known from recent (post-2010) mussel watch surveys and historic (1900 - 1959) WAM records for the Serpentine River along the southern boundary of the Myara North region. It was also recorded from upper Wungong Brook (Vardi Road gauging station) approximately 10 km north of Myara North during Wungong Catchment Trial Project (WCT) monitoring (ARL 2007). The method used for the WCT was quantitative quadrat (Surber) sampling which is not designed to target mussels, so mussels may actually be more widespread throughout the upper Wungong catchment than recorded during field sampling for the WCT.

Table 1. CFM survey reports relevant to the study area

Reports and Journal Publications	Author	Year
Wungong Catchment Environment and Water Management Project: Aquatic Fauna Biodiversity Assessment October 2006	Storey & Creagh (ARL)	2007
Mitigating the Impact of Serpentine Pipehead Dam Works on Carter's Freshwater Mussel	Klunzinger et al.	2012
Range decline and conservation status of *Westralunio carteri* Iredale, 1934 (Bivalvia: Hyriidae) from south-western Australia	Klunzinger et al.	2015
Byford Railway Extension Targeted Fauna Survey for *Westralunio carteri* Carter's Freshwater Mussel	Stream Environment and Water	2021
SLR Myara North Carter's Freshwater Mussel Targeted Survey	SLR	2022

