Talison Greenbushes

Aquatic Ecological Assessment For The Proposed New Waste Rock Landform S8

Talison Lithium (Pty) Ltd

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Revision Record

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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 Talison Lithium Pty Ltd (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 Talison Lithium Pty Ltd. 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.

Executive Summary

Talison Lithium Australia Pty Ltd (Talison) operate the Talison Lithium Mine, near Greenbushes, in the south west of Western Australia. The Greenbushes Mine is proposing to construct a new water dam and new waste rock landform Salt Water Gully waste Rock Landform (SWG WRL). The footprint of the SWG WRL has not yet been finalised however an ecological baseline study was required to determine any potential impacts from the construction footprint and subsequent runoff and seepage from the SWG WRL into Cascade Gully and Hester Brook. Talison required a survey for aquatic fauna, macrophytes (aquatic plants), aquatic habitat condition, water quality and sediment quality of Cascade Gully and downstream Hester Brook to support a section 38 referral for the project (under the *Environmental Protection Act 1986*). The scope of services for the field survey included:

- Conduct a desktop assessment for potential groundwater-dependent ecosystems (indicative vegetation communities) downstream of the new WRL.
- Conduct a field survey within Cascade Gully and Hester Brook including the following components:
  - Water quality, including *in-situ* measurements (e.g., pH, dissolved oxygen, temperature, etc.), and collection of samples for general ions, dissolved organic carbon, nutrients and metals.
  - Sediment quality (AEAP analyte suite).
  - Macrophyte (aquatic flora) species identification and coverage estimate.
  - Habitat assessment
  - Fish and crayfish fauna, identified to species level (where possible) to determine conservation status.
  - Aquatic macroinvertebrates, identified to species level (where possible) to determine conservation status.
  - Targeted search for conservation-significant aquatic fauna species *Westralunio carteri* (Carter's freshwater mussel), listed Vulnerable at state, federal and international levels, and *Hydromys chrysogaster* (Rakali/water rat), listed by the Department of Biodiversity Conservation and Attractions as a Priority 4 species (Rare, Near Threatened and other species in need of monitoring)

SLR Consulting Australia successfully conducted the Spring 2023 Aquatic Ecological Assessment survey for Cascade Gully and Hester Brook associated with the proposed new Waste Rock Landform (WRL) S8. Due to land access restrictions an alternative survey design was followed as only one site on Cascade Gully upstream of the proposed WRL could be accessed. Sampling for water quality, sediment quality and aquatic fauna, and qualitative assessments for macrophytes and habitat composition was conducted at five sites, two upstream (one on Cascade Gully and one on Hester Brook) and three downstream (two on Hester Brook and one below confluence of Cascade Gully and Hester Brook. Cascade Gully and Hester Brook were found to support an assemblage of aquatic biota species representative of other nearby aquatic ecosystems. No aquatic fauna species of listed conservation-significance were recorded during the survey, however, based on habitat and location, the Department of Biodiversity, Conservation and Attractions Priority 4-listed mammal species *Hydromys chrysogaster* is likely to inhabit Cascade Gully and downstream Hester Brook.

The aquatic habitat in this study area showed evidence of past disturbances and has been classified in other reports as "moderately disturbed ecosystems". While water and sediment quality in general was within the default and/or site-specific guidelines, other sources within the catchment could contribute to higher concentrations if not managed correctly.

The construction of a new WRL could have an impact on the water and sediment quality, especially if the WRL was subject to AMD/NMD, as surface water runoff from the landform could impact both the quality and quantity of water received by Hester Brook and Cascade Gully. Similarly, the seepage of potentially AMD/NMD-contaminated water into the groundwater could impact the receiving aquatic

ecosystem as the groundwater flow patterns are towards Hester Brook and Cascade Gully. If mitigation and management measures are put in place during construction and operation of the WRL, then these potential impacts should be prevented, and have a minimal effect on the aquatic ecosystems. Monitoring along these water bodies is recommended to assess the potential impact of the new WRL S8 on the receiving aquatic environment.

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Acronyms and Abbreviations

ABRS	Australian Biological Resources Study
AEAP	Annual Ecological Assessment Program
ALA	Atlas of Living Australia
AMD	Acid Mine Drainage
As	Arsenic
AusRivAS	Australia River Assessment Scheme
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BC	Biodiversity Act
Ca	Calcium
CERN	Council of Nuclear Research
Cd	Cadmium
Co	Cobalt
Cr	Chromium
Cu	Copper
DBCA	Department of Biodiversity, Conservation and Attractions
DGV	Default Guideline Value
DIWA	Directory of Important Wetlands in Australia
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DWER	Department of Water and Environmental Regulation
ESU	Evolutionary Significant Units
EPA	Environmental Protection Agency
EPBC	Environment Protection and Biodiversity Act
EPP	Environmental Protection Policy
FBA	Freshwater Biological Association
Fe	Iron
GV	Guideline Value
IBSA	Index of Biodiversity Surveys for Assessments
IUCN	International Union for Conservation of Nature
K	Potassium
Li	Lithium
LOR	Limits of Reporting
MNES	Matters of National Environmental Significance
MDE	Mine Development Area
Mg	Magnesium
Mn	Manganese
NATA	National Association of Testing Austhorities
NWQMS	National Water Quality Management Strategy

$N\text{-}NH_3$	Nitrogen from Ammonia
$N\text{-}NO_2$	Nitrogen from Nitrite
$N\text{-}NO_3$	Nitrogen from Nitrate
$N\text{-}NO_x$	Nitrogen from Nitrate and Nitrite
NMD	Neutral Mine Drainage
N-Total	Total Nitrogen
Na	Sodium
Ni	Nickel
PAF	Potentially Acid Forming
P-SR	Soluble Reactive Phosphorus
P-Total	Total Phosphorus
Pb	Lead
PCoC	Potential Contaminant of Concern
PMTDI	Provisional Maximum Tolerable Daily Intake
PTMI	Provisional Total Monthly Intake
PTWI	Provisional Total Weekly Intake
Redox	Oxidation/Reduction Potential
Sn	Tin
SO_4_S	Sulphur from Sulphate
SRE	Short Range Endemic
SSGV	Site Specific Guideline Value
SWG	Salt Water Gully
SWIRC	South West Index of River Condition
TDS	Total Dissolved Solids
TGLM	Talison Greenbushes Lithium Mine
Th	Thorium
TSF	Tailings Storage Facility
TSS	Total Suspended Solids
U	Uranium
UWA	University of Western Australia
V	Vanadium
WAPRES	WA Plantation Resources
WRL	Waste Rock Landform
Zn	Zinc

1.0 INTRODUCTION

1.1 Background

Talison Lithium Australia Pty Ltd (Talison) operate the Talison Lithium Mine, near Greenbushes, in the south west of Western Australia. The Greenbushes Mine is proposing to construct a new water dam and new waste rock landform Salt Water Gully Waste Rock Landform (SWG WRL; Figure 1). The footprint of the SWG WRL has not yet been finalised however an ecological baseline study will be required to determine any potential impacts from the construction footprint and subsequent runoff and seepage from the SWG WRL into Cascade Gully and Hester Brook. The sampling and analysis will inform the S38 referral and assessment (under the *Environmental Protection Act 1986*, "The EP Act").

The design and construction of a new WRL (the Project) should consider the following potential adverse effects on the aquatic fauna within the creeklines downgradient of the project which are considered in environmental impact assessments under the Environmental Protection Authority's (EPA) Environmental Factor Guidelines *Inland Waters* and *Terrestrial Fauna*:

- Increased surface water runoff from the landform into the receiving aquatic environment
- Potential mobilisation of certain elements in the runoff into the creek lines. Similarly, the potential for surface water contamination due to seepage into the groundwater
- Mobilisation of sediment during the construction phase due to clearing of vegetation

Talison have a number of environmental monitoring programs in place to inform management and meet their current operational requirements under Department of Water and Environmental Regulation (DWER) Licence L4247/1991/13 (issued under the EP Act). An Annual Ecological Assessment Program (AEAP) has been conducted annually in spring season since 2016 for detection of potential impacts of adverse water quality on aquatic fauna of Norilup Brook. A revision of the AEAP monitoring programme was conducted in 2023 to expand the sampling locations to provide sufficient coverage of assessment of risk to other surface water receptors to the east, west and south of the Greenbushes area, and to the Blackwood River.

As part of the updated Annual Ecological Monitoring Program (AEAP), SLR Consulting was engaged to conduct a field survey to assess the aquatic ecological values on additional points within Cascade Gully and Hester Brook, which could be impacted by the proposed project.

1.1.1 Scope of Works (SoW)

The following scope of services were undertaken as part of the ecological values assessment associated with the construction and operation of the new proposed SWG WRL:

- Conduct a desktop assessment for potential groundwater-dependent ecosystems (indicative vegetation communities) downstream of the new SWG WRL.
- Conduct a field survey within Cascade Gully and Hester Brook including the following components:
    - Water quality, including *in-situ* measurements (e.g., pH, dissolved oxygen, temperature, etc.), and collection of samples for general ions, dissolved organic carbon, nutrients and metals.
    - Sediment quality (AEAP analyte suite).
    - Macrophyte (aquatic flora) species identification and coverage estimate.
    - Habitat assessment
    - Fish and crayfish fauna, identified to species level (where possible) to determine conservation status.
    - Aquatic macroinvertebrates, identified to species level (where possible) to determine conservation status.

    - Targeted search effort for conservation-significant aquatic fauna species *Westralunio carteri* (Carter's freshwater mussel), listed Vulnerable at state, federal and international levels, and *Hydromys chrysogaster* (Rakali/water rat), listed by the Department of Biodiversity Conservation and Attractions as a Priority 4 species (Rare, Near Threatened and other species in need of monitoring)

- Produce a technical report detailing the findings of the desktop review and field survey, suitable to assist with the referral of the project to the EPA under section 38 of the EP Act.

- Provide survey data to meet the EPA's Index of Biodiversity Surveys for Assessments (IBSA) requirements.

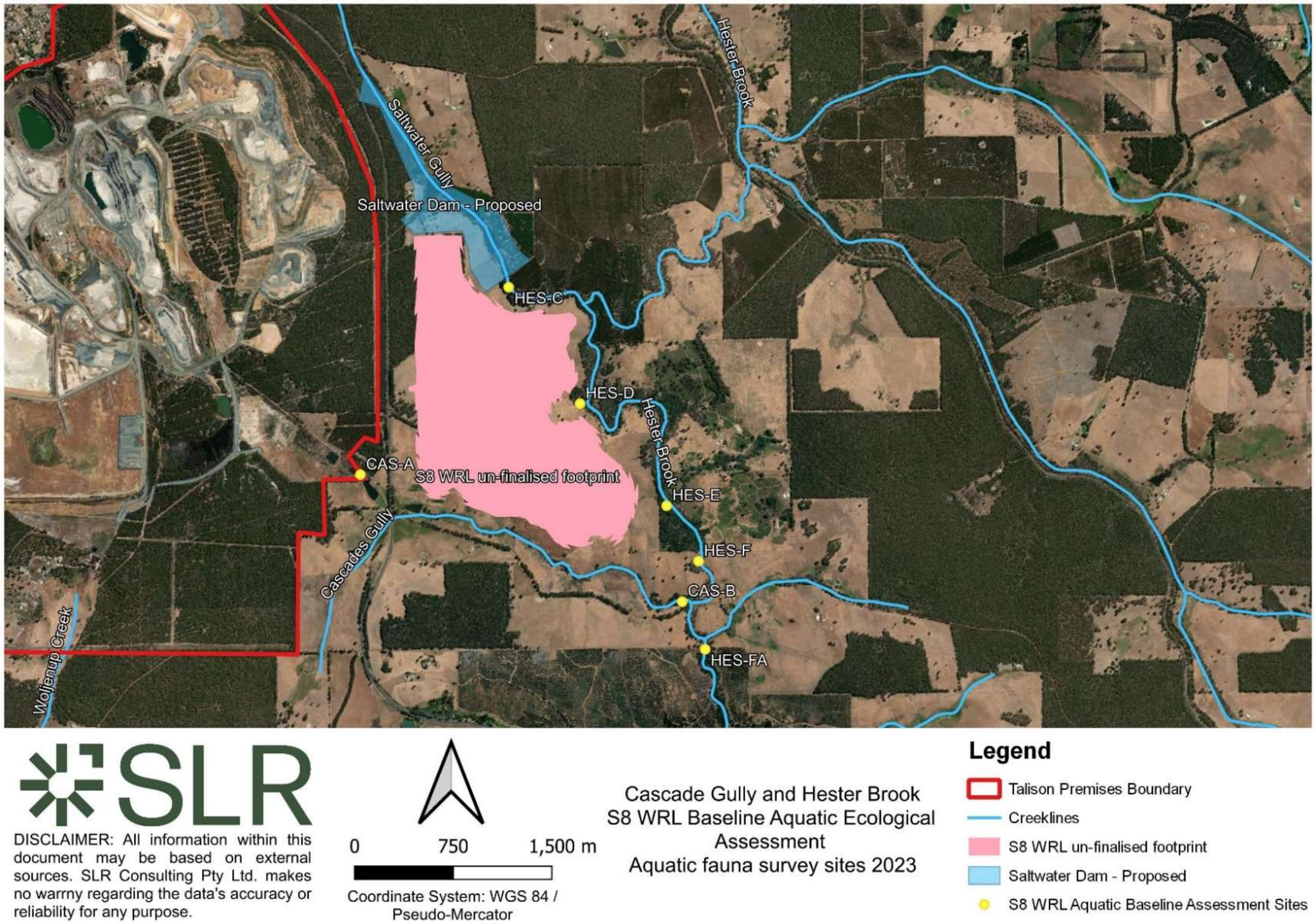

Figure 1: Aquatic Fauna Survey Sites Spring 2023

1.1.2 Legislative Framework

The Western Australian Environmental Protection Agency's (EPA) environmental objective for Inland Waters is to maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected (EPA 2018). Inland waters are considered to include groundwater systems, wetlands, estuaries, and any river, creek, stream or brook (and its floodplain), including systems that "flow permanently, for part of the year or occasionally, and parts of waterways that have been artificially modified" (EPA 2018). Environmental value is defined under the Environmental Protection Act 1986 (EP Act) as a beneficial use or an ecosystem health condition. Aquatic fauna and flora and the ecological processes that support them are specifically listed in the Inland Waters Environmental Factor Guideline as one of the ecosystem health values that must be considered as part of the environmental impact assessment process (EPA 2018).

Impacts on the EPA factor *Inland Waters* can impact on the factor *Terrestrial Fauna* which encompasses aquatic vertebrate and invertebrate fauna (EPA 2016a). The EPA's objective for the *Terrestrial Fauna* is: "To protect terrestrial fauna so that biological diversity and ecological integrity are maintained" (EPA 2016a). EPA define ecological integrity as "the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements". Considerations for Environmental Impact Assessment (EIA) for the factor *Terrestrial Fauna* include, but are not necessarily limited to:

- application of the mitigation hierarchy to avoid or minimise impacts to terrestrial fauna, where possible,
- the terrestrial fauna affected by the proposal,
- the potential impacts and the activities that will cause them, including direct and indirect impacts,
- the implications of cumulative impacts,
- whether surveys and analyses have been undertaken to a standard consistent with EPA technical guidance,
- the scale at which impacts to terrestrial fauna are considered,
- the significance of the terrestrial fauna and the risk to those fauna,
- the current state of knowledge of the affected species/assemblages and the level of confidence underpinning the predicted residual impacts, and
- whether proposed management approaches are technically and practically feasible.

There are multiple considerations for EIA for the factors Inland Waters and Terrestrial Fauna, however the focus for this desktop review and aquatic ecological survey was identifying and characterising the aquatic habitats and aquatic fauna values that may potentially be affected by the Project, and in particular:

- threatened fauna species or communities listed as matters of National Environmental Significance (MNES) under the commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and ecosystems that support them,
- threatened and Priority fauna species or communities listed under the WA *Biodiversity Conservation Act 2016* (BC Act), and ecosystems that support them,
- wetlands of international importance as listed under the Ramsar Convention,
- wetlands of national importance as listed in the Directory of Important Wetlands in Australia (DIWA).
- wetlands protected by Environmental Protection Policies (EPP) under Part 3 of the EP Act,
- wetland types which may be poorly represented in the conservation reserves system,

- springs and permanent pools which act as refugia,
- ecosystems which support significant flora, vegetation and fauna species or communities, including migratory waterbirds, bats, and subterranean fauna,
- ecosystems which support significant amenity, recreation and cultural values,
- saline lakes, estuaries and near shore ecosystems reliant on groundwater or surface water inputs,
- downstream marine ecosystems, and
- short-range endemic (SRE) aquatic fauna.

Aquatic fauna is encompassed by the EPA's *Terrestrial Fauna* factor, and their habitat is encompassed by the *Inland Waters* factor. Despite the Environmental Factor relating to *Inland Waters* being updated in 2018 (EPA 2018), there are still no prescriptive guidance statements at the State or Commonwealth level outlining surface water quality and aquatic fauna sampling design and methods. Therefore, the aquatic fauna sampling employed methods and general approaches / rationale consistent with the following:

- EPA Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA 2020),
- EPA Technical Guidance: Sampling of short range endemic invertebrate fauna (EPA 2016b),
- the National Monitoring River Health Program (NRHP) Australia River Assessment Scheme (AusRivAS),
- DWER's South-West Index of River Condition (SWIRC) methodology (Storer *et al*. 2020), and
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018), developed as art of the National Water Quality Management Strategy (NWQMS) (Australian Government 2018).