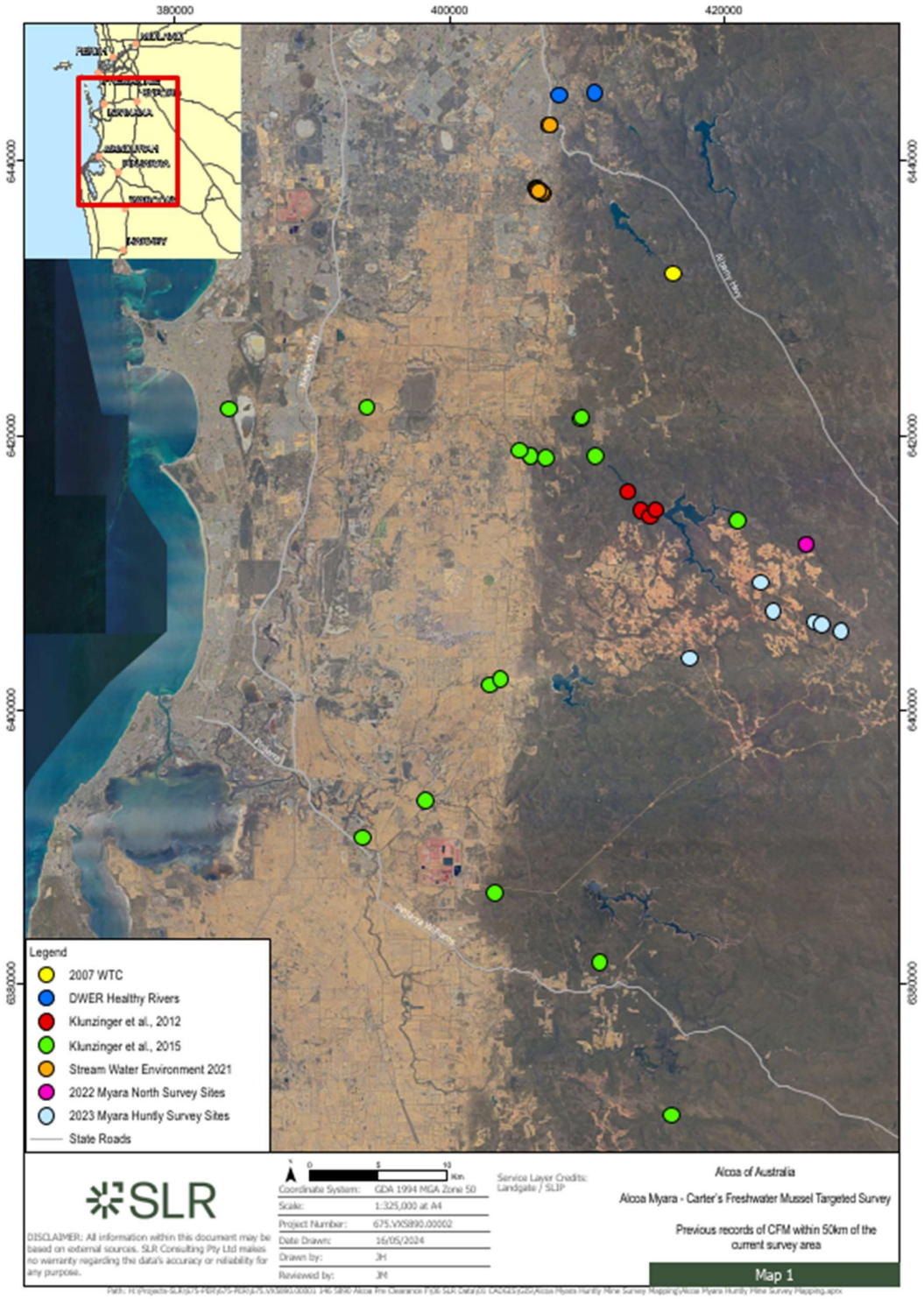


Figure 2. Carter's freshwater mussel previous records within 50 km of the current survey area. Note 2022 Myara North Survey did not record any evidence of CFM presence.

3.0 Survey methods

The project area surveyed for CFM is shown in Figure 3. It consists of six sites in a survey area approximately 12 km upstream of the Serpentine Dam (Table 2). A team of two aquatic ecologists visited all six proposed sites in October 2023, conducting a targeted search of inundated channel areas for mussels. To establish the presence of mussels in the search area, a range of methods were used, including visual observations for shells, manual hand sorting through benthic sediments, and the gentle use of mussel rakes and wire baskets where water depth allowed. GPS locations of captured mussels were to have been recorded, along with a density estimate (live mussels per m^2) and micro-habitat preference. All mussels were to have been gently returned alive to the site of capture. These targeted survey methods for CFM followed that of Klunzinger *et al.* (2012) and the *Technical Guidance – Terrestrial vertebrate fauna surveys for environmental impact assessment* (EPA, 2020).

Table 2: Locations of Myara, Huntly Mine 2023 sampling sites (GDA2020)

Huntly Site Names	ID	Easting	Northing
Cable 1	6	426452	6406264
Cable 2	7	427003	6406067
Cable 5	8	428416	6405571
Kisler Road realignment	9	422552	6409146
Rhodes 2	10	417377	6403642
Schou 1	11	423460	6407074