Relatively few aquatic species in Western Australia are listed as threatened or endangered under the BC Act or EPBC Act. Aquatic invertebrates in particular, have historically been under-studied. Lack of knowledge of their distributions often precludes aquatic invertebrates for listing as threatened or endangered, however, they often constitute diverse assemblages, and are a valuable, sensitive tool for monitoring impacts. In an attempt to rectify this situation candidate Priority aquatic invertebrate species have been identified for potential listing on the Department of Biodiversity, Conservation and Attractions (DCBA) Western Australian Priority Fauna list, but are yet to be formally assessed (Pennifold 2018).

1.2 Study Area Environmental Setting

The study area for the Spring 2023 S8 WRL aquatic fauna survey comprised of Hester Brook and Cascade Gully creek line inclusive of monitoring points along the creek lines. The study area is located in the Southern Jarrah Forest sub-region (JAF02) of the Jarrah Forest Interim Biogeographic Regionalisation of Australia (JAF IBRA) region as defined by the Department of Water and Environmental Regulation (DWER; Figure 2). The active mining area, also referred to as mine development envelope (MDE), predominantly occurs within Greenbushes State Forest 20 (SF20) and within some small areas of freehold land (GHD 2021). The SF20 is a Class A State Forest managed by DBCA for timber production, recreation and biodiversity conservation.

1.2.1 Climate

The study area experiences a temperate climate of warm, dry summers and cold, wet winters (BOM 2006) and is located within the Hardy Estuary-Blackwood River Catchment. Due to absent data from the Greenbushes (GS 009552) gauging station over the past year, data from the surround Bridgetown (GS 009617, ~12.9km SE of Greenbushes) and Kirup (GS 009714, ~22.1km NW of Greenbushes) gauging stations were used to represent rainfall data in the region (Figure 3). Historically, the highest rainfall typically occurs between May and September at the Greenbushes gauging station (highest average monthly rainfall in July - 165.7mm) and the lowest rainfall typically occurs between October and April (lowest average monthly rainfall in February 15.7mm). Monthly total rainfall volumes received in the wider Greenbushes/Kirup/Bridgetown area in the lead up to the October 2023 survey were generally lower than, or comparable to, the long-term monthly averages with October 2023 being the driest October on record for Western Australia (BOM 2023**,** Figure 3).

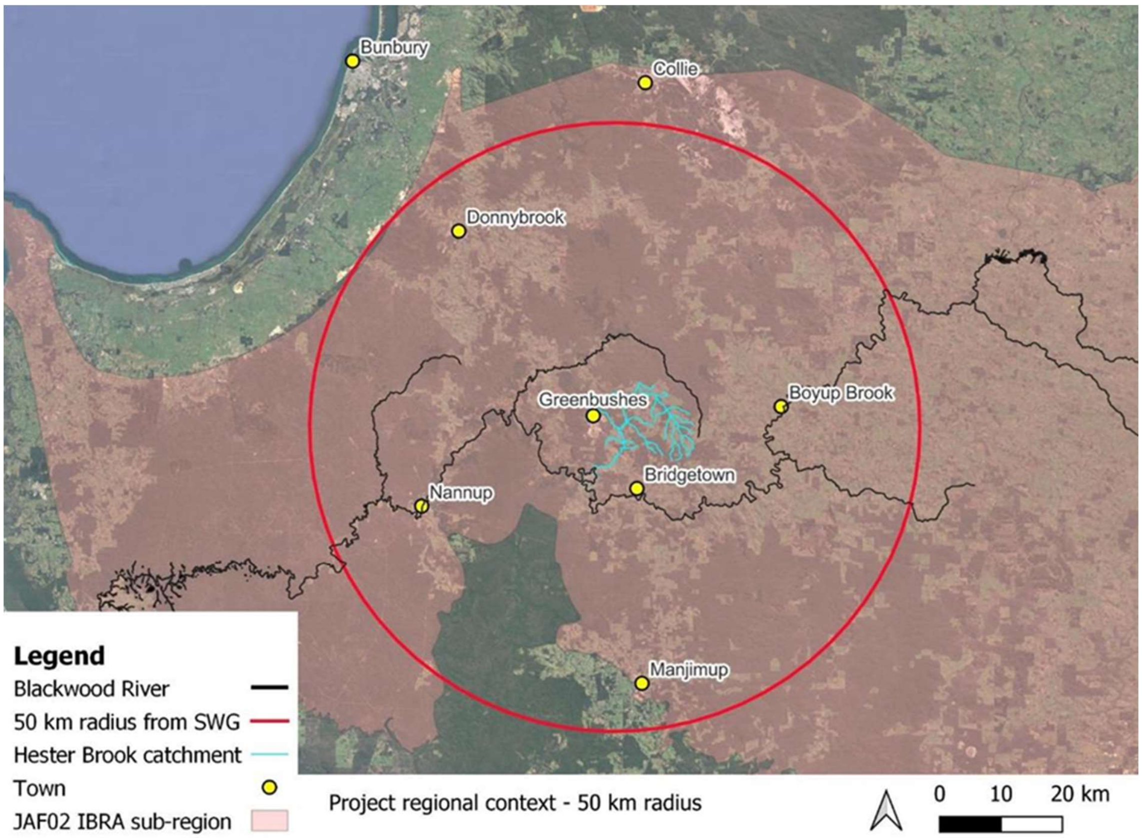

Figure 2: Project area regional context

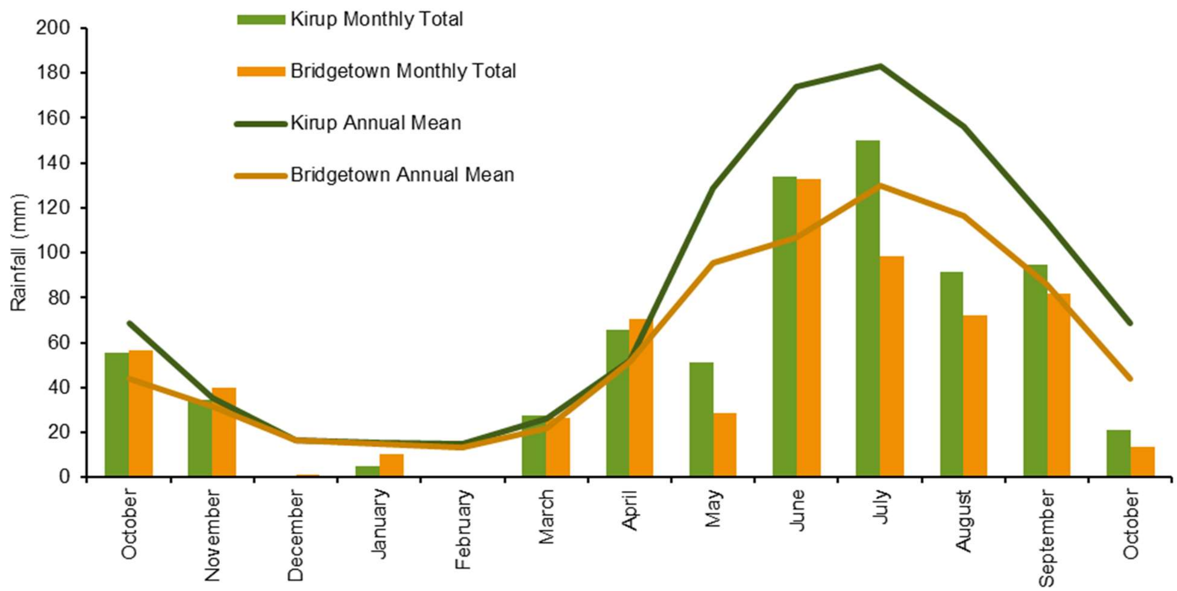

Figure 3: Total monthly rainfall recorded from October 2022 to October 2023 (inclusive) at the Bridgetown (GS 009617) and Kirup (GS 009714) gauging stations, compared to the long-term monthly average rainfall data

1.2.2 Surface Water Hydrology

The project area resides fully within the greater Hester Brook catchment, down to its confluence with the Blackwood River. Hester Brook rises northeast of Greenbushes and has two main tributaries that drain parts of the mine site, namely Saltwater Gully and Cascades Gully (Figure 1) (GHD, 2023). The combined catchment areas of Saltwater Gully and Cascade Gully makes up 10 % of the total Hester Brook Catchment and are considered minor contributors to the overall flow in Hester Brook.

Table 1-1: Hester Brook and Tributaries Catchment Areas (GHD, 2023)

Catchment Name	Catchment Area[1]	
	(Ha)	% of Total
Hester Brook total	18,517	100%
Hester Brook upstream of Saltwater Gully confluence	13,173	71%
Hester Brook downstream of Cascades Gully confluence	3,076	17%
Saltwater Gully	1,252	7%
Cascades Gully	643	3%

The establishment of the new WRL (S8) will alter the catchments and consequently flows discharging off site (Table 1-2).

Table 1-2: Changes in Catchment Areas (Ha) (GHD, 2023)

Landform	Land use	Saltwater Gully	Cascade Gully	Hester Brook (Total)
Existing	Mine affected[2]	180	41	220
	Other[3]	1,072	603	18,296
	Total	1,252	643	18,517
Existing + S1	Mine affected	190	40	230
	Other	986	555	18,164
	Total	1,176	595	18,394
Existing + S1 + S8	Mine affected	279	123	402
	Other	876	497	17,992
	Total	1,155	620	18,394

1.2.3 Groundwater Hydrology

Groundwater recharge mechanisms within the mine boundary relate to Tailings Storage Facility (TSF) seepage, infiltration through material deposited within SWG WRL boundaries, and infiltration from rainfall falling directly upon areas where alluvial sands and gravels are expressed at the surface. Groundwater levels in the shallow groundwater system indicate seasonal and/or episodic surface water

1 Catchment areas based on existing extents of waste rock landforms.

2 Mine affected catchment areas refers to the footprints of mine facilities.

3 Other refers to natural vegetation, forested and cleared for agriculture.

features that can be categorised as expressions of the water table and represent recharge points in topographic lows within the mine boundary. These would also be discharge points at times when groundwater is expressed.

Groundwater discharge points are reflected closely by the network of local dams, creeks and streams. The overall radial flow pattern exhibited outside the central mining open pit operations area suggests groundwater discharges into Cowan Brook Dam, Clear Water Dam and Austins Dam in the West, Woljenup Creek to the South, and Cascade Gully, Saltwater Gully and potentially as far as Hester Brook in the East.

The localised flow pattern observed within the bounds of the open pit mining area suggests the majority of the groundwater moving through the pattern described, discharges into the open pits. The most notable groundwater discharges within the Greenbushes Area are the primary receptors of Cascade Gully and Saltwater Gully, both tributaries to Hester Brook.

The common occurrence of groundwater within the alluvium is associated with the expression of groundwater at the surface. Within the shallow alluvial system, upon infiltrating the soil profile within recharge zones groundwater flow will generally follow local topography, along current drainage lines and paleochannels. The paleochannels also, generally, reflect surface water drainage lines along topographical lows and discharging to local water bodies or to the open pits of the mining operation itself.

Zones of lateritic caprock within the surficial profile create a preferential pathway for infiltration in the WRL area. Rainfall infiltrates through the WRL material, then primarily moves laterally down-gradient through the thin laterite caprock along the top of the saprolitic profile, discharging into Saltwater Gully to the east, and joining the paleo-drainage channels flowing north into the open pits to the west.

Groundwater levels across monitoring bores MB22_27, MB22_28 and MB30 indicate groundwater flows through lenses of re-deposited gravel and clay within the mine boundary, confirming the heterogenous nature of the shallow groundwater system, assumedly because of the historical deposition of different mine waste materials. Within the immediate vicinity of TSF1 and the southern end of the open pit operations, groundwater flow is northwards, towards the open pits, while at the southern end of the WRL, groundwater flows in a south-easterly direction, beneath Cascade Gully.

2.0 AQUATIC ECOLOGY DESKTOP REVIEW

2.1 Methods

2.1.1 Study Area for the Desktop Review

The study area for the desktop review comprised all inland surface water bodies up to 50 km from the proposed new SWG WRL S8 (Figure 1).

2.1.2 Literature and Database Searches

Relevant aquatic biology survey reports were sourced and reviewed for 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. The main aquatic biology reports reviewed are summarised in Table 2-1. Table 2-2 lists the databases searched to ascertain aquatic fauna distributions and significance and relevance to this desktop assessment. Distributions of aquatic fauna on the “Threatened and priority fauna list” (last updated by DBCA in October 2023), listed as occurring in the “Southwest” and “Warren” regions, were cross-checked with other databases in Table 2-1 to determine the likelihood of these species occurring in Cascade Gully and Hester Brook.

Table 2-1: Aquatic biology reports relevant to the study area (50km radius of WRL) arranged by year of publication (for full citation see References section)

Field Survey Date	Report Date	Report Title	Author	Report Type
Surveys within the study area				
Unreported	Aug. 2013	Ecotoxicology of lithium	CENRM UWA	Consultancy report
Surveys within 50 km of the study area				
2005 - 2008	Jan. 2011	Southwest Forest Stream Biodiversity Monitoring. Forest Management Plan 2004-2013:Key Performance Indicator 20 Interim Report	Pennifold and Pinder	WA State government report
Oct. 2011	Nov. 2011	Greenbushes Level 1 Fauna Survey	Biologic	Consultancy report
Oct. 2013	Feb. 2014	Surveys of aquatic flora and fauna along the Norilup Brook to determine the presence and health thereof and any evidence of bioaccumulation of heavy metals from the Talison Lithium Mine, Greenbushes, Western Australia	CENRM UWA	Consultancy report
Oct. 2021	Apr. 2022	2021 Ecological assessment study for Cowan and Norilup Brook at the Talison Lithium Mine, Greenbushes, Western Australia	CENRM UWA	Consultancy report
Metadata analysis	Jun. 2018	Identifying Priority Species Within the Southwestern Australian Aquatic Invertebrate Fauna	Pennifold	WA State government report

Field Survey Date	Report Date	Report Title	Author	Report Type
Desktop assessment	Jul. 2018	Greenbushes Vertebrate, SRE and Subterranean Fauna Desktop Assessment	Biologic	Consultancy report
Desktop Assessment and Site Walkover	2023	Appendix B – Conditions Survey of Waterways Downstream of TSF4	GHD (Pty) Ltd	Consultancy Report
October 2022	March 2023	Saltwater Gully New Water Storage Aquatic Ecological Assessment 2022	SLR Consulting	Consultancy Report

Table 2-2: Database searches

Database	Search Date	Authority	Area of Search/ Species
Protected Matters Search Tool	Search conducted by SLR on 23rd January 2024	DAWE	50 km radius of Project area
Australian Wetlands Database	Search conducted by SLR on 23rd January 2024	DAWE	50 km radius of Project area
Dandjoo Biodiversity Data Repository	Search conducted by SLR on 23rd January 2024	DBCA	50 km radius of Project area
Freshwater Fish Distribution in Western Australia	Search conducted by SLR on 23rd January 2024	DPIRD	Blackwood River Catchment
Wild Rivers (DWER-087)	Search conducted by SLR on 23rd January 2024	DWER	Blackwood River Catchment
Threatened Ecological Communities (DBCA-038)	Search conducted by SLR on 23rd January 2024	DBCA	50 km radius of Project area
Threatened and priority fauna list	Search conducted by SLR on 23rd January 2024	DBCA	Southwest and Warren region
Groundwater Dependent Ecosystems Atlas	Search conducted by SLR on 23rd January 2024	Bureau of Meteorology	Cascade Gully and Hester Brook downstream of the Project area
The Australian Faunal Directory (AFD)	Utilised in assessing taxonomic status and distribution of aquatic fauna	Australian Biological Resources Study (ABRS; an initiative of DAWE)	All relevant species
Atlas of Living Australia (ALA)	Search conducted by SLR on 23rd January 2024. Utilised in assessing taxonomic status and distribution of aquatic fauna	Collaborative project between academic, private and community groups.	All relevant species

Database	Search Date	Authority	Area of Search/ Species
SLR (formerly WRM) invertebrate and fish databases	Utilised in assessing taxonomic status and distribution of aquatic fauna	SLR (formerly WRM)	50 km radius of Project area

2.2 Results

2.2.1 Wetlands of National and International Importance

There are no Ramsar, DIWA or EPP listed wetlands within the immediate vicinity of the proposed project area. The closest Ramsar site, the Vasse-Wonnerup System is located outside of the 50km buffer zone towards the coastline and will not be affected by the project.

2.2.2 Aquatic Fauna

2.2.2.1 Conservation significant aquatic fauna and candidates for priority listing

The literature and database search found eight aquatic fauna species of conservation significance listed under the BC Act and/or EPBC Act with records within 50 km of the proposed WRL S8 landform, or distribution ranges that included the Project area (Table 2-3). Only three species are likely to occur within the 50 km buffer area of the proposed project: Carter's freshwater mussel, Balston's Pygmy Perch and Rakali (water rat). Further information on these four species is provided below.