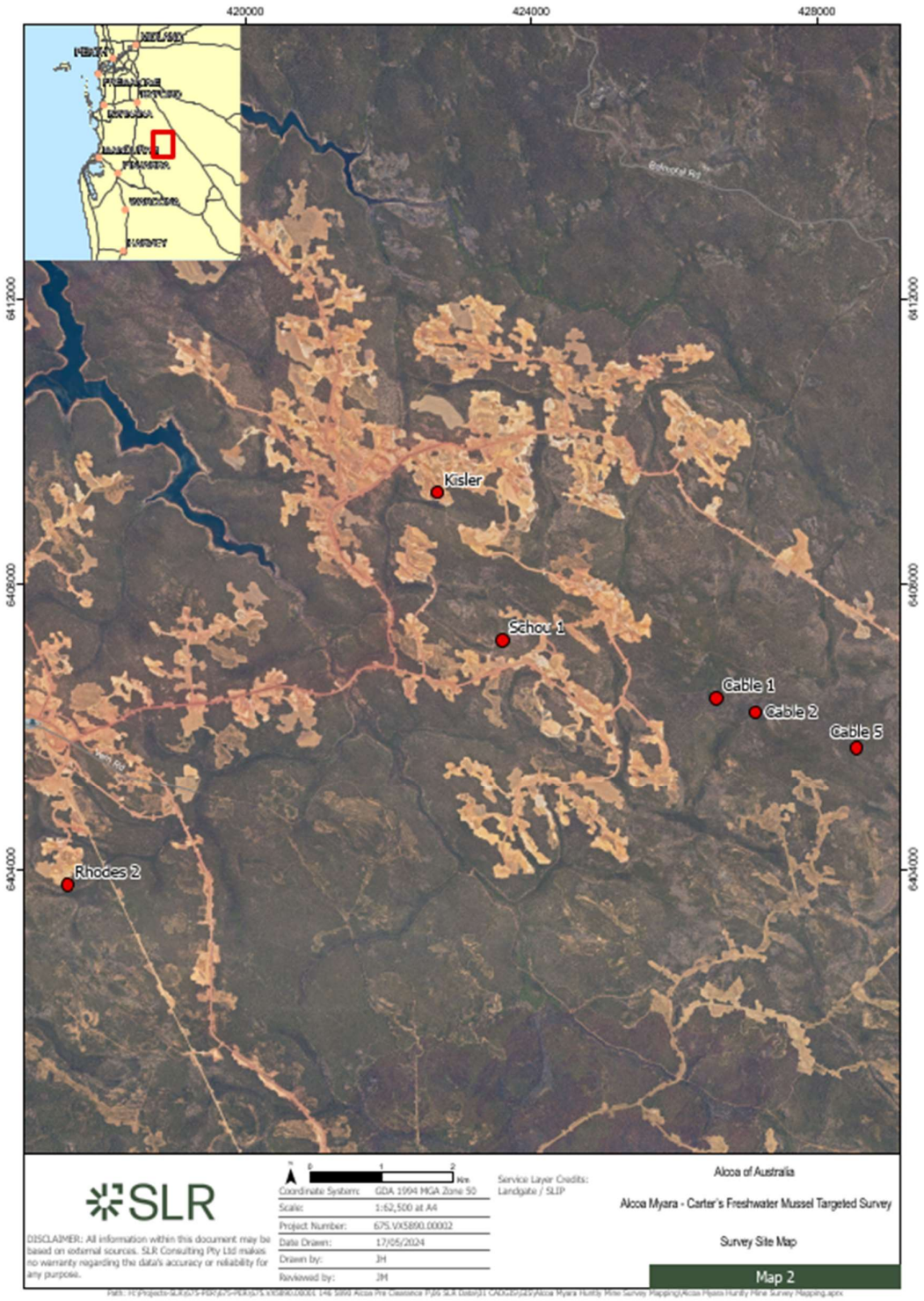


Figure 3: Locations of the Myara, Huntly Mine 2023 sampling sites and the previous 2022 Myara North mussel survey.

3.1 Licences

The survey was carried out under a Department of Biodiversity, Conservation and Attractions (DBCA) for Authorisation to Take or Disturb Threatened Species (TFA 2223-0096) and a Fauna Taking (Biological Assessment) License issued under Regulation 27 of the Biodiversity Conservation Regulations 2018 and the *Biodiversity Conservation Act 2016* (BA27000735), issued 5th October 2022. SLR Consulting (nee Wetland Research & Management) also hold a current Instrument of Exemption under the *Fish Resources Management Act 1994* to undertake freshwater aquatic fauna surveys in major rivers and tributaries of South-West WA, including the Serpentine River.

3.2 Survey Limitations

Table 3 below summarises the potential limitations and constraints affecting the Myara, Huntly Mine CFM targeted survey.

Table 3. Survey limitations

Aspect	Constraint?	Comment
Competency	No	The survey was conducted by two aquatic ecologists with prior experience in CFM targeted surveys in South West Western Australia aquatic ecosystems. The combined number of years' experience in aquatic ecology held by the personnel is 9 years. Both personnel hold university-level degrees in biological sciences. The survey was conducted under a Fauna Taking (Biological Assessment) License and an Authorisation to Take or Disturb Threatened Species issued by DBCA on the 5th October 2022.
Scope	No	The scope was prepared by Alcoa. The scope is considered sufficient to inform the impact assessment with regards to the distribution and density of mussels within the survey area.
Fauna detected if present in the survey area	No	All sites were thoroughly assessed for any evidence of CFM. This included visual observations, physical searches and searches for desiccated shell remnants in dry creek beds.
Sources of information	No	The desktop assessment collated the previous findings in the region as presented in relevant targeted CFM surveys and the DWER databases.
The proportion of the task achieved and further work	No	The surveys were completed adequately, carried out to a sufficient level with respect to the scope.
Timing/weather/season/cycle	No	Surveys were carried out in spring after the winter rainfall season. Three sites were dry however if these sites are dry immediately after the winter rainfall season it indicates these sites do not hold water in a permanent/semi-permanent capacity. Timing of the survey was not a limitation for the survey.
Disturbances	No	There were no disturbances that affected the survey.