<u>Carter's Freshwater Mussel ("*Westralunio carteri*")</u>

The current listing of *Westralunio carteri* is Vulnerable under the EPBC Act, Vulnerable under the BC Act, and as Vulnerable by International Union for Conservation of Nature (IUCN) red list (Klunzinger & Walker 2014), which is based on an estimated decline of 49% in southwest Western Australian populations over the last 60 years, with a trend of continuing decline. 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. The current distribution 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). A recently published study by Klunzinger et al. (2022) has undertaken morphological and genetic analysis of *W. carteri* across the southwest and determined there are three evolutionarily significant units (ESUs) within this taxon. *W. carteri* is restricted to western coastal drainages south of Perth, with those on the southwest and south coast described as a different species, split into two subspecies; those along the south coast and those in the very southwest corner around Margaret River. This paper therefore greatly reduces the known range of *W. carteri* to western flowing drainages off the Darling Scarp, and by inference increases its level of threat. Two of the ESUs are known to occur in the Blackwood River catchment; and within the 50km project radius, *W. inbisi inbisi* subsp. nov. (= "*W. carteri*" II) and W. *inbisi meridiemus* subsp. nov. (= "*W. carteri*" III). There appears to be no major differences in biology between the three "*W. carteri*" ESUs.

Primary threats are salinisation and dewatering. Secondary threats are habitat destruction, trampling by cattle, changes in water quality and possible loss of suitable host fishes for larval stages (glochidia). Confirmed host species for glochidia are freshwater cobbler, western minnows, western pygmy perch, nightfish, Swan River goby, southwestern goby, 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 mussels, restrict distributions and prevent recolonisation. As well as weirs and dams, barriers include low flow regimes due to damming or abstraction that make natural barriers (waterfalls, riffle zones) impassable for fish.

Freshwater mussels are filter feeders and vulnerable to water pollutants and sedimentation. They prefer shallow water habitats with stable, sandy or muddy bottom and inhabits both permanent and seasonal rivers and lakes. It can survive prolonged periods of drought by burrowing into bottom muds in shaded reaches and sealing the bivalve. It may thus survive potential drawdown of river pools, however it is unable to withstand extreme drying without shade for more than 5 days (Klunzinger et al. 2014). Burial by deep loose sands and silts will also kill mussels. Carter's freshwater mussel also appear intolerant of average salinity levels >1,500 mg/L (~3,000 *uS*/cm).

The nearest recent record of Carter's freshwater mussel to the study area is in St Johns Brook near Nannup, approximately 31 km west of Cascade Gully (Klunzinger 2012). Both *W. inbisi inbisi* subsp. nov. (= "*W. carteri*" II) and *W. inbisi meridiemus subsp. nov*. (= "*W. carteri*" III) were detected in St Johns Brook from genetic analysis conducted in Klunzinger et al. (2022) study. Historic records for the distribution of "*W. carteri*", likely belonging to either or both of the new subspecies, include Hester Brook (ALA database record), along with the greater Blackwood River catchment (Klunzinger 2012). Therefore, this/these species were considered a low-moderately likelihood of occurrence in Cascade Gully/Hester Brook.

Balston's Pygmy Perch (*Nannatherina balstoni*)

Balston's Pygmy Perch is a small freshwater fish that grows to a maximum length of around 90 mm (commonly 60 mm). The total length of this species at one year of age (when sexually mature) averages 60 mm for males and 63 mm for females (Morgan et al. 1995). This species is brownish dorsally and silver below, usually with a prominent brown mid-lateral stripe and a series of vertical brown bars on sides giving a cross-hatched pattern (Allen et al. 2002).

Historically, Balston's Pygmy Perch had a distribution that ranged from Moore River (approximately 75 km north of Perth), in the north, to Two Peoples Bay (Goodga River near Albany, approximately 400 km south-east of Perth), in the south, and the Collie River (approximately 150 km south of Perth), to the east (Allen et al. 2002; Morgan et al. 1995, 1998). It is extremely rare within the Blackwood River but known to occur within the buffer area. It is now regarded as the rarest of all the endemic freshwater fishes of south-west Australia (Morgan et al. 1995).

The very dry summers characteristic of south-west Western Australia result in many of the pools in which Balston's Pygmy Perch occur becoming very low, or even dry, in the later summer and autumn (Berra & Allen 1989). The species does not appear to have any adaptations to withstand desiccation, relying on their ability to recolonise these areas when water flow resumes (Morgan et al. 1995).

Rakali (*Hydromys chrysogaster*)

Rakali, listed by DBCA (2022) as **P4,** have been recorded in Salt Water Gully during a fauna survey by Onhsore Environmental in 2023. Other records include records within 10 km of the Greenbushes lithium mine and there are numerous records within the broader 50 km radius of Cascade Gully and Hester Brook. Rakali are typically associated with permanent waters, including wetlands, rivers and streams, but will venture into temporary waterways in search of food (Scott & Grant 1997). They also utilise a wide variety of man-made water bodies or modified natural habitats such as irrigation channels, reservoirs, farm dams and fish farms (Watts & Aslin 1981). They are opportunistic feeders, often preying on large aquatic invertebrates, mussels, crayfish and fish. Breeding can occur throughout the year, but more typically in spring. They build nests at the ends of tunnels dug into banks near tree roots or in hollow logs, with some found in dense stands of reeds (Speldewinde et al. 2013). Therefore, there is a habitat requirement for stable banks, tree roots and large woody debris, at least in some sections of the river. General threats to their distribution include habitat reduction through the clearing of and in filling of wetlands, flood mitigation practices, and salinisation (Smart et al. 2011, Speldewinde et al. 2013). The rakali has a broad distribution across the southwest of Western Australia and is also found in all other Australian states and territories, as well as Papua New Guinea and Indonesian West Papua (DWER 2023).

Biologic (2011) and Biologic (2018) determined it likely that rakali are present in the Greenbushes area, and it is likely that rakali are present downstream along Hester Brook, as suitable habitat for this species exists in these areas.

DBCA candidate priority aquatic macroinvertebrate species

Pennifold (2018), under the direction of the DBCA, developed a protocol for assessing candidate aquatic invertebrate species from the entire southwest of WA (a broad area defined as west of a line between Shark Bay and Cape Arid) for listing on the WA Priority Fauna list, and provided an overview on a selection of those species for listing. Using DBCA records, a search was conducted to find species which only occurred west of a line between Shark Bay and Cape Arid, with restricted distributions. This process yielded a set of 49 species, determined to be candidates for listing as priority species in need of further investigation (Pennifold 2018). Eight species on this list were identified as having records within 50 km of Cascade Gully, or distribution ranges that included the Project area (Table 2-3. Of these eight species, three were assessed as moderately likely to occur either in Cascade Gully or in Hester Brook downstream of the Project area; the beetles *Batrachomatus nannup* and *Rhantus simulans*, and the backswimmer bug *Notonecta handlirschi*. These species require further assessment to determine if they should be listed as priority/threatened fauna; these species are not currently listed under any State or Commonwealth legislation.

Table 2-3: Likelihood of occurrence of conservation significant aquatic fauna within the Project area (Cascade Gully / downstream Hester Brook), based on presence of suitable habitat in Cascade Gully/downstream Hester Brook and records of occurrence within a 50 km radius of the project area, or with distribution extents that overlap with the search area. NT = near threatened, VU = vulnerable, EN = endangered, P3 = priority 3 poorly known species, P4 = priority 4 species rare, near threatened and/or in need of monitoring

GROUP	SCIENTIFIC NAME	COMMON NAME	CONS. STATUS	LIKELIHOOD OF OCCURRENCE WITHIN THE PROJECT AREA
INVERTEBRATE	*Westralunio carteri* subspecies W. *inbisi inbisi* subsp. nov. and W. *inbisi meridiemus* subsp. nov.	Carter's freshwater mussel	VU (EPBC)	Low-Moderate likelihood of occurrence. Sites previously surveyed in creeklines around Greenbushes did not support the species (DWER Healthy Rivers distribution map, survey details not available). Nearest recent record ~31 km from Project area – St Johns Brook near Nannup (Klunzinger 2012). Historic records for the distribution of this species include Hester Brook, along with the greater Blackwood River catchment. Found in seasonal and perennial streams, rivers and reservoirs within 50-100 km from the coast, from Gingin Brook to Waychinicup River (Klunzinger et al. 2015).
INVERTEBRATE	*Glacidorbis occidentalis*	Minute freshwater snail	P3	Moderate likelihood of occurrence. Prefers relatively undisturbed seasonal headwater streams and swamps (Bunn & Stoddart 1983, WRM unpub. dat.).
INVERTEBRATE	*Musculium kendricki*	Pea shell clam	DBCA candidate Priority species	Moderate likelihood of occurrence. Inhabits lakes and lagoons. Nearest record 7.5 km west of the Project area in Norilup Brook, in October 2021 (CENRM 2022). Known distribution Perth to Augusta, and inland to Stirling Ranges (Pennifold 2018).
INVERTEBRATE	*Apsilochorema urdalum*	Caddisfly	DBCA candidate Priority species	Unlikely to occur. Inhabits rapidly flowing, small forest streams. Nearest record ~63 km to the south near Pemberton (ALA database, record date unknown). Known distribution Perth to Walpole (Pennifold 2018).

GROUP	SCIENTIFIC NAME	COMMON NAME	CONS. STATUS	LIKELIHOOD OF OCCURRENCE WITHIN THE PROJECT AREA
INVERTEBRATE	*Armagomphus armiger*	Armourtail dragonfly	VU (IUCN)	Unlikely to occur. Inhabits rapid, clear upland streams. Nearest record ~37 km to the north-west near Donnybrook (ALA database, record date unknown). Known distribution Perth to Walpole (Pennifold 2018).
INVERTEBRATE	*Archaeosynthemis spiniger*	Spiny tigertail dragonfly	VU (IUCN)	Unlikely to occur. Preferred habitat forested permanent rapid flowing streams. Nearest record ~38 km west of Project area (Pinder and Pennifold 2011, Dandjoo database, record date 2008). Known distribution Perth to Albany (Pennifold 2018).
INVERTEBRATE	*Archiargiolestes pusillissimus*	Tiny flatwing damselfly	DBCA candidate Priority species NT (IUCN)	Unlikely to occur. Preferred habitat for aquatic nymphs include shallow, boggy, seasonal waters and shallow vegetated areas along the edge of streams and rivers (Watson 1977). Nearest historic record ~32 km south of Project area (ALA database, record date 1965). Known distribution Perth to Albany (Watson 1977).
INVERTEBRATE	*Hesperocordulia berthoudi*	Orange streamcruiser	DBCA candidate Priority species	Unlikely to occur. Appears to be restricted to habitat with high flows (near riffles and waterfalls) and permanent water in high rainfall areas. Nearest recent record ~33 km from Project area – St Johns Brook near Nannup (Dandjoo database, record date 2013). Known distribution Perth to Walpole (Pennifold 2018).
INVERTEBRATE	*Batrachomatus nannup*	Diving beetle	DBCA candidate Priority species	Likely to occur – recorded by CENRM UWA in their 2013 survey of Norilup Brook for Talison Greenbushes lithium mine. Pennifold (2018) recommended it as a candidate for listing due to an apparently restricted distribution; a 30km section of the Blackwood River between Sue's Bridge and Bridgetown.

GROUP	SCIENTIFIC NAME	COMMON NAME	CONS. STATUS	LIKELIHOOD OF OCCURRENCE WITHIN THE PROJECT AREA
INVERTEBRATE	*Zephyrogomphus lateralis*	Lilac hunter dragonfly	DBCA candidate Priority species	Unlikely to occur. Preference for permanent water and high flow habitats (*e.g*. riffles and near waterfalls). Nearest record ~65 km to the south (ALA database). Known distribution Perth to Pemberton (Pennifold 2018).
INVERTEBRATE	*Notonecta handlirschi*	Backswimmer	DBCA candidate Priority species	Moderately likely to occur. Nearest record ~14.5 km to the southwest (ALA database). Elsewhere only known from three scattered populations in peat swamps (Muir-Byenup, Blackwood/Karridale and Jarrah Forest near Perth; Pennifold 2018), and Lake Pleasant View near Albany (Cale and Pinder 2019).
INVERTEBRATE	*Rhantus simulans*	Diving beetle	DBCA candidate Priority species	Likely to occur. Nearest record 12 km north-east of SWG in Balingup Brook (Dandjoo database, record date 2013). Widely distributed but rarely recorded (see Pennifold 2018).
FISH	*Galaxiella munda*	Mud minnow, western dwarf galaxias	VU	Unlikely to occur. Nearest record 22 km west of Project area. Prefers relatively undisturbed, forested permanent stream habitats. Occasionally recorded from ponds, swamps and roadside drains (Gomon & Bray 2020). Known distribution Gingin to Albany (DWER Healthy Rivers distribution map).
FISH	*Geotria australis*	Pouched lamprey	P3	Unlikely to occur. Nearest record ~ 35 km south of Project area, from Blackwood River at Nannup (DWER Healthy Rivers distribution map). Restricted to riverine habitats with marine connections (DWER 2023).

GROUP	SCIENTIFIC NAME	COMMON NAME	CONS. STATUS	LIKELIHOOD OF OCCURRENCE WITHIN THE PROJECT AREA
FISH	*Nannatherina balstoni*	Balston's pygmy perch	VU	Highly unlikely to occur. Nearest record ~ 49 km south-west of Project area, from the Blackwood River in Jalbarragup (DWER Healthy Rivers distribution map). Likely restricted to near-coastal permanent/semi-permanent stream, riverine and wetland habitats (DWER 2023).
MAMMAL	*Hydromys chrysogaster*	Rakali, native water rat	P4	Moderate-high likelihood of occurrence. Nearest record 10 km north of Project area (Biologic 2018). Requires permanent water and stable banks and tree-roots for burrowing (Speldewinde et al. 2013)

2.2.2.2 Previous Aquatic and Semi Aquatic Fauna surveys Relevant to the Project Area

The literature search did not identify any previous biological surveys that targeted aquatic fauna of Cascade Gully specifically. However, studies within the project area have been undertaken by various consultants including the AEAP monitoring on Hester Brook, Aquatic Ecological survey of Saltwater Gully and bioaccumulation studies within the dams located in the catchment.

CENRM UWA conducted an aquatic biota survey in October 2021 at six sites along Norilup Brook downstream of the Talison Greenbushes mine, and at four reference sites on Hester Brook. Macroinvertebrate samples were collected using a 250 µm dip net, however, not all habitats were targeted using the heel-kick sweeping method (sweep method only), and the samples were live-picked for 60-minutes prior to the picked individuals being preserved. This method has been shown to consistently result in fewer taxa being detected than when whole samples are preserved in the field and then sorted under high-power microscope in a laboratory (Humphrey et al. 2000). Three fish species (the native pygmy perch *N. vittata* and minnow *Galaxias occidentalis*, and the introduced *Gambusia sp*.), one crayfish (species uncertain) were recorded by CENRM UWA.

Biologic Environmental conducted a fauna survey in 2011 and a desktop assessment in 2018 for the Greenbushes Lithium mine, with a broader focus on all fauna groups, including both terrestrial and aquatic vertebrate fauna, and short-range endemic invertebrate fauna. Their 2011 survey targeted the active mine area, Saltwater Gully, and Talison-held tenements to the north and west of the Greenbushes lithium mine. Fauna recorded during this survey, that inhabit aquatic ecosystems either permanently or occasionally, included the Southwestern Snake-Necked Turtle *Chelodina colliei*, five frog species (the quacking frog *Crinia georgiana*, clicking froglet *Crinia glauerti*, western banjo frog *Limmnodynastes dorsalis*, slender tree frog *Litoria adelaidensis* and motorbike frog *Litoria moorei*), and six water birds (little black cormorant *Phalacrocorax sulcirostris*, little pied cormorant *Microcarbo melanoleucos*, musk duck *Biziura lobata*, Pacific black duck *Anas superciliosa*, Australian wood duck *Chenonetta jubuta* and black swan *Cygnus atratus)*. Turtles, frogs and water birds were not specifically targeted in the current survey, however, their presence was noted if by-catch from fishing activity occurred.

A desktop and walkover were undertaken by GHD in 2023 to assess the condition of waterways downstream of TSF4. The sites were all on the Woljenup Creek and Blackwood River further downstream of the project area. The Woljenup Creek was assessed as a highly disturbed ecosystem in its upper reaches. The middle Blackwood River was assessed as a moderately disturbed ecosystem with a predominantly cleared rural catchment, degraded foreshore condition and high salinity levels influenced by flow from the extensively cleared upper catchment.

SLR Consulting conducted an aquatic ecological survey for the Saltwater Gully New Water Storage in 2022:

<u>Water and sediment quality</u>

Saltwater Gully and downstream Hester Brook waters recorded generally neutral to basic pH, fresh to brackish conductivity and adequate to high dissolved oxygen levels. Water quality analyte levels recorded from the study area in spring 2022 were generally below or within the ANZG (2018) DGVs. Electrical conductivity, which exceeded the ANZG DGV at all sites, and was higher in sites downstream of the proposed new dam location, and total nitrogen levels also exceeded the ANZG default eutrophication GV at the majority of sites. Dissolved metal (arsenic, lithium, manganese and uranium) concentrations were higher within dam sites downstream of the North emissions monitoring point which may indicate an accumulation of these metals in the Saltwater Gully dams downstream of the Floyds WRL. Sulfate and magnesium concentrations recorded through laboratory analysis were at least two-times greater than upstream sites within Saltwater Gully. This may be indicative of acid/neutral mine drainage from the Floyds South emissions point.