Aspect	Constraint?	Comment
Intensity (in retrospect was the intensity adequate)	No	Based on the results the survey intensity is considered adequate to have met the scope. The entire area of possible habitat within the survey area was searched for CFM.
Completeness (e.g., was relevant area fully surveyed)	No	The entire area of possible habitat within the survey area was searched for CFM.
Resources	No	The resources made available to the survey were sufficient.
Remoteness and/or access problems	No	The entire length of the channel within the survey area was accessible.

4.0 Fauna

No CFM were recorded in the survey location during the targeted field survey (Table 4). This included live specimens, but also absence of shells of deceased individuals. Habitat observations of each site identified the substrate composition to be unsuitable for mussels to be present. Rhodes 2 consisted primarily of gravels and pebbles covered with large amounts of detritus/leaf litter. Schou 1 had a similar mineral substrate mainly consisting of gravel and pebbles with bedrock also present. Kisler had a substrate consisting primarily of clay with a large layer of detritus/leaf litter covering it. CFM generally occur in stable sand and finer sediment areas where they can bury themselves partially or completely (Klunzinger *et al.* 2010, Klunzinger 2012). Habitats consisting of course gravel and pebbles or hard clays prevent mussels from burying themselves.

Dispersal of glochidia, the obligate parasitic larval stage of CFM, may have also been impacted for these sites due to the distance upstream and the vegetation barriers present between the Serpentine Dam and the upstream survey sites. The CFM relies on native fish species to act as hosts for the parasitic larval stage allowing the CFM to disperse as these fish species move upstream. If obstructions to fish movement are present then the movement of CFM larvae would also be limited.

CFM have a limited ability to survive in a system that has receded and dried out. This species cannot withstand exposure for longer than five days without moist sediments and shade (Lymbery *et al.* 2021). As sites dry out and remain dry over long periods of time mussel populations will die out.

Table 4: Summary of mussels caught during the Alcoa Huntly 23 survey. Water quality was taken at three of the six sites – three sites were dry

Huntly Site Names	ID	Water quality	Mussel presence
Cable 1	6	Dry	Not detected
Cable 2	7	Dry	Not detected
Cable 5	8	Dry	Not detected
Kisler	9	✓	Not detected
Rhodes 2	10	✓	Not detected
Schou 1	11	✓	Not detected

5.0 Water quality

Water quality was compared to ANZG (2018) default guidelines of water quality for the South-West region of Western Australia (Table 5). Water quality concentrations and exceedances of note included:

- EC exceeded the ANZG (2018) default guideline at; Kisler and Rhodes 2
- pH values below ANZG (2018) default guidelines at all sites where water quality was taken; Kisler, Schou 1, and Rhodes 2
- Dissolved oxygen readings were below ANZG (2018) default guidelines at all sites where water quality was taken; Kisler, Schou 1, and Rhodes 2
- Exceedance of Al at Schou 1 in comparison to ANZG (2018) guidelines

5.1 Electrical conductivity

Electrical conductivity (EC) readings ranged from 224.6 μS/cm (Schou 1) to 436.2 μS/cm (Rhodes 2). EC at Kisler and Rhodes 2 was above the default DGV (300 μS/cm). However, this exceedance is not one of concern as CFM are tolerant to levels < 3,000 μS/cm (Klunzinger *et al*. 2012).

5.2 pH

Readings for all sites where water quality samples were taken were below ANZG (2018) guidelines (pH 6.5-8.0). All sites were slightly acidic with values ranging from 5.6 pH (Shou 1) to 6.1 pH (Rhodes 2). The slightly acidic levels of pH could be related to the recent influx of rainwater at sampling sites. pH is not classified as a predicting environmental factor for CFM distribution and no established tolerance levels have been defined for CFMs however previous studies have recorded the presence of CFM in a pH range from 6.7 to 8.2 (Klunzinger *et al.* 2015, Paice and Beatty 2021, Stream Water and Environment 2021, SLR unpub. dat.). This indicates that the current state of the water quality is outside the preferred range of the CFM.

5.3 Dissolved oxygen

Dissolved oxygen (DO) was recorded slightly under the ANZG (2018) values (85-120%) at all sites. With the lowest dissolved oxygen at 60.5% (Rhodes 2). The low levels of dissolved oxygen could be in relation to the lack of aeration due to low flows. DO generally exhibits a diurnal pattern, reflecting the flux between aquatic respiration and photosynthesis, so spot measurements of DO such as these provide only a snapshot of typical daily conditions, which may vary considerably depending on the time of measurement. Additionally in field observations of CFM have been made by SLR with healthy CFM populations occurring in freshwater systems experiencing dissolved oxygen levels ranging from 30-100%.