Sediment quality analyte levels recorded from the study area in spring 2022 were all below the ANZG (2018) sediment DGVs, and submerged sediments in the study area are non-acid forming, therefore posing low risk to aquatic ecology.

Aquatic habitat condition

Aquatic habitat condition varied throughout the study area. Sites upstream of the Floyds north monitoring point had aquatic habitat in near pristine condition, while sites located in the Saltwater Gully dams were categorised as degraded, with areas of weedy grass cover, erosion of banks, and sediment plumes (beds of deposited sediment). Habitat condition was slightly better immediately downstream of the existing dams, with native instream and riparian vegetation present, though with visible evidence of cattle activity and bank erosion. Further downstream in Hester Brook, the aquatic habitat condition was poor, with sedimentation, weedy riparian zones and considerable bank erosion.

Macrophytes

Macrophytes were present at six of the eight sites sampled, with a total of four taxa observed at the time of sampling. Of note was the relatively high coverage of the bullrush *Typha orientalis*. at downstream site SGD3, and the relatively high coverage of charophyte algae (genera *Chara* sp. and *Nitella* sp.) at upstream site SGU4. Both *Typha orientalis* and charophyte provide ecological benefits for aquatic ecosystems by providing food, shelter and biofiltration of potential PCOCs.

Aquatic fauna

A total of 133 macroinvertebrate taxa, eight fish and crayfish species, one turtle species, one frog species and four waterbird species were recorded from the study area in spring 2022. No conservation significant aquatic fauna species were recorded during the surveys, which recorded fourteen southwest WA endemic macroinvertebrate species, two endemic fish species, two endemic crayfish species, one endemic turtle species and one endemic frog species. The bivalve *Musculium kendricki*, collected from Saltwater Gully in spring 2022, was identified as a candidate for priority listing by Pennifold (2018), but may be more widespread than previously documented. The desktop review found the aquatic fauna species of conservation-significance most likely occur in Saltwater Gully and downstream Hester Brook is the Rakali (*Hydromys chrysogaster*, DBCA-listed P4 species). The listed Vulnerable mollusc species *Westralunio carteri/inbisi* (Carter's freshwater mussel) and *Glacidorbis occidentalis* (minute freshwater snail) were considered to have a low-moderate likelihood of occurrence in Saltwater Gully/Hester Brook based on historical records in lower Hester Brook for Carter's freshwater mussel, and the presence of appropriate habitat for minute freshwater snail in the study area, which is within the species' recorded range.

2.2.3 Groundwater dependent ecosystems

No groundwater dependent ecosystems were identified in Cascade Gully or along Hester Brook downstream of the proposed new WRL location (Bureau of Meteorology's Groundwater Dependent Ecosystems Atlas).

3.0 SURVEY METHODS

3.1 Aquatic fauna sampling sites

The study proposal selected two sites along Cascade Gully and four along Hester Brook to provide adequate survey coverage to characterise each system within the likely footprint of the WRL,however not all these sites could be accessed during the survey due to landholder permissions not being granted. Site locations were therefore adjusted to provide the best coverage of both systems, given the restrictions of land access. Sampling for water quality, sediment quality and aquatic fauna, and qualitative assessments for macrophytes and habitat composition was conducted at the following five site locations (Figure 1, Table 3-1):

- One site along Cascade Gully upstream of the proposed WRL landform
- Four sites along Hester Brook (one upstream and three downstream) including a site immediately downstream of the confluence with Cascade Gully

Photographs of sites are provided in Appendix A

Table 3-1: Site locations for the 2023 survey. Coordinates are provided in UTM datum MGA94, zone 50. WRL=Waste Rock Landform.

AREA	CODE	DATE SAMPLED	EASTING	NORTHING
Upstream of WRL on Hester Brook	HES-C	13/10/2023	416653	6252240
Upstream of WRL on Hester Brook	HES-E	17/10/2023	417854	6250578
Downstream of WRL on Hester Brook	HES-F	17/10/2023	418096	6250157
Downstream of WRL after confluence of Hester Brook and Cascade Gully	HES-FA	25/10/2023	418147	6249486
Upstream of WRL on Cascade Gully	CAS-A	25/10/2023	415526	6250815

3.2 Sampling Methods

3.2.1 Water Quality

A number of general water quality variables were recorded *in situ* using calibrated, portable hand-held field meters, including pH, salinity (as electrical conductivity µS/cm), dissolved oxygen (% and mg/L), turbidity as Nephelometric Turbidity Units (NTU) and water temperature (°C).

Water quality was assessed against current Australian and New Zealand Guidelines 2020 (ANZG 2020), for the protection of aquatic ecosystems, using data specific to slightly-moderately disturbed freshwater ecosystems of southwest Western Australia.

Undisturbed water samples were collected in plastic (Nalgene) bottles at 0.1 m below the water surface for laboratory analysis of general ions, dissolved metals, total phosphorus and total nitrogen. Samples for metals and nutrient analyses were filtered through 0.45 µm Millipore nitrocellulose filters in the field. To reduce incidental contamination, all samples were collected with personnel wearing polyethylene gloves. Samples were kept cool in an esky while in the field, and frozen as soon as possible for subsequent transport to the ChemCentre, Bentley, WA (National Association of Testing Authorities - NATA accredited laboratory) for analysis.

Data were analysed descriptively, with water quality measurements and concentrations reported against ANZG (2020) Default Guideline Values (DGVs) for slightly-moderately disturbed lowland river ecosystems in southwest. For stressors, such as conductivity, pH, dissolved oxygen, temperature and turbidity, which typically display naturally high variability, ANZG (2020) recommend the use of local DGVs where available, or development of site-specific GVs. Where neither local DGVs nor site-specific GVs are available, ANZG (2020) recommend use of regional DGVs reported in ANZECC/ARMCANZ (2000), which are designed to protect at least 95% of species. See Appendix 3 for the list of relevant ANZG DGVs.

3.2.2 Sediment Quality

At each site, five replicate 250 g composite sediment samples were collected from the undisturbed inundated stream bed, from five x 1 m^2 quadrat locations selected (at random, though stratified to target locations of suitable sediment size and accessibility). Areas of fine sediment (sand/silt/clay) were targeted, in shallow areas at each site (< 1 m depth). Sediments were collected at five points with each quadrat (four corners and middle) with a clean plastic trowel, with the top 2-3 cm of sediment combined into one composite sample per quadrat. To reduce incidental contamination, the collector wore nitrile gloves while conducting the sampling. All sediment samples were kept cool in an esky while in the field, refrigerated and transported to ChemCentre, Bentley, WA (a NATA accredited laboratory). In the laboratory, each sample was analysed for particle size, moisture content, concentrations of ions Ca, K, Mg, Na, PO4 and SO4, and total and bioavailable concentrations (as determined by weak acid extraction digest), in total sediment and the <63 µm (fine) fraction, of the following analytes: As, Cd, Cr, Co, Cu, Fe, Pb, Li, Mn, Ni, organic carbon, Th, Sn, U, V and Zn.

Sediment samples and field duplicates were collected and handled in compliance with AS/NZS 5667.1 and AS/NZS 5667.12 standard methods, and the Australian and New Zealand Guidelines for Fresh and Marine Water (ANZG 2018). Analyte concentrations in sediment presented in this report reflect the median bioavailable concentrations of ions recorded within sediments.

3.2.3 Habitat

Details of aquatic habitat characteristics at each site were recorded to assist in explaining any patterns in faunal assemblages. Habitat parameters are assessed for the approximately 10 m section of creekline over which each macroinvertebrate sample was collected. Substrate type was visually assessed and recorded as estimated percent cover by bedrock, boulders, cobbles, pebbles, gravel, sand, silt and clay, from which mean particle size was determined using the phi scale. As an indication of habitat heterogeneity, the number of organic and inorganic substrate types represented at each site was totaled. Habitat characteristics recorded included estimated percent cover by inorganic sediment, submerged macrophyte, floating macrophyte, emergent macrophyte, algae, large woody debris, detritus, roots and trailing vegetation. SLR Consulting have developed specific worksheets, adapted from the DoW (2009) "Western Australia AUSRIVAS sampling and processing manual", for this task to ensure qualitative habitat recordings between sites are as comparable as possible. To limit variation due to different observers, all estimations are made by the same sampler.

At least two photographs showing site conditions/habitat characteristics were also taken at each site.

3.2.4 Macroinvertebrates

A 250 µm Freshwater Biological Association (FBA) 'D' frame style dip net was used to selectively collect benthic macroinvertebrates at all sites, and involved kick-sweep sampling over an equivalent 50 m x 0.3 m area within each site in order to provide a semi-quantitative measure of richness and abundance. All mesohabitats at each site were sampled, including trailing riparian vegetation, woody debris, open water column and benthic sediments, with the aim of maximising the number of species recorded. Each sample was washed through a 250 µm sieve to remove fine sediment, leaf litter and other debris, with any large coarse material (i.e. leaves, bark etc.), carefully washed in the sieve to remove attached fauna and discarded. Samples were then transferred to a 1L polypropylene container and preserved in 100% ethanol for laboratory enumeration and identification.

In the laboratory, each sample was sorted into different size fractions (1 mm, 500 µm and 250 µm) by washing through a series of sieves. Each size fraction was then sorted under high-power microscope to remove a maximum of 40 specimens of each family (or sub-family for Chironomidae). All specimens were identified to the lowest taxonomic level practicable (typically species or genus) and enumerated to log_{10} scale abundance per sample for all fractions combined (i.e. 1 = 1 individual, 2 = 2 - 10 individuals, 3 = 11 - 100 individuals, 4 = 101 - 1,000 individuals, etc.). In-house expertise was used to identify invertebrate taxa using available published keys and through reference to the established voucher collections held by SLR.

3.2.5 Fish, crayfish and other fauna

Methods used were in accordance with SWIRC methods recommended by DWER and as described by Storer et al. (2020). Fish and crayfish were surveyed using fyke nets and baited box traps, both of which are 'passive' techniques that rely on fish and/or crayfish moving into them to be caught. Electrofishing, being an 'active' fishing technique, was added to ensure most habitats within each site were adequately sampled. Sampling methods were standardised as much as practical across habitat types to reduce the influence of sampling method on data collected.

At each site, two fyke nets and 10 baited box traps were deployed in pools for 24 hours. Fyke nets and traps were set each morning, and then removed the following morning. Fyke nets comprise a dual 10 m leader/wing (7 mm mesh, 1.5 m drop) and a 5 m hooped net (75 cm diam. semi-circular opening, 10 mm mesh). Fyke nets were orientated to provide data on directional movement of fish out of the pool, *i.e.* positioned to catch fish/crayfish moving upstream out of the top of the pool, or downstream, out of the bottom end of the pool. Floating fauna platforms were placed inside each fyke net to form an air pocket in the case of any tortoises or other aquatic fauna becoming trapped.

Box traps comprised five large (21 x 47 x 60 cm, 3 mm mesh) and five small (26 x 26 x 46 cm, 20 mm mesh) traps, each baited with a mixture of cat biscuits and chicken pellets.

Electrofishing (Smith-Root Model LR24B electrofisher) was conducted at all sites for a standard 30 minutes duration. All meso-habitats were sampled with intention of recovering as many species as possible. Shocking was not continuous, but targeted areas of optimum habitat, whereby the operator would shock, move to a new habitat before shocking again, as to prevent fish being driven along and in front of the electrical field.

All fish and crayfish caught were identified to species, measured for standard length[4] (SL mm), for fish or occipital carapace length (OCL mm), for crayfish, health and reproductive status recorded, and released alive if native. All introduced species were retained and humanely euthanized in an ice slurry, as per the conditions of the Fisheries exemption.

Records were kept of opportunistic sightings of any rakali, freshwater mussels, frogs, birds or turtles. Unbaited camera traps were also set overnight at each site to record opportunistic fauna sightings. Turtles caught in fyke nets were returned to the water unharmed.

All data collected were consistent with SWIRC methodology, and were entered onto the appropriate SWIRC field data sheets as specified in the scope (Storer et al. 2020).

3.3 Data Analysis

Multivariate analyses of macroinvertebrate community structure were performed using the PRIMER v7 computer program (Clarke and Gorley 2006) with the PERMANOVA+ add-on package (Anderson *et al*. 2008). All multivariate analyses on fauna data were performed on the basis of Bray-Curtis dissimilarities calculated from $\log_{10}$ abundance data. All sediment and water quality analytes, except for pH (which is recorded as log-scale data), were log transformed and normalised prior to analysis of environmental relationships with macroinvertebrate assemblages. To measure the spatial variation in sediment and water quality data and macroinvertebrate community structure, patterns of dissimilarity among the sites were visualised using Principal Coordinates Analysis (PCO) ordination techniques based on Bray-Curtis similarity matrices for abundance data (Bray and Curtis 1957) and Euclidean Distance Measure for environmental data. Relationships between water quality and biotic data were assessed using:

[4]Standard length (SL) = tip of the snout to the posterior end of the last vertebra (*i.e.* this measurement excludes the length of the caudal fin). Carapace length (CL) = anterior tip of the rostrum to the posterior median edge of the carapace.

PERMANOVA - Permutational multivariate analysis of variance (PERMANOVA) was used to test for significant ($p < 0.05$) differences in fauna assemblages between upstream and downstream sites (Anderson 2001, McArdle & Anderson 2001, Anderson et al. 2008).

BVSTEP (PRIMER v7) – a procedure which assesses the correlation between the physical and chemical environmental factors and biotic data, and calculates the minimum suite of parameters that explain the greatest percent of variation (i.e. the parameters which most strongly influence the species ordination). BVSTEP was conducted to determine the strength of association between the fauna assemblage composition Bray-Curtis similarity matrices and sediment and water quality parameters.

Bubble plots – "bubbles" of sizes representative of sediment or water quality values superimposed on the macroinvertebrate assemblage PCO ordination were used to visualise spatial differences in correlated analytes (as determined through BVSTEP).

3.4 Licences

The survey was carried out under a DBCA Fauna Taking (Biological Assessment) License issued under Regulation 27 of the Biodiversity Conservation Regulations 2018 and the *Biodiversity Conservation Act 2016* (BA27000914), issued 23/09/2023.

SLR Consulting also hold a current Instrument of Exemption (EXEM 251148723) under the *Fish Resources Management Act 1994* to undertake research and environmental protection studies with respect to the activities of Talison Greenbushes Lithium Mine (TGLM) in the south-west region of Western Australia.

3.5 Survey Limitations

The table below summarises the potential limitations and constraints affecting Cascade Gully Aquatic Ecological survey.

Table 3-2: Potential limitations and constraints

Aspect	Constraint?	Comment
Competency	No	The survey was conducted by two aquatic ecologists with prior experience in aquatic fauna surveys in South West Western Australia aquatic ecosystems. The combined number of years' experience in aquatic ecology held by the personnel is 8 years. Both personnel hold university-level degrees in biological sciences. The survey was conducted under a Fauna Taking (Biological Assessment) Licence issued by DBCA and a current Instrument of Exemption (EXEM 251148723) under the *Fish Resources Management Act 1994* to undertake freshwater aquatic fauna surveys.
Scope	No	The scope was prepared by Talison and SLR, informed by the consultant's knowledge of previous, similar assessments and limited to upstream and downstream of the proposed new dam/WRL location. The scope is considered sufficient to characterise the current ecological condition of aquatic environments in the upstream and downstream areas.
Fauna detected if present in the survey area	Minor	It was not feasible to sample the entire area that may be affected by the proposed waste rock landform, therefore five sites representative of habitat areas and locations present in upstream and downstream areas were selected and targeted for sampling to maximise species detection. Due to land holder access permission, not all

Aspect	Constraint?	Comment
		these preferred locations were accessed, especially on Cascade Gully, limiting the coverage of survey effort on Cascade Gully. Rare species with low abundance may not have been detected. Survey results and fauna detection will be cross-checked with results of desktop assessments to identify all fauna likely to be present in the survey area.
Sources of information	No	The desktop assessment collated the previous findings in the region as provided by Talison and presented in publicly available reports and 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 favourable conditions. Timing of the survey was not a limitation for the survey.
Disturbances	No	There were no disturbances that affected the survey.
Intensity (in retrospect was the intensity adequate)	No	Based on the results the survey intensity is considered adequate to have met the scope. However, coverage was limited due to landowner access.
Completeness (e.g., was relevant area fully surveyed)	Minor	It was not feasible for the entire area of possible habitat within the survey area to be sampled for aquatic fauna. Areas of representative habitat were selected and targeted to maximise species detection.
Resources	No	The resources made available to the survey were sufficient.
Remoteness and/or access problems	Minor	There were restrictions on entering properties by private landowners. Certain sites and areas could not be visited and alternative sites were identified if and where possible.
Change in monitoring sites	Minor	Due to access restrictions some sites were moved and where no alternative site was available the monitoring plan was changed to exclude those sites

4.0 RESULTS AND DISCUSSION

4.1 Water Quality

Water quality within Cascade Gully and downstream Hester Brook recorded generally neutral to basic pH (7.57 – 7.9), fresh to brackish conductivity (1473 µS/cm -3380 µS/cm) and adequate dissolved oxygen (82 % to 107.1 % % saturation) at most sites. Water quality analyte levels recorded from the study area in spring 2023 were generally below or within the ANZG (2000) DGVs (Table 4-1 and Appendix B). Analytes which recorded exceedances of ANZG DGVs and Talison SSGVs included:

- Conductivity (EC) measured in the field exceeded the ANZG/DGV (300 µS/cm) at all sites (range 1453 µs/cm at HES-C to 3380 µS/cm at HES-E)
- The DO saturation at HES-E was slightly under the 85% ANZG guideline with 82% saturation during the spring 2023 survey
- Uranium recorded through laboratory analysis exceeded the ANZG 95% (0.0005 mg/L) in both samples at site HES-FA (0.0007mg/L) with HES-E-1, HES-E-2 and HES-F-1 all equal to the ANZG DGV

There were some spatial differences in water quality across the study area. EC, TDS, Turbidity and concentrations of associated ions were generally lower in the Cascade Gully site located upstream of the proposed SWG WRL. Total nitrogen concentrations tended to increase downstream of the proposed SWG WRL, with levels likely to be related to the greater extent of agricultural land adjacent to the monitoring points compared to the upstream catchment dominated by mining activities. Patterns in dissolved metals concentrations were highly variable throughout the sampled sites with a slight increase in Cobalt (dCo), Iron (dFe), Uranium (dU) and Vanadium (dV) at site downstream of the confluence of Hester Brook and Cascade Gully (HES-FA).