5.4 Metals

The majority of the metal levels recorded at all sites were at the limit of reporting and below the ANZG (2018) DGV. Slight exceedances of the 95% ANZG (2018) protection guideline for Al was recorded at Shou1. This concentration is likely due to evapo-concentration effects on reducing sites and lack of streamflow.

Table 5. Water quality parameters (in situ and laboratory analysis) measured at Myara, Huntly Mine October 23. Values are compared to the ANZG (2018) Water quality default guideline values (DGVs) relevant to the South-West region (np = not provided). Highlighted values indicate values in exceedance of respective guideline values.

Analyte	*Limits of Reporting*	ANZG (2018) 95% DGV	Units	Kisler	Schou 1	Rhodes 2
Al	*0.005*	0.055	mg/L	0.007	0.084	0.011
Alkalin	*1*	np	mg/L	7	3	8
As	*0.00005*	np	mg/L	<0.00005	<0.00005	<0.00005
B	*0.02*	np	mg/L	0.03	<0.02	<0.02
Ba	*0.002*	np	mg/L	0.052	0.011	0.015
CO3	*1*	np	mg/L	<1	<1	<1
Ca	*0.1*	np	mg/L	2.5	1	1.9
Cd	*0.0001*	np	mg/L	<0.0001	<0.0001	<0.0001
Cl	*1*	np	mg/L	115	64	123
Co	*0.0001*	np	mg/L	0.0007	0.0001	0.0006
Cr	*0.0005*	0.0002	mg/L	<0.0005	<0.0005	<0.0005
Cu	*0.0001*	0.0014	mg/L	0.0001	<0.0001	0.0001
ECond	*0.2*	np	mS/m	40.8	22.9	42.3
Fe	*0.005*	np	mg/L	0.091	0.025	0.36
HCO3	*1*	np	mg/L	8	4	10
Hardness	*1*	np	mg/L	38	17	25
K	*0.1*	np	mg/L	2.6	0.8	1.3
Mg	*0.1*	np	mg/L	7.6	3.5	4.9
Mn	*0.001*	1.9	mg/L	0.005	0.005	0.013
Mo	*0.001*	0.073	mg/L	<0.001	<0.001	<0.001
N_NH3	*0.01*	0.9	mg/L	<0.01	<0.01	<0.01
N_NO2	*0.01*	9.3	mg/L	<0.01	<0.01	<0.01
N_NO3	*0.01*	np	mg/L	0.01	0.02	<0.01
N_NOx	*0.01*	np	mg/L	0.01	0.02	<0.01
N_total	*0.01*	0.3	mg/L	0.04	0.16	0.11
Na	*0.1*	np	mg/L	57.6	33.8	67.2
Ni	*0.001*	0.011	mg/L	<0.001	<0.001	<0.001
OH	*1*	np	mg/L	<1	<1	<1
P_total	*0.005*	np	mg/L	<0.005	<0.005	<0.005
Pb	*0.0001*	0.0034	mg/L	<0.0001	<0.0001	<0.0001
S	*0.1*	np	mg/L	3	1.7	1.9
SO4_S	*0.1*	np	mg/L	9.1	4.9	5.7
Se	*0.001*	np	mg/L	<0.001	<0.001	<0.001
Si	*0.05*	np	mg/L	3.7	2.1	2.2

Analyte	*Limits of Reporting*	ANZG (2018) 95% DGV	Units	Kisler	Schou 1	Rhodes 2
Sr	*0.002*	np	mg/L	0.049	0.019	0.029
TDS_calc	*5*	np	mg/L	220	130	230
U	*0.0001*	0.005	mg/L	<0.0001	<0.0001	<0.0001
V	*0.0001*	0.0006	mg/L	0.0004	<0.0001	0.0001
Zn	*0.001*	0.008	mg/L	<0.001	<0.001	<0.001
pH	*0.1*	6.5-8.0		5.9	5.6	6.1
Turbidity-field (NTU)		20		1.7	4.5	4.64
DO-field (% sat)		85-120	%	71.6	71.67	60.5
EC-field (µs/cm)		300	µs/cm	401.2	224.6	436.2

6.0 Conclusion

No CFM were recorded in the survey location during the targeted field survey. This included live specimens, but also absence of shells of deceased individuals. Water quality parameters for the only three sites with water identified pH to be outside the ANZG (2018) DGV of 6.5-8.0 and outside the pH range of locations where mussels had been previously recorded in other studies. The remaining three sites without water appeared to potentially hold water on a short-term basis after a heavy rainfall event but not over long periods of time. Locations not holding water for long periods of time will most likely impact any potential mussel populations.

7.0 References

ANZG (2018) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines

ARL (2007) Wungong Catchment Trial Project: Aquatic Fauna Biodiversity Assessment October 2006. Unpublished report to the Water Corporation prepared by the Aquatic Research Laboratory, the University of Western Australia, June 2007.

Bauer G and Wächtler K (2001) *Ecology and evolution of the freshwater mussels Unionoida.* Springer-Verlag, New York

Department of Water and Environmental Regulation (2022) Carter's freshwater mussel - *Westralunio carteri*. Healthy Rivers fauna records https://rivers.dwer.wa.gov.au/species/westralunio-carteri/ [Accessed 17th October 2022].

Environmental Protection Authority (2020) Technical Guidance – Terrestrial vertebrate fauna surveys for environmental impact assessment, EPA, Western Australia. https://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/EPA-Technical-Guidance-Vertebrate-Fauna-Surveys.pdf [Accessed 17th October 2022].

GHD (2021) Terrestrial Fauna Survey and Black Cockatoo Habitat Assessment for Huntly Mine - Myara North Pinjarra Alumina Refinery Revised Proposal. Alcoa of Australia Limited, August 2021.

Klunzinger MW, Beatty SJ, and Lymbery A (2010) Acute salinity tolerance of the freshwater mussel *Westralunio carteri* Iredale, 1934 of south-west Western Australia. *Tropical Natural History* **Suppl. 3**: 112.

Klunzinger MW, Beatty SJ, Allen MG, Keleher (2012) Mitigating the Impact of Serpentine Pipehead Dam Works on Carter's Freshwater Mussel. Prepared for the Department of Fisheries by the Freshwater Fish Group and Fish Health Unit, Murdoch University. April 2012.

Klunzinger M, Walker KF (2014) *Westralunio carteri*. [*In*] IUCNRed List of Threatened Species. Version 2014.3. www.iucnredlist.org.

Klunzinger MW, Beatty, SJ, Morgan DL, Lymbery AJ, Haag WR (2014) Age and growth in the Australian freshwater mussel, *Westralunio carteri*, with an evaluation of the fluorochrome calcein for validating the assumption of annulus formation. *Freshwater Science* **33**: 1127-1135. doi:10.1086/677815.

Klunzinger M, Beatty S, Pinder A, Morgan D, Lymbery A (2015) Range decline and conservation status of *Westralunio carteri* Iredale, 1934 (Bivalvia: Hyriidae) from south-western Australia. *Australian Journal of Zoology* **63**: 127-135. doi:10.1071/ZO15002.

Lymbery A, Ma L, Lymbery S, Klungzinger M, Beatty S, Morgan D (2021) Burrowing behaviour protects a threatened freshwater mussel in drying rivers. *Hydrobiologia* **848**: 12-13.

Paice R and Beatty S (2021) Survey of Carter's Freshwater Mussel in the Lower Vasse River to inform future sediment removal. Prepared for City of Busselton. a71d58ad-4cba-48b6-8dab-f3091fc31cd5 (environment.gov.au) [Accessed 17th May 2024].