Table 4-1: Water quality recorded at the aquatic fauna survey sites in spring 2023, compared with ANZG (2020) DGVs. Recorded values which exceeded (or fell outside the range of) the ANZG 95% DGVs are highlighted pale orange

Analyte	Limits of Reporting	ANZG (2000) 95% DGV	Talison SSGV	Units	Upstream of WRL S8 Cascade Gully		Upstream of WRL S8 Hester Brook		Downstream of WRL S8					
					CAS-A-1	CAS-A-2	HES-C-1	HES-C-2	HES-E-1	HES-E-2	HES-F-1	HES-F-2	HES-FA-1	HES-FA-2
Alkalinity	*1*	-	-	mg/L	151	160	114	115	131	132	131	132	143	149
Arsenic (As)	*0.001*	-	0.013	mg/L	0.00061	0.00067	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00019	0.00019
Calcium (Ca)	*0.1*	-	-	mg/L	23.3	26.5	65.6	65.2	42	44	38.3	34.4	35.6	37.1
Cadmium (Cd)	*0.0001*	0.0002	0.0016	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt (Co)	*0.0001*	-	-	mg/L	0.0004	0.0005	0.002	0.0019	0.0005	0.0006	0.0004	0.0003	0.0004	0.0004
Chromium (Cr)	*0.0005*	-	0.007	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Copper (Cu)	*0.0001*	0.0014	-	mg/L	0.0004	0.0004	0.0002	0.0002	0.0005	0.0006	0.0005	0.0005	0.0006	0.0006
Dissolved Oxygen (DO) (field)*	-	85-120	-	%	102.2		96.7		82		97.3		107.1	
Dissolved Organic Carbon (DOC)	*1*	-	-	mg/L	7.2	8.1	3.7	3.7	12	12	11	11	10	11
Conductivity (field)*	-	300	-	µs/cm	1473		1453		3380		3290		3000	
Iron (Fe)	*0.005*	-	-	mg/L	0.14	0.12	0.1	0.073	0.24	0.17	0.15	0.22	0.29	0.24
Hardness	*1*	-	-	mg/L	180	200	180	360	390	410	370	370	330	340
Potassium (K)	*0.1*	-	-	mg/L	1.5	1.7	3.3	3.3	5.8	6.2	4.9	4.2	4.2	4.6
Lithium (Li)	*0.0001*	np	2	mg/L	0.014	0.015	0.25	0.25	0.033	0.034	0.032	0.026	0.013	0.011
Magnesium (Mg)	*0.1*	-	-	mg/L	29.4	31.6	47.7	47.6	68.5	73	60.3	52.4	58.2	59.5
Manganese (Mn)	*0.0001*	1.9	-	mg/L	0.1	0.11	0.23	0.23	0.11	0.11	0.07	0.063	0.079	0.082
Nitrogen from Ammonia (N_NH3)	*0.01*	0.9	-	mg/L	<0.01	-	<0.01	-	0.04	-	0.01	-	<0.01	-
Nitrogen from Nitrite (N_NO2)	*0.01*	0.3	-	mg/L	<0.01	-	<0.01	-	<0.01	-	<0.01	-	<0.01	-
Nitrogen from Nitrate (N_NO3)^	*0.01*	2.4	-	mg/L	<0.01	-	0.15	-	0.15	-	0.11	-	0.13	-

Analyte	Limits of Reporting	ANZG (2000) 95% DGV	Talison SSGV	Units	Upstream of WRL S8 Cascade Gully		Upstream of WRL S8 Hester Brook		Downstream of WRL S8					
					CAS-A-1	CAS-A-2	HES-C-1	HES-C-2	HES-E-1	HES-E-2	HES-F-1	HES-F-2	HES-FA-1	HES-FA-2
Nitrogen from Nitrate + Nitrite (N_NOx)	*0.01*	0.15	-	mg/L	<0.01	-	0.15	-	0.15	-	0.11	-	0.13	-
Total Nitrogen (N_total)	*0.01*	1.2	-	mg/L	0.35	-	0.37	-	1.1	-	0.81	-	0.7	-
Sodium (Na)	*0.1*	-	-	mg/L	135	148	154	155	494	532	439	374	439	457
Nickel (Ni)	*0.001*	0.011	0.08	mg/L	<0.001	<0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Soluble Reative Phosphorus (P_SR)	*0.01*	-	-	mg/L	<0.01	-	<0.01	-	<0.01	-	<0.01	-	<0.01	-
Total Phosphorus (P_total)	*0.005*	0.065	-	mg/L	0.007	-	0.006	-	0.023	-	0.012	-	0.017	-
pH (field)*	-	6.5-8.0	-	pH	7.9		7.57		7.7		7.9		7.9	
Lead (Pb)	*0.0001*	0.0034	-	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Redox (field)*	-	-	-	mV	-57.9		-38.7		-45.8		-54.5		-66.2	
Sulphur from Sulphate (SO4_S)	*0.1*	np	429	mg/L	19.5	20.9	315	305	89.8	96.3	85.3	71.7	66	70.8
Tin (Sn)	*0.0001*	-	-	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total Dissolved Solids (TDS_grav)	*10*	-	-	mg/L	740	720	790	780	1700	1600	1600	1600	1500	1500
Temperature (field)*	-	-	-	°C	24.2		19.7		19.8		18.8		20.9	
Total Suspended Solids (TSS)	*1*	-	-	mg/L	2	2	2	2	6	6	3	4	6	6
Thorium (Th)	*0.0001*	-	-	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Thallium (Tl)	*0.0001*	-	-	mg/L	-	-	-	-	-	-	-	-	-	-
Turbidity (field)*	-	20	-	NTU	8.36		5.43		11.61		11.18		12.18	
Uranium (U)	*0.0001*	0.0005	0.0005	mg/L	0.0001	0.0001	0.0003	0.0003	0.0005	0.0005	0.0005	0.0004	0.0007	0.0007
Vanadium (V)	*0.0001*	0.006	0.006	mg/L	0.0003	0.0003	0.0011	0.0011	0.001	0.001	0.0008	0.0007	0.0011	0.0011
Zinc (Zn)	*0.001*	0.008	0.06	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

4.2 Sediment Quality

The median sediment quality analytes recorded from the study area in spring 2023 for total sediment and sediment < 63 microns are presented in **Error! Reference source not found.** below. The median sediment results indicate increased nickel levels in < 63 microns samples across all sites. The bioavailable levels of Cr in the < 63 microns sampled exceeded the DGV at site CAS-A (upstream site). Similarly elevated Ni levels were recorded at CAS-A, significantly higher than the Hester Brook sites in the project area.

There were also spatial differences in sediment metals and nutrient concentrations across the study area. Sediment within the Hester Brook sites were significantly different than the Cascade Gully site with higher concentrations of arsenic (7.55 mg/kg), cobalt (84.5 mg/kg), iron (66 500 mg/kg), lithium (65.5 mg/kg) and tin (5.2 mg/kg) at CAS-A upstream of the proposed WRL. Downstream of the WRL and the confluence of Hester Brook and Cascade Gully higher concentrations of calcium (2800 mg/kg), magnesium (3 250 mg/kg), sodium (1 750 mg/kg) and zinc (43 mg/kg) were recorded. Variation in sediment concentrations of these analytes throughout the study area may be linked to the site locations in relation to potential sources and existing dam structures trapping sediments, and variation in sediment characteristics between sites. Different types of metals and nutrients vary in their propensity to bind with sediments, depending on the organic matter, sand and clay content of the sediment (Gregory 2008).

Table 4-2: Sediment quality recorded at the aquatic fauna survey sites in spring 2023, compared with ANZG (2022) DGVs. Sediments were sieved (<63 µm) and extracted using a weak acid digest to reflect the bioavailable fraction of metals. Recorded values which exceeded (or fell outside the range of) the ANZG DGV and ANZG GV-High are highlighted yellow and pale orange respectively.

Analyte	Units	DGV	High - DGV	Site Code									
				CAS-A Median	CAS-A Median <63mic	HES-C Median	HES-C Median <63mic	HES-E Median	HES-E Median <63mic	HES-F Median	HES-F Median <63mic	HES-FA Median	HES-FA Median <63mic
As	mg/kg	20	70	0.6	7.55	0.93	12	0.47	2.1	0.19	2.3	0.45	1.95
Ca	mg/kg	NP	NP	720	1650	710	3050	760	2200	370	2350	850	2800
Cd	mg/kg	1.5	10	0.001	0.0305	0.001	0.095	0.001	0.001	0.001	0.05	0.001	0.09
Co	mg/kg	NP	NP	15	84.5	4.3	43.5	4.8	38.5	2.4	31	3.5	25.5
Cr	mg/kg	80	370	0.88	130	0.86	64	0.92	66.5	0.55	55	0.89	61
Cu	mg/kg	65	270	5.3	28.5	1.5	22.5	4.8	28.5	1.4	22.5	3.9	23
Fe	mg/kg	NP	NP	2000	66500	4300	57000	1600	48000	1600	42500	2100	35500
K	mg/kg	NP	NP	46	270	25	795	47	870	31	835	54	870
Li	mg/kg	NP	NP	0.49	85	0.72	52	0.42	30.5	0.28	27.5	0.63	41.5
Mg	mg/kg	NP	NP	570	1950	210	1700	620	3000	230	2350	660	3250
Mn	mg/kg	NP	NP	350	1040	240	1250	64	310	120	950	130	310
Na	mg/kg	NP	NP	240	765	140	695	420	1250	270	1400	480	1750
Ni	mg/kg	21	52	3.1	65.5	1.5	31	1.5	40	0.9	31.5	1.6	35
Pb	mg/kg	50	220	4	16	3.5	23	5.9	26	2.9	19.5	4.5	21.5
SO4_S	mg/kg	NP	NP	64	2000	2000	9700	27	660	98	2450	64	2400
Sn	mg/kg	9	70	0.11	5.2	0.08	3.8	0.05	2.65	0.001	2.5	0.085	2.8
Th	mg/kg	NP	NP	0.16	11	0.12	11.2	0.32	11	0.08	11.5	0.09	11
U	mg/kg	NP	NP	0.32	2.05	0.41	3.7	1.9	7.25	0.65	4.35	0.86	3.75
V	mg/kg	NP	NP	12	150	9.8	110	6.9	120	4.5	93.5	11	105
Zn	mg/kg	200	410	2.9	27.5	4.9	43.5	2.5	35.5	1.7	31.5	4.2	43

4.3 Habitat

Recorded values for habitat variables are tabulated in Appendix C and a summary of the habitat condition and composition assessment at each site is provided below.

4.3.1 HES-C

Site HES-C was located in a low-lying area with dense exotic grasses and other weeds surrounded by sparse large native trees and pine trees. The continuous channel was approximately 1.5 m in width with a maximum depth of approximately 0.5 m and contained multiple short riffle sections along the channel. Slow flow was observed at this site and was supplied by a series of small waterfalls originating from a dam culvert approximately 50 m upstream. The water observed at this site was overall clear and free of tannins with isolated patches of algae observed in the slower moving portions of the channel. Large, persistent sediment plumes were observed in areas where sediment had been recently disturbed. There was evidence of direct livestock access to this site with pugging holes observed along the embankment and livestock fencing preventing access to sections of the channel. Livestock access was the primary visible source of disturbance observed at this site.

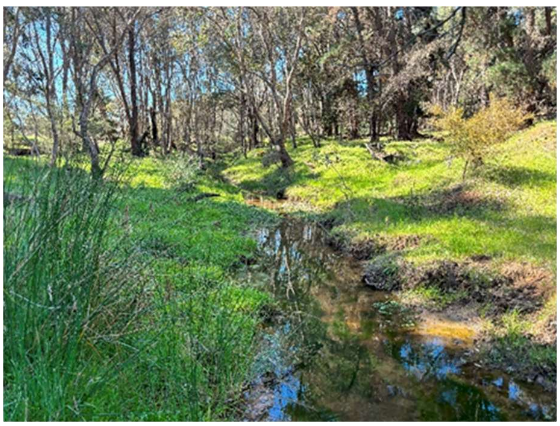

Plate 1: HES-C Upstream

Plate 2: HES-C Downstream

4.3.2 HES-E

Site HES-E was located approximately 3.41 km downstream of the sampling point for HES-C. The site was situated at the lowest point of a property and was characterized as a moderate-fast flowing continuous channel approximately 1.5 m in width with a maximum depth of 1m. Large woody debris comprised approximately 15 % of the surface area of the site. Very dense blackberry dominated most of the riparian zone along the channel. The water observed was moderately turbid and mineral substrates were a mix of moderately coarse sand and clay. Both the left and right banks showed evidence of mild-moderate erosion. No evidence of direct cattle access to the channel was observed.

Plate 3: HES-E Upstream

Plate 4: HES-E Downstream

4.3.3 HES-F

Site HES-F was located approximately 550 m downstream of HES-E at the lowest point of a large livestock grazing paddock. The continuous channel was approximately 3 m in width with a maximum depth of approximately 1.5 m with a slow-moderate flow. Large woody debris comprised approximately 20 % of the surface area of the site. Water observed at this site was moderately turbid and most of the mineral substrates were a mix of fine sand and gravel. Multiple small riffle sections were present at this site. Evidence of direct livestock access to the channel was observed at this site resulting in cattle access likely being the primary visible source of disturbance at this site. Evidence of substantial erosion was observed in the downstream portion of this site where large woody debris had altered the course of the main channel.

Plate 5: Upstream HES-F

Plate 6: Upstream HES-F

4.3.4 HES-FA

Site HES-FA was located approximately 930 m downstream of HES-F, approximately 400 m south of the confluence of Hester brook and Cascade gully. The site is situated at the northern boundary of the WAPRES blue gum tree farm. The continuous channel was approximately 2.5 m in width with a maximum depth of approximately 0.5 m. Water observed at this site was moderately turbid with a slow-moderate flow. Mineral substrate was primarily comprised of coarse and fine sands. Banks were dominated by exotic grasses and blackberry with significant evidence of erosion on both banks. No evidence of livestock access was observed with most contamination to this site likely occurring further upstream. A large dugite was observed crossing the creek line at time of sampling.

Plate 7: HES-FA Upstream

Plate 8: HES-FA Downstream

4.3.5 CAS-A

Site CAS-A was located approximately 200 m downstream of an old water supply dam and was supplied through an artificial channel connecting it upstream. The channel was continuous and had a width of approximately 40 m and a maximum depth of greater than two meters. Downstream of the site, excess water passed through a V-notch weir into a privately owned dam. Sediments at this dam were comprised primarily of very fine silty clay and large gravel. Sparse, submerged macrophyte was present at this site and a significant population of tadpoles. Small native trees, shrubs and exotic grasses made up the majority of the riparian zone. No evidence of livestock access was observed with most contamination to this site likely occurring through input from the old water supply dam upstream.

Plate 9: CAS-A Upstream

Plate 10: CAS-A Downstream

4.4 Macrophytes

Macrophytes were present at two of the five (5) sites sampled in Spring 2023. Taxa richness was low, with a total of two taxa observed at the time of sampling. Low macrophyte taxa richness is typical of Australian stream environments (usually a maximum of three taxa per reach; Quinn et al. 2011). No bullrush *Typha sp.* was observed during the Spring 2023 survey within the project area. Vegetation was dominated by overhanging grasses and by Blackberry (*Rubus ulmifolius*).

Table 4-3: Aquatic flora (macrophytes) recorded at the aquatic fauna survey sites in spring 2023

Site	Emergent veg %	Submerged veg %	Algal cover %	Taxa
CAS-A	30	15	10	
HES-C	10	10	20	*Triglochin sp*. and *Schoenoplectus sp.*
HES-E	5	0	0	
HES-F	5	5	0	*Triglochin sp*. and *Schoenoplectus sp.*
HES-FA	15	0	0	

4.5 Macroinvertebrates

A total of 110 macroinvertebrate taxa[5] were recorded during the spring survey, with 88 taxa recorded upstream of the proposed waste rock landform and 67 taxa recorded downstream. Insecta was the dominant group observed across all five (5) sites with Diptera (two-winged fly larvae) recording the highest number of taxa, followed by Coleoptera (aquatic beetles and their larvae). The most prevalent macroinvertebrate species recorded during the spring 2023 survey were the aquatic worms *Oligochaeta sp.* and the non-biting midge *Paramerina levidensis* with individuals recorded at every site.

The upstream site within Cascade Gully CAS-A had the highest species richness of all sites with 66 taxa. Greater diversity of Coleoptera and Diptera were recorded in the upstream sites, compared to the

[5] In this context, "taxa" includes groups which could not be identified to species level, due to unresolved taxonomy and/or immaturity of specimens. Therefore, the total macroinvertebrate taxa richness is likely greater than reported here.

downstream sites. This would be due to the difference in flow status between areas, with these taxa known to tolerate various flows and habitat such as within Cascade Gully.

The majority of macroinvertebrate taxa recorded were common, ubiquitous species, with distributions extending across southwestern Australia, Australasia, and the world (i.e., cosmopolitan species). No conservation significant macroinvertebrate species were recorded during the surveys. The earlier literature review found two invertebrate species listed under the EPBC Act and BC Act may occur in the Hester Brook catchment (molluscs *Westralunio carteri/inbisi* and *Glacidorbis occidentalis*), however, neither species were recorded in spring 2023.

Eight southwest WA endemic species were recorded in the macroinvertebrate samples, including the amphipod *Perthia acutitelson,* aquatic beetle *Sternopriscus browni*, crustacean *Cherax cainii*, midges *Botryocladius 35reeman*, prong-gilled mayfly *Leptophlebiidae sp,* dragonfly *Austroaeschna anacantha*, stonefly *Newmanoperla exigua* and *Gripopterygidae sp.*

Table 4-4: Summary of higher-order macroinvertebrate taxa composition recorded from the study area in spring 2023

Macroinvertebrates		Number of Taxa	
Scientific Name	**Common name**	**Upstream of Proposed WRL S8**	**Downstream of Proposed WRL S8**
Cnidaria	Hydra	0	0
Nematoda	Nematodes	1	1
Mollusca	Freshwater Snails	5	1
Annelida	Aquatic worms and Leeches	1	1
Amphipoda	Amphipods	1	3
Arachnida	Water Mites	5	5
Collembola	Springtails	0	1
Diptera	Two-winged flies	32	31
Odonata	Dragonflies and Damselflies	5	4
Plecoptera	Stoneflies	0	2
Trichoptera	Caddisflies	5	4
Lepidoptra	Butterfly / Moths	2	1
Ephemeroptera	Mayflies	3	3
Hemiptera	True Bugs	5	3
Coleoptera	Aquatic Beetles	23	7
	Total taxa richness	88	67

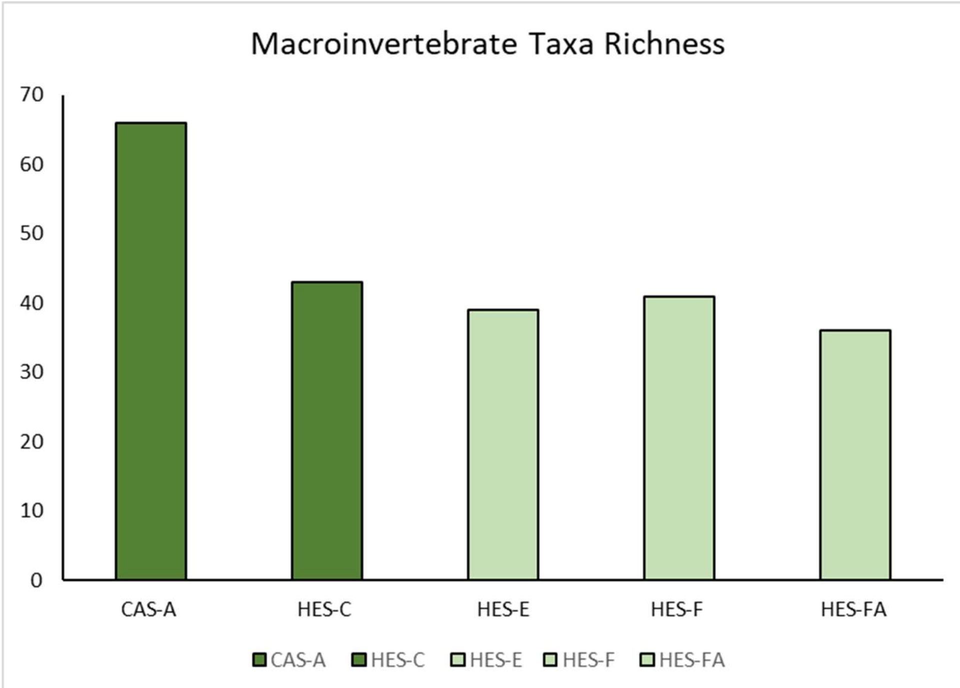

Figure 4: Macroinvertebrate Taxa Richness Recorded at Upstream (CAS-A and HES-C) and Downstream (HES-E, HES-F and HES-FA) of proposed WRL during Spring 2023

4.5.1 Relationship between Macroinvertebrate Assemblages and Environmental Data

Spatial patterns across the study area were evident in the macroinvertebrate assemblage PCO ordination (Figure 5). A total of 77 % of the variation between sites was explained by two PCO axes. Upstream and downstream sites separated along PCO1, which explained 54.4 % of the total variation in assemblages between sites.

The separation of upstream sites was correlated with greater abundance of family Leptoceridae (stick caddis), *Notalina spira, Oecetis sp.*, *Triplectides australicus.* and Ramshorn snail *Glyptophysa sp*. and pond snail *Bullastra vinosa* and slender ringtail *Austrolestes analis* and blue ringtail *Austrolestes annulosus* and mayfly *Baetide sp.* and non-biting midge taxa *Parachironomus sp., Dicrotendipes sp*., *Larsia albiceps*, and diving beetles *Sternopriscus sp., Tiporus sp (L).* The separation of downstream sites was correlated with greater abundances of mayfly taxa *Caenidae sp* and sideswimmer *Austrochiltonia subtenuis.*

Sites HES-E and HES-FA separated from the other sites along PCO2, which explained 22.6 % of the total variation in assemblages between sites. Taxa correlated with this separation that recorded greater abundances at these sites include the sideswimmer *Austrochiltonia subtenuis*, southwest endemic amphipod *Perthia acutitelson*. and the southwest endemic stonefly larvae *Newmanoperla exigua* and *Gripopterygidae sp*. Taxa that recorded lower abundance or were absent from HES-E and HES-FA was small water strider *Veliidae sp.*

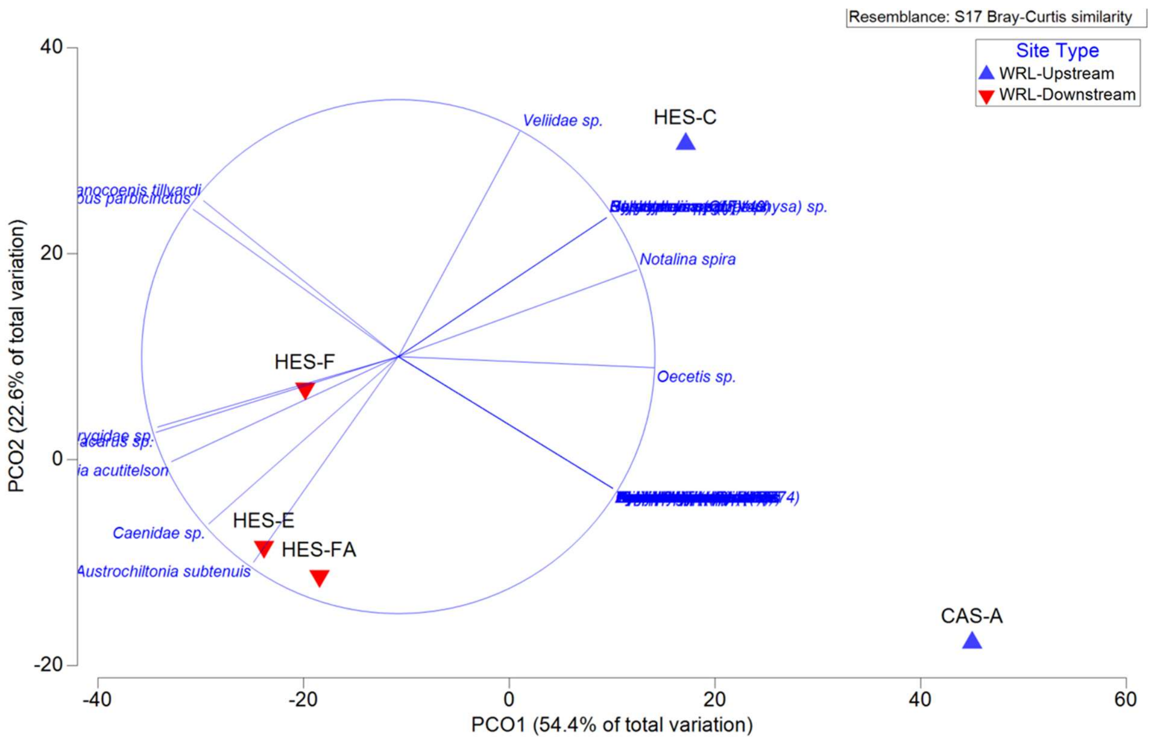

Figure 5 Cascade Gully macroinvertebrate assemblage PCO ordination in two dimensions, log abundance data, Spring 2023. Macroinvertebrate taxa with correlations r > 0.95 with the separation of sites are overlaid.

PERMANOVA indicated that the macroinvertebrate assemblage upstream was different from the downstream sites but not ecological significantly (One-way PERMANOVA df = 1, pseudo-F = 3.08, p = 0.098), at only 35.66 % similarity between the two areas. Assemblage composition similarity was higher within the downstream site group (60 %), compared to the upstream site group (42.2 %). Low site replication and high between-site variability in similarity likely prevented the two groups from being statistically significantly different, although they were well separated in ordination space.

Linear correlations of water quality variables (r > 0.8) were overlaid on the macroinvertebrate assemblage PCO (Figure 6). The separation of CAS-A was correlated with greater temperature, and HES-C assemblage was correlated with greater levels of SO_4 and Ca. The downstream assemblages correlated with greater levels of Turbidity, dFe, DOC, TSS, P-Total, TDS, N-Total and Conductivity. There was a significant, strong non-linear correlation between macroinvertebrate assemblage composition and a similar, though slightly different suite of water and sediment quality variables in Cascade Gully and Hester Brook (BVSTEP; Rho = 0.952, p = 0.038). The suite of variables found through BVSTEP to have the greatest correlation with the differences in macroinvertebrate assemblage composition was hardness with a 0.952 correlation in water (Figure 7).

Sediment arsenic concentrations were higher in upstream Hester Brook sites compared to upstream sites, while higher concentrations of copper, nickel, chromium, cobalt, lithium, tin, iron were greater in the upstream sites towards CAS-A within Cascade Gully.

While sediment and water quality analytes were correlated with the macroinvertebrate assemblage variation in the study area, this correlation does not necessarily indicate causation for observed differences in assemblage composition. Rather, the differences between sites in habitat composition and condition, flow status and position in the catchment (and surrounding land uses) are likely to be highly influential factors for the variation in macroinvertebrate assemblages across the study area.

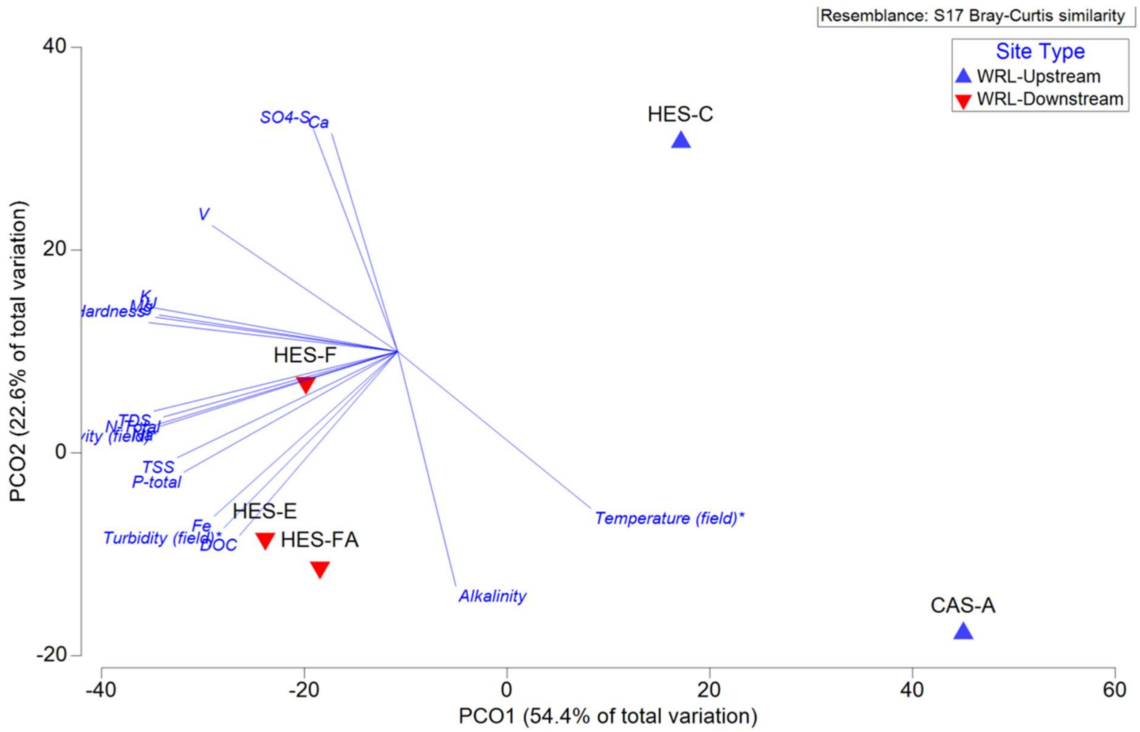

Figure 6 Macroinvertebrate assemblage PCO with environmental variables of correlations r > 0.8 with the separation sites are overlaid

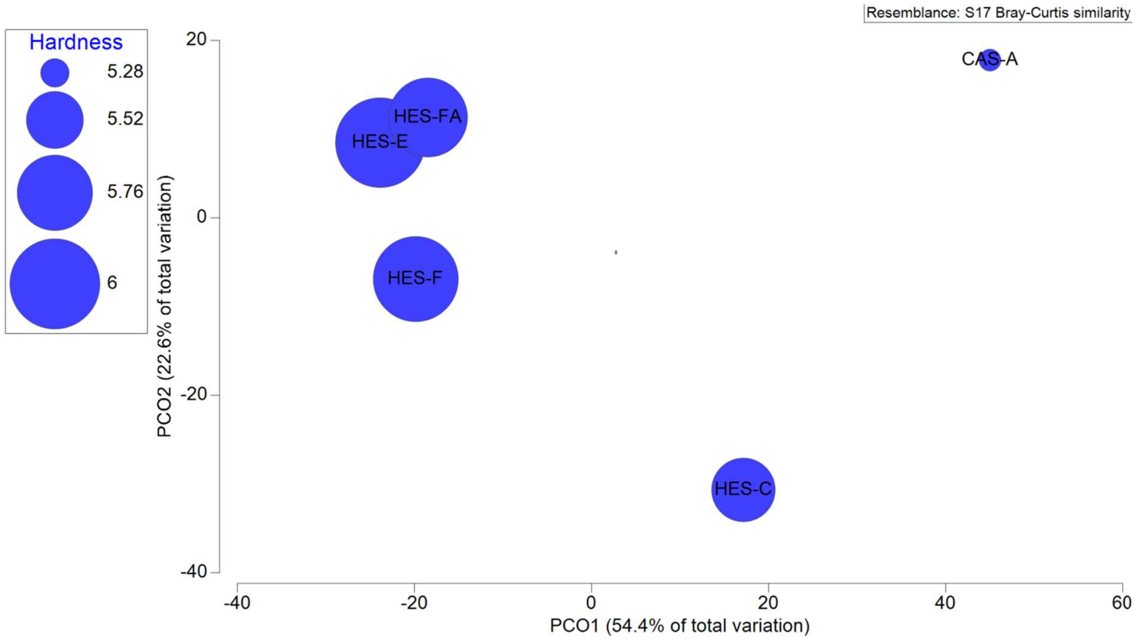

Figure 7 Macroinvertebrate PCO overlaid with water hardness bubble plots

4.6 Fish, Crayfish and Turtles

The spring 2023 survey of Cascade Gully recorded two native fish species, one introduced fish species, two native crayfish species, one introduced crayfish species and the endemic southwestern snake-necked turtle. Six crayfish collected during the spring 2023 survey were too immature to identify to species level, and have been referred to as *Cherax sp* (Table 4-5). Photographs of fauna are presented in Plate 1. The most commonly recorded species of fish was the native Western Pygmy Perch (369 individuals collected), followed by the introduced Eastern Gambusia (139 individuals collected). All of the species captured are widespread throughout the southwest WA region, and all native species captured are endemic to this region. Records on DWER Healthy Rivers website (DWER 2023) indicate the historical presence of other species within the project area but were not detected in the current study, such as Nightfish (*Bostokia porosa*), Freshwater Cobbler (*Tandanus bostocki*) and the Blue-Spot Goby(*Pseudogobius olorum*).