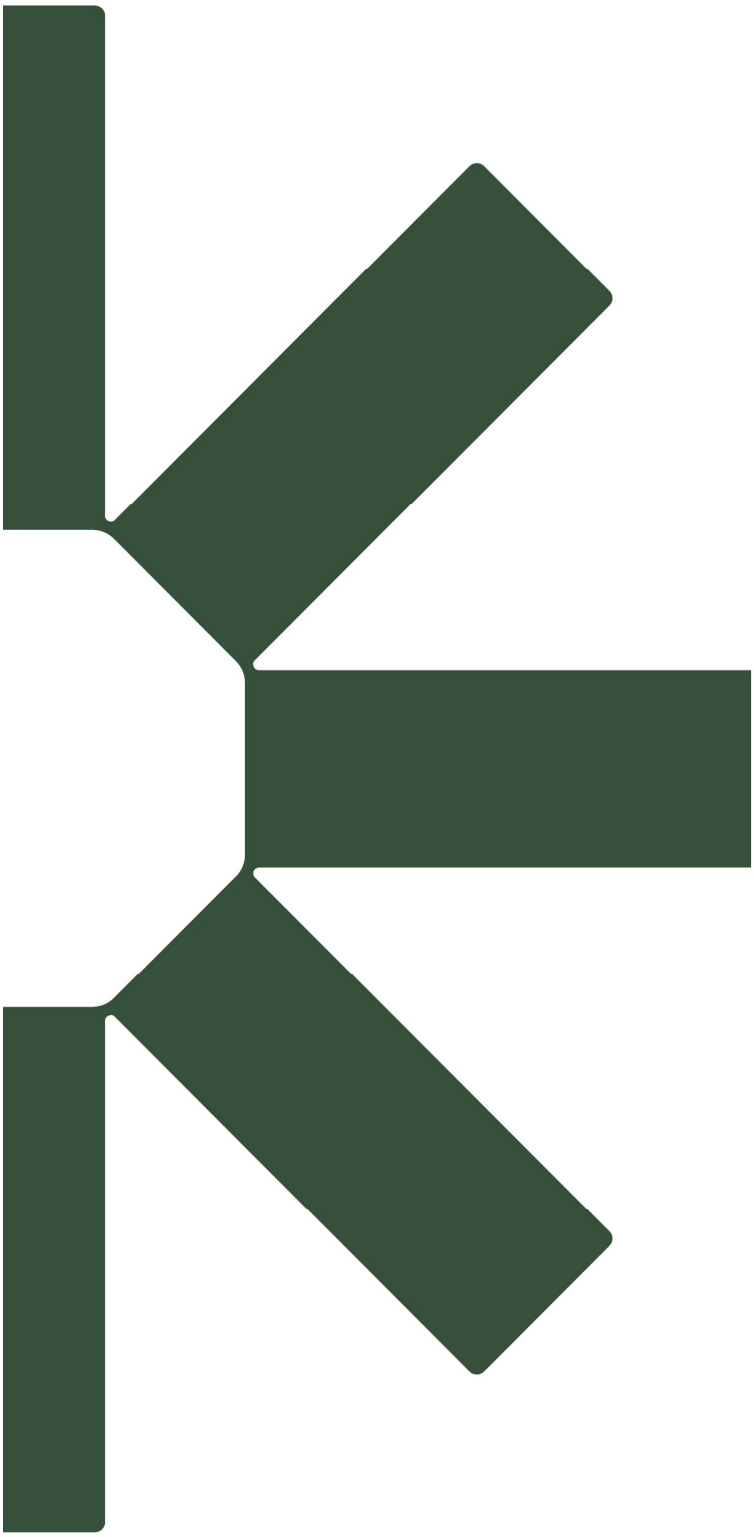
Spooner D and Vaughn CC (2008) A trait-based approach to species' roles in stream ecosystems: climate change, community structure, and material cycling. *Oecologia* (Berlin), **158**, 307–317.

Stantec (2022) Carter's Freshwater Mussel Survey at Williams and Hotham Rivers. EPA, Western Australia. Proposal / Report Template (epa.wa.gov.au) [Accessed 15th May 2024].

Strayer DL (2008) *Freshwater mussel ecology: a multifactor approach to distribution and abundance*. University of California Press, Berkley.

Stream Water and Environment (2021) Byford Railway Extension Targeted Fauna Survey for *Westralunio carteri* Carter's Freshwater Mussel. Prepared for GHD Pty Ltd on behalf of Western Australian Government's METRONET program, January 2021. https://www.epa.wa.gov.au/sites/default/files/PER_documentation2/Appendix%20H%20-%20Carters%20Mussel%20Stream%20Environment%20and%20Water%20200405%20BRE%20Targeted%20Fauna%20Survey_Rev0_Final%20-%2018%20January%202021.pdf [Accessed 17th October 2022].

Vaughn CC and Hakenkamp CC (2001) The functional role of burrowing bivalves in freshwater ecosystems. *Freshwater Biology,* **46**, 1431–1446.



Making Sustainability Happen