The native the Southwestern Snake-Necked Turtle *Chelodina colliei* was recorded as by-catch of fishing activities at CAS-A. This species is endemic to the south-west of Western Australia, inhabiting both permanent and seasonal waterbodies in fresh and saline systems. *C. colliei* is not listed at state or federal level, however, it is currently listed as 'near threatened' by the IUCN, and its status has not been assessed for 20 years (DWER 2023). Threats to local populations may include injury by traffic when crossing roads to reach nesting habitat, predation by foxes, fencing that blocks migrations, illegal fishing by humans, and destruction of natural habitat.

Fauna abundance was generally highest in the sites upstream of the proposed WRL with HES-C accounting for 43% off all fauna collected during the spring 2023 survey. The greatest species richness was recorded at HES-FA, despite recording the second lowest total abundance of aquatic fauna. Species richness was the lowest at CAS-A with one species of fish recorded and no crayfish. CAS-A was the only site that recorded *C. colliei*.

No exotic Redfin Perch was recorded at any of the sites as the species has previously been recorded upstream in Saltwater Gully and potentially poses a high risk to native fauna in Cascade Gully and Hester Brook. Redfin Perch are one of the most significant predators of native fish and crayfish in the south-west and can grow in excess of 60 cm and weigh up to 10 kg (DWER 2023).

Table 4-5 Fish, crayfish and turtle species recorded in Cascade Gully and Hester Brook, spring 2023

Common Name	Species Name	Site					Total Abundance
		CAS-A	HES-C	HES-E	HES-F	HES-FA	
South-Western Snake-Necked Turtle	*Chelodina colliei*	2	0	0	0	0	**2**
Smooth Marron	*Cherax cainii*	0	1	2	0	3	**6**
Yabby	*Cherax destructor*	0	38	0	0	22	**60**
Koonac	*Cherax preissii*	0	13	4	8	2	**27**
Freshwater Crayfish	*Cherax sp.*	0	4	1	0	1	**6**
Western Minnow	*Galaxias occidentalis*	49	0	10	0	33	**92**
Eastern Gambusia	*Gambusia holbrooki*	0	124	2	0	13	**139**
Western Pygmy Perch	*Nannoperca vittata*	0	122	83	151	13	**369**
		51	**302**	**102**	**159**	**87**	**701**

4.6.1 Other Fauna

The water bird species Pacific Black duck (*Anas superciliosa*) was observed at HES-F with two species of frog, the south-western Australia slender tree frog (*Litoria adelaidensis)* and more commonly encountered motorbike frog (*Litoria moorei)* observed during the survey. A chance observation of a dugite (*Pseudonaja affinis affinis*) was recorded in the upstream portion of HES-FA.

Dugite (*Pseudonaja affinis affinis)*

Australian slender tree frog *(Litoria adelaidenis*)

Plate 11: Photographs of other fauna recorded in the study area, spring 2023

5.0 Project-Specific Risks to Aquatic Fauna

An environmental impact assessment for the project to aquatic ecosystems was beyond the scope of this survey and report, however, potential risks were considered at a higher level. The following potential impacts to Cascade Gully aquatic fauna from the Project.

Increased surface water run-off from the SWG WRL 8

The construction of the WRL could increase the surface water run-off from the landform due to the hardening of the surface that could potentially flow into the receiving aquatic environment (Cascade Gully and Hester Brook). Alternatively, the WRL could reduce runoff due to the infiltration.

The increase in runoff could impact on the water quality in these creek lines due to an increase in TSS as well as alter the hydrology as an increase in flow within the creek lines could be observed. These changes could have a negative impact on the flows and water quality in these systems.

Mobilisation of sediments which may increase turbidity levels and concentrations of PCOCs in Cascade Gully and Hester Brook downstream of the Project, during construction phase

Siltation from construction activities is a risk that can be managed effectively through appropriate mitigation measures during the construction phase. Some sedimentation is evident in the furthest downstream sites, likely due to recent fires removing riparian vegetation, therefore downstream habitat is not in pristine condition.

Ground Water seepage into Creek Lines

The operation of the WRL could cause seepage from the waste rock into the groundwater. The groundwater studies confirmed the flow of groundwater towards Cascade Gully and Hester Brook that could impact on the water quality within these systems. The classification and determination of the type of waste rock is critical to understand the barrier system required during construction to ensure that seepage from the WRL is limited during operation over time. If Acid Mine Drainage (AMD) or Neutral Mine Drainage (NMD) occurs, seepage from WRL direct to creeks as surface flow seepage from toe of WRL, or as infiltration into groundwater and seepage as groundwater to creeklines may mobilise metals/ions and adversely affect water quality - with any exceedances of DGVs posing risk to aquatic fauna. Manage WRL design and construction to manage any Potentially Acid Forming (PAF) material to be encompassed in sufficient neutralising material may manage risk of AMD/NMD.

6.0 Summary and Conclusions

The Cascade Gully Aquatic Ecological Assessment associated with the proposed new WRL was undertaken in Spring 2023. Aquatic biota, water and sediment quality sampling was conducted at five sites along Cascade Gully and Hester Brook with two upstream sites or reference sites and three downstream or impact sites. The study area is located in the Southern Jarrah Forest IBRA sub-region (JAF02). There are no Ramsar, DIWA or EPP listed wetlands within the immediate vicinity of the proposed project area. No groundwater dependent ecosystems were identified in Cascade Gully or along Hester Brook downstream of the proposed new WRL location (Bureau of Meteorology's Groundwater Dependent Ecosystems Atlas).

Water and Sediment Quality

Water quality within Cascade Gully and downstream Hester Brook recorded generally neutral to basic pH (7.57 – 7.9), fresh to brackish conductivity (1473 µS/cm -3380 µS/cm) and adequate dissolved oxygen (82 % to 107.1 % saturation) at most sites. Water quality analyte levels recorded from the study area in spring 2023 were generally below or within the ANZG (2000) DGVs (Table 4-1 and Appendix B). Analytes which recorded exceedances of ANZG DGVs and Talison SSGVs included:

- Conductivity (EC) measured in the field exceeded the ANZG/DGV (300 µS/cm) at all sites (range 1453 µs/cm at HES-C to 3380 µS/cm at HES-E)
- The DO saturation at HES-E at 82 % was slightly under the lower ANZG DO guideline of 85 % saturation during the spring 2023 survey
- Uranium recorded through laboratory analysis exceeded the ANZG 95 % species protection guideline value (0.0005 mg/L) in both samples at site HES-FA (0.0007 mg/L) with HES-E-1, HES-E-2 and HES-F-1 all equal to the ANZG DGV

The median sediment results indicate increased Nickel levels at < 63 micron samples across all sites. The bioavailable levels of Cr in the < 63 micron fraction exceeded the DGV at site CAS-A (upstream site). Similarly elevated Ni levels were recorded at CAS-A significantly higher than the Hester Brook sites in the project area.

Aquatic Habitat Condition and Macrophytes

Aquatic habitat condition varied throughout the study within the Hester Brook and Cascade Gully systems. General habitat conditions within Hester Brook and Cascade Gully were categorised as degraded as most sites had signs of livestock and bank erosion, and this became more substantial further downstream on Hester Brook. Various land uses were observed along the project area that could impact on the habitat conditions of Hester Brook and Cascade Gully. All sites were dominated by Blackberry and exotic grasses within the riparian zone. Only two sites recorded macrophytes with *Triglochin sp*. and *Schoenoplectus sp.* present within these sites.

Aquatic Fauna

A total of 110 macroinvertebrate taxa[6] were recorded during the spring survey, with 84 taxa recorded upstream of the proposed waste rock landform and 64 taxa recorded downstream. Insecta was the dominant group observed across all five (5) sites with Diptera (two-winged fly larvae) recording the highest number of taxa, followed by Coleoptera (aquatic beetles and their larvae). The most prevalent macroinvertebrate species recorded during the spring 2023 survey were the aquatic worms *Oligochaeta sp.* and the non-biting midge *Paramerina levidensis* with individuals recorded at every site.

No conservation significant macroinvertebrate species were recorded during the surveys. The earlier literature review found two invertebrate species listed under the EPBC Act and BC Act which may occur in the Hester Brook catchment (molluscs *Westralunio carteri/inbisi* and *Glacidorbis occidentalis*), however, neither species were recorded in spring 2023.

There was a strong correlation between macroinvertebrate assemblage composition and sediment and water quality variables in Cascade Gully and lower Hester Brook. However, it is not possible to conclude that sediment and water quality are the most influential factors determining assemblage composition.

The most commonly recorded species of fish was the native Western Pygmy Perch (369 individuals collected), followed by the introduced Eastern Gambusia (139 individuals collected). All the species captured are widespread throughout the southwest WA region, and all the native species captured are endemic to this region. Records on DWER Healthy Rivers website (DWER 2023) indicate the historical presence of other species within the project area, but these were not detected in the current study, such as Nightfish (*Bostokia porosa*), Cobbler (*Tandanus bostocki*) and the Blue-Spot Goby(*Pseudogobius olorum*).

Conclusion

Cascade Gully and downstream Hester Brook supports an assemblage of aquatic biota species representative of other nearby aquatic ecosystems. The aquatic habitat in this study area showed evidence of past disturbances and has been classified in other reports as “moderately disturbed ecosystems”. While water and sediment quality in general were within the default and/or site-specific guidelines, other sources within the catchment could contribute to higher concentrations if not managed correctly. An environmental impact assessment for the project to determine the potential impact to the aquatic ecosystems was beyond the scope of this survey and report, however, potential risks were considered at higher level. The construction of a new WRL could impact on the water and sediment quality as surface water runoff from the landform could impact on the quality and quantity of water received within Hester Brook and Cascade Gully. Similarly, if AMD or NMD eventuates within the WRL, there is potential for seepage of contaminated water either as surface seepage from the toe of the WRL, or as subsurface seepage into the groundwater to impact on the receiving aquatic ecosystem as the surface and groundwater flow patterns are towards Hester Brook and Cascade Gully. If mitigation and management measures are put in place during construction and operation these impacts should have a minimal effect on the aquatic ecosystems. Monitoring along these water bodies is recommended to assess the potential impact of the new SWG WRL on the receiving aquatic environment. Data collected as part of this survey provide a sound baseline against which to assess future changes in fauna, sediment and water quality. Additional sites on Cascade Gully, adjacent to the WRL would be beneficial, once landholder access issues have been resolved.

[6] In this context, “taxa” includes groups which could not be identified to species level, due to unresolved taxonomy and/or immaturity of specimens. Therefore, the total macroinvertebrate taxa richness is likely greater than reported here.

7.0 References

Anderson MJ (2001) A new method for non-parametric multivariate analysis of variance. Austral Ecology 26:32-46.

Anderson MJ, Gorley RN, Clarke KR (2008) Permanova + for PRIMER: guide to software and statistical methods. PRIMER-E Ltd, Plymouth, UK.

ANZECC/ARMCANZ (2000). Australian and New Zealand Guidelines for fresh and marine water quality. Australia and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand. Paper No. 4. Canberra.

ANZG (2023). 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. [Accessed 17th January 2023] www.waterquality.gov.au/anz-guidelines

Australian Government (2018) Charter: National Water Quality Management Strategy, Department of Agriculture and Water Resources, Canberra, March. CC BY 3.0.

Beatty, S.J. and Morgan, D.L. (2017) Rapid proliferation of an endemic galaxiid following eradication of an alien piscivore (Perca fluviatilis) from a reservoir. Journal of Fish Biology, 90 (3). pp. 1090-1097.

Biologic (2011) Greenbushes Level 1 Fauna Survey. Consultancy report to Talison Lithium Australia Pty Ltd, November 2011. https://www.epa.wa.gov.au/sites/default/files/Referral_Documentation/Appendix%20B%20-%20Fauna%20Surveys%20Biologic.pdf [Accessed 11th January 2023].

Biologic (2018) Greenbushes Vertebrate, SRE and Subterranean Fauna Desktop Assessment. Consultancy report to Talison Lithium Limited, 10 July 2018. https://www.epa.wa.gov.au/sites/default/files/Referral_Documentation/Appendix%20B%20-%20Fauna%20Surveys%20Biologic.pdf [Accessed 11th January 2023].

BOM (2006) Bureau of Meteorology. Climate classification maps. http://www.bom.gov.au/climate/maps/averages/climate-classification/ [Accessed 25th January 2024]

BOM (2022) Bureau of Meteorology Climate Data Online. http://www.bom.gov.au/climate/data/.

Bray JR, Curtis JT (1957) An ordination of the upland forest communities of Southern Wisconsin. Ecological Monographs 27: 352-349.

Bunn SE, Stoddart JA (1983). A new species of the prosobranch gastropod Glacidorbis and its implications for the biogeography of south-western Australia. Records of the Western Australian Museum 11(1): 49-57.

Bunn SE, Davies PM, Edward DHD (1989). The association of Glacidorbis occidentalis Bunn & Stoddart (Gastropoda: ?Hydrobiidae) with intermittently-flowing forest streams in south-western Australia. Journal of the Malacology Society of Australia 10: 25-34.

Cale DJ, Pinder AM (2019) Wheatbelt Wetland Biodiversity Monitoring: Fauna Monitoring at Lake Pleasant View 1999-2012. Department of Biodiversity, Conservation and Attractions, Perth. Report WWBM-FR03. January 2019

CENRM (2013) Ecotoxicology of lithium. Unpublished report by Centre of Excellence in Natural Resource Management, The University of Western Australia Albany, 6330, to Talison Lithium Australia Pty Ltd, August 2013.

CENRM (2014) Surveys of aquatic flora and fauna along the Norilup Brook to determine the presence and health thereof and any evidence of bioaccumulation of heavy metals from the Talison Lithium Mine, Greenbushes, Western Australia. Unpublished report by Centre of Excellence in Natural Resource Management, The University of Western Australia Albany, 6330, to Talison Lithium Australia Pty Ltd. February 2014.

CENRM (2022) 2021 Ecological assessment study for Cowan and Norilup Brook at the Talison Lithium Mine, Greenbushes, Western Australia. Unpublished report by Centre of Excellence in Natural

Resource Management, The University of Western Australia Albany, 6330, to Talison Lithium Australia Pty Ltd, April 2022.

Clarke KR, Gorley RN (2006) PRIMER v6: User manual/Tutorial, Primer E: Plymouth. Plymouth Marine Laboratory, Plymouth, UK.

DBCA (2022) Threatened and priority fauna list. Department of Biodiversity, Conservation and Attractions, Species and Communities Branch, Parks and Wildlife Service. https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-animals. [Accessed 11th January 2023].

DWER (2023) Healthy Rivers fauna records https://rivers.dwer.wa.gov.au/southwest/fauna/ [Accessed 11th January 2023].

EPA (2016a) Environmental Factor Guideline: Terrestrial Fauna. Environmental Protection Authority, Western Australia. 13 December 2016.

EPA (2016b) Technical Guide: Sampling of short range endemic invertebrate fauna. Environmental Protection Authority. December 2016.

EPA (2018) Environmental Factor Guideline: Inland Waters. Environmental Protection Authority, Western Australia. 27 June 2018.

EPA (2020). Technical Guidance – Terrestrial vertebrate fauna surveys for environmental impact assessment, EPA, Western Australia. June 2020.

GHD (2021) Water Quality Guidelines Assessment | Greenbushes Mine, Western Australia. Report to Talison Lithium Australia Pty Ltd, 14th October 2021.

GHD (2022) TSF4 Seepage Assessment - Development of Site-Specific Water Quality Guidelines. Draft report to Talison Lithium Australia Pty Ltd, 10th September 2022.

Gregory, S. (2008). The classification of inland salt lakes in Western Australia. MSc thesis, School of Environmental Biology, Curtin University of Technology, Perth, Western Australia.

Humphrey, C.L., Storey, A.W. & Thurtell, L. (2000). AUSRIVAS: operator sample processing errors and temporal variability – implications for model sensitivity. [In] JF Wright, DW Sutcliffe & MT Furse (eds) Assessing the Biological Quality of Freshwaters. RIVPACS and Similar Techniques. Freshwater Biological Association, Ambleside, UK pp 143-163.

IUCN (2022). Glacidorbis occidentalis. The IUCN Red List of Threatened Species. Version 2022-2. https://www.iucnredlist.org. Accessed on 17 January 2023.

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, Beatt, 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 southwestern Australia. Australian Journal of Zoology 63: 127-135. doi:10.1071/ZO15002.

Klunzinger MW, Whisson C, Zieritz A, Benson JA, Stewart BA & Kirkendale L (2022) Integrated taxonomy reveals new threatened freshwater mussels (Bivalvia: Hyriidae: Westralunio) from southwestern Australia. Sci Rep, 12, 20385. https://doi.org/10.1038/s41598-022-24767-5

McArdle BH, Anderson MJ (2001) Fitting multivariate models to community data: a comment on distance-based redundancy analysis. Ecology 82: 290-297.

Pennifold MG and Pinder A (2011) Southwest Forest Stream Biodiversity Monitoring. Forest Management Plan 2004-2013:Key Performance Indicator 20 Interim Report. Department of Environment and Conservation Science Division, Perth.

Pennifold MG (2018) Identifying Priority Species within the Southwestern Australian Aquatic Invertebrate Fauna. Department of Biodiversity, Conservation and Attractions, Perth.

Ponder, W.F. & Slack-Smith, S. (1996). Glacidorbis occidentalis. The IUCN Red List of Threatened Species 1996: e.T9201A12970029. https://dx.doi.org/10.2305/IUCN.UK.1996.RLTS.T9201A12970029.en. Accessed on 17 January 2023.

Quinn LD, Schooler SS, van Klinken RD. (2011). Effects of land use and environment on alien and native macrophytes: Lessons from a large-scale survey of Australian rivers. Divers Distrib 17:132-143

Scott A. & Grant T. (1997). Impacts of Water Management in the Murray-Darling Basin on the Platypus (Ornithorhynchus anatinus) and the Water Rat (Hydromys chrysogaster). CSIRO Land & Water Technical Report 23.

Smart, C., Speldewinde, P. and Mills, H. (2011). Influence of habitat characteristics on the distribution of the water-rat (Hydromys chrysogaster) in the greater Perth region, Western Australia. Journal of the Royal Society of Western Australia. 94:533-9.

Speldewinde, P.C., Close, P., Weybury, M. and Comer, S. (2013). Habitat preference of the Australian water rat (Hydromys chrysogaster) in a coastal wetland and stream, Two Peoples Bay, south-western Australia. Australian Mammalogy. 35: 188-94.

Storer T, White G, O'Neill K, Galvin L, van Looij E (2020) South-West Index of River Condition, Method overview 2020, River Science Technical Series 1, Healthy Rivers program, Department of Water and Environmental Regulation, Perth.

Watts C.H.S. & Aslin H.J. (1981). The Rodents of Australia. Angus and Robertson, Sydney.

8.0 Feedback

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Appendix A Site Photographs – Spring 2023

Talison Greenbushes

Aquatic Ecological Assessment For The Proposed New Waste Rock Landform S8

Talison Lithium (Pty) Ltd

SLR Project No.: 675.072130.00001

27 May 2024

CAS-A Upstream

CAS-A Downstream

HES-C Upstream

HES-C Downstream

HES-E Upstream

HES-E Downstream

HES-F Upstream

HES-F Downstream

HES-FA Upstream

HES-FA Downstream

Appendix B ANZG (2023) Default Guideline Values

Table A1-1. Default guideline values for physical and chemical stressors for southwest Australia for slightly disturbed ecosystems (Chl a = chlorophyll a, TP = total phosphorus; FRP = filterable reactive phosphorus; TN = total nitrogen; NOx = total nitrates/nitrites; NH3 = NH4+ = ammonium, DO = dissolved oxygen).

Ecosystem type		Chl *a*	TP	FRP	TN	NO_x	NH_4^+	DO (% saturation)[i]		pH	
		(µg L^{-1})	(µg P L^{-1})	(µg P L^{-1})	(µg N L^{-1})	(µg N L^{-1})	(µg N L^{-1})	Lower limit	Upper limit	Lower limit	Upper limit
Upland river[f]		na[a]	20	10	450	200	60	90	na	6.5	8.0
Lowland river[f]		3–5	65	40	1200	150	80	80	120	6.5	8.0
Freshwater lakes & reservoirs		3–5	10	5	350	10	10	90	no data	6.5	8.0
Wetlands[d]		30	60	30	1500	100	40	90	120	7.0[e]	8.5[e]
Estuaries		3	30	5	750	45	40	90	110	7.5	8.5
Marine[g,h]	Inshore[c]	0.7	20[b]	5[b]	230	5	5	90	na	8.0	8.4
	Offshore	0.3[b]	20[b]	5	230	5	5	90	na	8.2	8.2

na = not applicable

a = monitoring of periphyton and not phytoplankton biomass is recommended in upland rivers — values for periphyton biomass (mg Chl *a* m^{-2}) to be developed;

b = summer (low rainfall) values, values higher in winter for Chl *a* (1.0 µgL^{-1}), TP (40 µg P L^{-1}), FRP (10 µg P L^{-1});

c = inshore waters defined as coastal lagoons (excluding estuaries) and embayments and waters less than 20 metres depth;

d = elevated nutrient concentrations in highly coloured wetlands (gilven >52 $g_{440}m^{-1}$) do not appear to stimulate algal growth;

e = in highly coloured wetlands (gilven >52 $g_{440}m^{-1}$) pH typically ranges 4.5–6.5;

f = all values derived during base river flow conditions not storm events;

g = nutrient concentrations alone are poor indicators of marine trophic status;

h = these trigger values are generic and therefore do not necessarily apply in all circumstances e.g. for some unprotected coastlines, such as Albany and Geographe Bay, it may be more appropriate to use offshore values for inshore waters;

i = dissolved oxygen values were derived from daytime measurements. Dissolved oxygen concentrations may vary diurnally and with depth. Monitoring programs should assess this potential variability (see Section 3.3.3.2).

Table A1-2. Range of default guideline values for salinity and turbidity for the protection of aquatic ecosystems, applicable to slightly disturbed ecosystems in southwest Australia.

Ecosystem type	Salinity (μScm^{-1})	Explanatory notes
Upland & lowland rivers	120–300	Conductivity in upland streams will vary depending upon catchment geology. Values at the lower end of the range are typically found in upland rivers, with higher values found in lowland rivers. Lower conductivity values are often observed following seasonal rainfall.
Lakes, reservoirs & wetlands	300–1500	Values at the lower end of the range are observed during seasonal rainfall events. Values even higher than 1500 μScm^{-1} are often found in saltwater lakes and marshes. Wetlands typically have conductivity values in the range 500–1500 μScm^{-1} over winter. Higher values (>3000 μScm^{-1}) are often measured in wetlands in summer due to evaporative water loss.
	Turbidity (NTU)	
Upland & lowland rivers	10–20	Turbidity and SPM are highly variable and dependent on seasonal rainfall runoff. These values representative of base river flow in lowland rivers.
Lakes, reservoirs & wetlands	10–100	Most deep lakes and reservoirs have low turbidity. However, shallow lakes and reservoirs may have higher turbidity naturally due to wind-induced resuspension of sediments. Lakes and reservoirs in catchments with highly dispersible soils will have high turbidity. Wetlands vary greatly in turbidity depending upon the general condition of the catchment or river system draining into the wetland and to the water level in the wetland.
Estuarine & marine	1–2	Turbidity is not a very useful indicator in estuarine and marine waters. A more appropriate measure for WA coastal waters is light attenuation coefficient. Light attenuation coefficients (log_{10}) of 0.05–0.08 m^{-1} are indicative of unmodified offshore waters and 0.09–0.13 m^{-1} for unmodified inshore waters, depending on exposure. Light attenuation coefficients (log_{10}) for unmodified estuaries typically range 0.3–1.0 m^{-1}, although more elevated values can be associated with increased particulate loading or humic rich waters following seasonal rainfall events.

Table A2-3. Default guideline values for toxicants at alternative levels of protection (mg/L).

	Guideline values for freshwater			
	Level of protection (% species) in mg/L			
Compound	***99%***	***95%***	***90%***	***80%***
METALS & METALLOIDS				
Aluminium pH > 6.5	0.027	0.055	0.08	0.15
Aluminium pH < 6.5	ID	ID	ID	ID
Antimony	ID	0.009	ID	ID
Arsenic (As III)	0.001	0.024	0.094	0.36
Arsenic (As IV)	0.0009	0.013	0.042	0.14
Boron [R]	0.34	0.94	1.5	2.5
Cadmium	0.00006	0.0002	0.0004	0.0008
Cobalt	ID	ID	ID	ID
Chromium (Cr III) [R]	0.00016	0.00031	ID	ID
Chromium (Cr VI)	0.00001	0.001	0.006	0.04
Copper	0.001	0.0014	0.0018	0.0025
Iron [R]	0.43	0.7	ID	ID
Manganese	0.0012	0.0019	2.5	3.6
Molybdenum	ID	0.034	ID	ID
Mercury	0.00006	0.0006	0.0019	0.0054
Nickel	0.008	0.011	0.013	0.017
Lead	0.001	0.0034	0.0056	0.0094
Selenium (Se total)	0.005	0.011	0.018	0.034
Selenium (Se IV)	ID	ID	ID	ID
Uranium	ID	0.005	ID	ID
Vanadium	ID	0.0006	ID	ID
Zinc	0.0024	0.008	0.015	0.031
NON-METALLIC INORGANICS				
Ammonia [R]	0.32	0.9	1.43	2.3
Nitrate [R]	1.1	2.1	3.1	5.4

Table A1-3. Recommended toxicant default guideline values for sediment quality.

Type of toxicant	Toxicant	DGV	DGV- High
Metals (mg/kg dry weight)*	Antimony	2	25
	Cadmium	1.5	10
	Chromium	80	370
	Copper	65	270
	Lead	50	220
	Mercury	0.15	1
	Nickel	21	52
	Silver	1	4
	Zinc	200	410

* Primarily adapted from the effects range low (ERL) and effects range median (ERM) values of Long et al. (1995)

Appendix C Habitat Assessments

Site	CAS-A	HES-C	HES-E	HES-F	HES-FA
Date	25-10-2023	13-10-2023	17-10-2023	17-10-2023	25-10-2023
Time	15:45	15:15	16:45	15:15	14:00
Eastings	415526	416653	417854	418096	418147
Northing	6250815	6252240	6250578	6250157	6249486
Canopy cover (%)	0	15	30	30	0
Length (m)	200+	200+	200+	200+	200+
Width (m)	40	1.5	1.5	3	2.5
Max Depth (m)	2+	0.5	1	1.5	0.5
Velocity m/sec	0.01	0.017	0.333	0.083	0.067
Bed compaction	1	1	1	Low	1
Mineral Substrate					
Bedrock &	0	0	0	0	0
Boulders %	0	2	5	2	0
Cobbles %	0	0	0	10	0
Pebbles %	10	8	0	15	0
Gravel %	25	5	0	23	2
Sand %	10	15	60	30	68
Silt %	15	20	0	2	0
Clay %	40	50	35	18	30
Mean substrate size (phi)	4.025	5.71	4.075	0.475	4.17
Substrate diversity	5	7	3	7	3
Surface Area					
Mineral Substrate %	30	40	80	65	70
Emergent vegetation %	30	10	5	5	15
Submerged vegetation %	15	10	0	5	0
Floating Vegetation %	0	0	0	0	0
Algal cover %	10	20	0	0	0
Detritus %	10	10	0	0	0
Trailing vegetation %	0	5	0	5	10
Large Woody Debris %	5	5	15	20	5
Other	0	0	0	0	0
Habitat diversity	6	7	3	5	4

Appendix D Macroinvertebrates

Phylum/Class/Order	Family	Lowest Taxon	CAS-A	HES-C	HES-E	HES-F	HES-FA
ANNELIDA							
		Oligochaeta spp.	4	3	4	4	4
ARTHROPODA							
Arachnida		*Acarina sp.*		1		3	2
Mesostigmata		*Mesostigmata sp.*				2	
Sarcoptiformes		*Oribatida sp.*	4	3	2		1
Trombidiformes		*Trombidioidea sp.*				2	
	Arrenuridae	*Arrenurus sp.*	1				
	Hydrodromidae	*Hydrodroma sp.*	2				
	Hygrobatidae	*Procorticacarus sp.*			4	4	3
	Limnocharidae	*Limnochares australica*	1				
Collembola							
Poduromorpha		*Poduroidea sp.*			2		
Insecta							
Coleoptera							
	Dytiscidae	*Allodessus bistrigatus*	1		2		
		Antiporus femoralis	2				
		Bidessini sp. (L)	1				
		Hyphydrus sp. (L)	2	2			
		Necterosoma darwini	2				
		Necterosoma regulare		2			
		Necterosoma sp. (L)	1	2		2	
		Onychohydrus sp. (L)	1				
		Platynectes sp. (L)		2	2	2	2
		Sternopriscus browni					1
		Sternopriscus sp. (L)	2				
		Tiporus sp. (L)	1				
	Haliplidae	*Haliplus gibbus*	1				
		Haliplus sp.	1				
	Hydrochidae	*Hydrochus sp.*		1			
		Hydrochus sp. (L)	2				
	Hydrophilidae	*Berosus sp. (L)*	2				
		Helochares foveicollis		1			
		Helochares sp. (L)		2		2	
		Limnoxenus sp. (L)		1			
		Limnoxenus zealandicus		1	1		
		Paracymus pygmaeus	1	1			
	Scirtidae	*Scirtidae sp. (L)*		1	2	1	1
Diptera	Cecidomyiidae	*Cecidomyiidae sp.*				2	1
		Cecidomyiidae sp. (P)	1				
	Ceratopogonidae	*Ceratopogonidae sp. (P)*	2	2		3	
		Ceratopogoninae sp.	2	3	3		2
		Dasyheleinae sp.			2		2
		Forcipomyiinae sp.		2			

Phylum/Class/Order	Family	Lowest Taxon	CAS-A	HES-C	HES-E	HES-F	HES-FA
	Chironomidae	*Ablabesmyia sp. (V37)*	3				
		Botryocladius freemani	1				
		Chironomidae sp. (P)	3	3	3	3	2
		Chironomus aff. alternans	1	2	2	4	4
		Chironomus tepperi				3	
		Cladopelma curtivalva	1				
		Cladotanytarsus sp.	1				2
		Corynoneura sp. (V49)	2	2			
		Cricotopus parbicinctus		3	3	4	3
		Cryptochironomus griseidorsum	1	2	2		2
		Dicrotendipes sp.			2		
		Dicrotendipes sp. (V47)	2				
		Larsia ?albiceps	3				
		Parachironomus sp. (V74)	2				
		Paramerina levidensis	3	2	2	3	3
		Paratanytarsus sp.			3	3	
		Polypedilum watsoni			2		2
		Procladius paludicola	3	2			2
		Tanytarsus sp.		3	3	4	
		Tanytarsus sp. (V6)	3				3
		Thienemanniella sp. (V19)		3	4	4	4
	Culicidae	*Aedes sp.*		2			
		Anopheles sp.	3		2	1	
		Culicidae sp. (P)	1				
	Empididae	*Empididae sp.*		2	3		2
	Muscidae	*Muscidae sp.*				1	
	Psychodidae	*Psychodidae sp.*		2		2	
	Sciomyzidae	*Sciomyzidae sp.*	1		1		
	Simuliidae	*Simuliidae sp.*		2	4	4	
		Simuliidae sp. (P)			3	3	4
	Stratiomyidae	*Stratiomyidae sp.*	1			2	2
	Tipulidae	*Tipulidae sp.*					2
		Tipulidae sp. (P)			1		
Ephemeroptera	Baetidae	*Baetidae sp.*	2				
	Caenidae	*Caenidae sp.*	2		3	3	3
		Tasmanocoenis tillyardi	2	3	3	4	3
	Leptophlebiidae	*Leptophlebiidae sp.*			1	2	
Hemiptera	Corixoidea	*Corixoidea sp.*	3	2			1
	Hydrometridae	*Hydrometridae sp.*				1	
	Notonectidae	*Anisops sp.*	2				
		Notonectidae sp.	2				

Phylum/Class/Order	Family	Lowest Taxon	CAS-A	HES-C	HES-E	HES-F	HES-FA
	Veliidae	*Nesidovelia sp. (F)*	1	1			
		Veliidae sp.	1	2		1	
Lepidoptera	Crambidae	*Acentropinae sp.*	1	1			2
		Parapoynx sp.	1				
Odonata		*Anisoptera sp.*	4		3	2	1
Zygoptera		*Zygoptera sp.*	4				
	Aeshnidae	*Anax papuensis*	2				
	Corduliidae	*Hemicordulia tau*				1	
	Lestidae	*Austrolestes analis*	3				
		Austrolestes annulosus	2				
	Libellulidae	*Orthetrum caledonicum*				1	
	Telephlebiidae	*Austroaeschna anacantha*			2		2
Plecoptera	Gripopterygidae	*Gripopterygidae sp.*			3	3	2
		Newmanoperla exigua			4	3	2
Trichoptera		*Trichoptera sp.*	3	2	3	3	4
	Ecnomidae	*Ecnomus sp.*					2
	Hydropsychidae	*Cheumatopsyche sp. AV2*			2		
	Hydroptilidae	*Hellyethira sp.*	3	2		2	
	Leptoceridae	*Notalina spira*	3	2			
		Oecetis sp.	3	1			
		Triplectides australicus	3				
Malacostraca							
Amphipoda	Chiltoniidae	*Austrochiltonia subtenuis*	4		4	4	4
	Perthiidae	*Perthia acutitelson*			3	2	3
Decapoda	Parastacidae	*Cherax cainii*			1		
MOLLUSCA							
Bivalvia							
Veneroida	Sphaeriidae	*Musculium sp.*	1	2			
Gastropoda	Lymnaeidae						
Hygrophila		*Bullastra vinosa*	2	2			
	Planorbidae						
		Bayardella sp.		2			
		Ferrissia petterdi	2			1	
		Glyptophysa (Glyptophysa) sp.	3	3			
NEMATODA		*Nematoda sp.*	1		1	3	
		Taxa Richness	**132**	**85**	**97**	**104**	**85**

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