TALISON GREENBUSHES

Saltwater Gully New Water Storage

Aquatic Ecological Assessment 2022

Prepared for:

Talison Lithium Pty Ltd

RSN 1662 Maranup Ford Road GREENBUSHES WA 6254

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (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.

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
675.30172-R01-v1.0	16 March 2023	Peter Ladd-McGovern	Bonita Clark	Andrew Storey
675.30172-R01-v1.0	23 January 2023	Peter Ladd-McGovern	Bonita Clark	Andrew Storey
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EXECUTIVE SUMMARY

Talison Lithium Australia Pty Ltd (Talison), operators of the Greenbushes Lithium Mine, are scoping a new water storage facility in Saltwater Gully, approximately 2 km east of the mine. Saltwater Gully is a tributary of Hester Brook, in the Blackwood River catchment. Saltwater Gully and lower Hester Brook are moderately-disturbed aquatic ecosystems, following a long history of mining and agricultural land use in the catchment. Talison required a survey for aquatic fauna, macrophytes (aquatic plants), aquatic habitat condition, water quality and sediment quality of the existing dams and downstream environment in Saltwater Gully and Hester Brook to support a section 38 referral for the project (under the *Environmental Protection Act 1986*). Talison also required a critical review of three aquatic ecotoxicology projects conducted for lithium entering surface water environments through emissions from their Greenbushes operations. The scope of services for the field survey and the ecotoxicology report review included:

- Identify any potential groundwater-dependent ecosystems (indicative vegetation communities) downstream of the new water storage dam.
- Conduct a field survey upstream, within and downstream of the existing Saltwater Gully dams including the following components:
  - Water quality, including *in situ* measurements (e.g., pH, dissolved oxygen, temperature, etc.), and gulp samples for general ions, nutrients and metals.
  - Sediment quality (metal concentrations and acid generating potential).
  - Macrophyte (aquatic flora) species identification and coverage estimate.
  - Habitat condition assessment utilising DWER's South West Index of River Condition (SWIRC) methodology).
  - Fish and crayfish fauna, following SWIRC methodology.
  - Aquatic macroinvertebrates, identified to species level (where possible) to determine conservation status.
- 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.

The Saltwater Gully New Water Storage Aquatic Ecological Assessment was successfully completed between 26th – 28th October 2022. Aquatic biota, water and sediment quality sampling was conducted at eight aquatic habitat survey sites; four upstream and four downstream of the proposed new dam location. Saltwater Gully and downstream 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, the Department of Biodiversity, Conservation and Attractions Priority 4-listed mammal species *Hydromys chrysogaster* is likely to inhabit Saltwater Gully and downstream Hester Brook.

The aquatic habitats in this study area showed evidence of past disturbances and have been classified in this and other reports as "moderately disturbed ecosystems". While water and sediment quality in Saltwater Gully was generally within the default and/or site-specific guidelines, discharges from Floyds waste rock landform are potentially a source of higher concentrations of several potential contaminants of concern (PCOCs) in the existing dams. Assessment of potential SWG Dam environmental impacts on aquatic ecosystems was beyond the scope of this baseline survey and report. However, potential risks were considered at a higher level.

In summary, while the construction and inundation of the new water storage area may pose some risks to resident aquatic fauna, none of these potential risks are likely to impact conservation significant species at a regional level species, given the high level of disturbance that has already occurred in Saltwater Gully since European settlement.

Considerations for detailed impact assessment include:

The construction of a new water storage, through raising the height of the existing dam, and the resulting increased area of inundation may be unlikely to increase the risk to aquatic biota from PCOCs within this area in the immediate future. However, further consideration should be given on the potential for a net build-up of PCOCs in dam water and/or sediment over time to be released into the downstream environment via seepage or overflow, causing water quality to deteriorate in both Saltwater Gully and downstream along Hester Brook.

Mobilisation of sediment to downstream aquatic environments during earthworks for the new dam poses a risk to receiving biota that may be mitigated through appropriate site management.

Hydrological investigations may also be required to determine whether the increased retention of water in Saltwater Gully will have a significant impact on environmental flows in Hester Brook.

It is also possible that the alterations to habitat within Saltwater Gully, through increasing the area of inundation, may favour the proliferation of invasive species (in particular, the redfin perch) to the detriment of the suite of native species, all of which are likely or known to be common throughout the southwest WA region.

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1 Introduction

1.1 Background

Talison Lithium Australia Pty Ltd (Talison) operate the Talison Lithium Mine, near Greenbushes, in Western Australia. Talison are scoping a new water storage facility in Saltwater Gully (the Project), an area approximately 2 km east of the mine, where a series of small dams already exist along the small Saltwater Gully stream (Figure 1). Saltwater Gully is a headwater tributary of Hester Brook, which in turn is a tributary of the Blackwood River. Talison required a survey for aquatic fauna, macrophytes (aquatic plants), aquatic habitat condition, water quality and sediment quality of the existing dams and downstream environment in Saltwater Gully to support a section 38 referral (under the *Environmental Protection Act 1986*; "EP Act") of the Project for Talison operations. The Project involves increasing the height of the furthest downstream dam in Saltwater Gully, would result in the existing water storages behind the enlarged dam wall combining into one large waterbody, and their existing embankments to become inundated (see Figure 2).

Increasing the height of the existing dam (the Project) should consider the following potential adverse effects to Saltwater Gully aquatic fauna, which are considered in environmental impact assessments under the Environmental Protection Authority's (EPA) Environmental Factor Guidelines *Inland Waters* and *Terrestrial Fauna*:

- Decreased water supply to downstream aquatic fauna habitat and riparian zone flora. Apart from having a direct impact on aquatic fauna in terms of available habitat, this could also affect the integrity of the riparian zone, leading to erosion and sedimentation and therefore degradation of in-channel habitat. The potential exposure of sediment from drying, followed by seasonal rewetting of downstream environments, could mobilise toxic metals, if present, to the water column and also pose a risk to aquatic fauna health. Reduced flow period downstream of the dam, due to greater capture by the proposed new dam, may adversely affect aquatic fauna depending on their environmental flow requirements.
- A potential increased barrier for fish species moving upstream to breed, if these fish species are currently able to pass the existing dams during winter flow periods.
- Mobilisation of sediments during construction phase which may increase turbidity levels and concentrations of potential contaminants of concern (PCOCs) in Saltwater Gully and Hester Brook downstream of the Project.

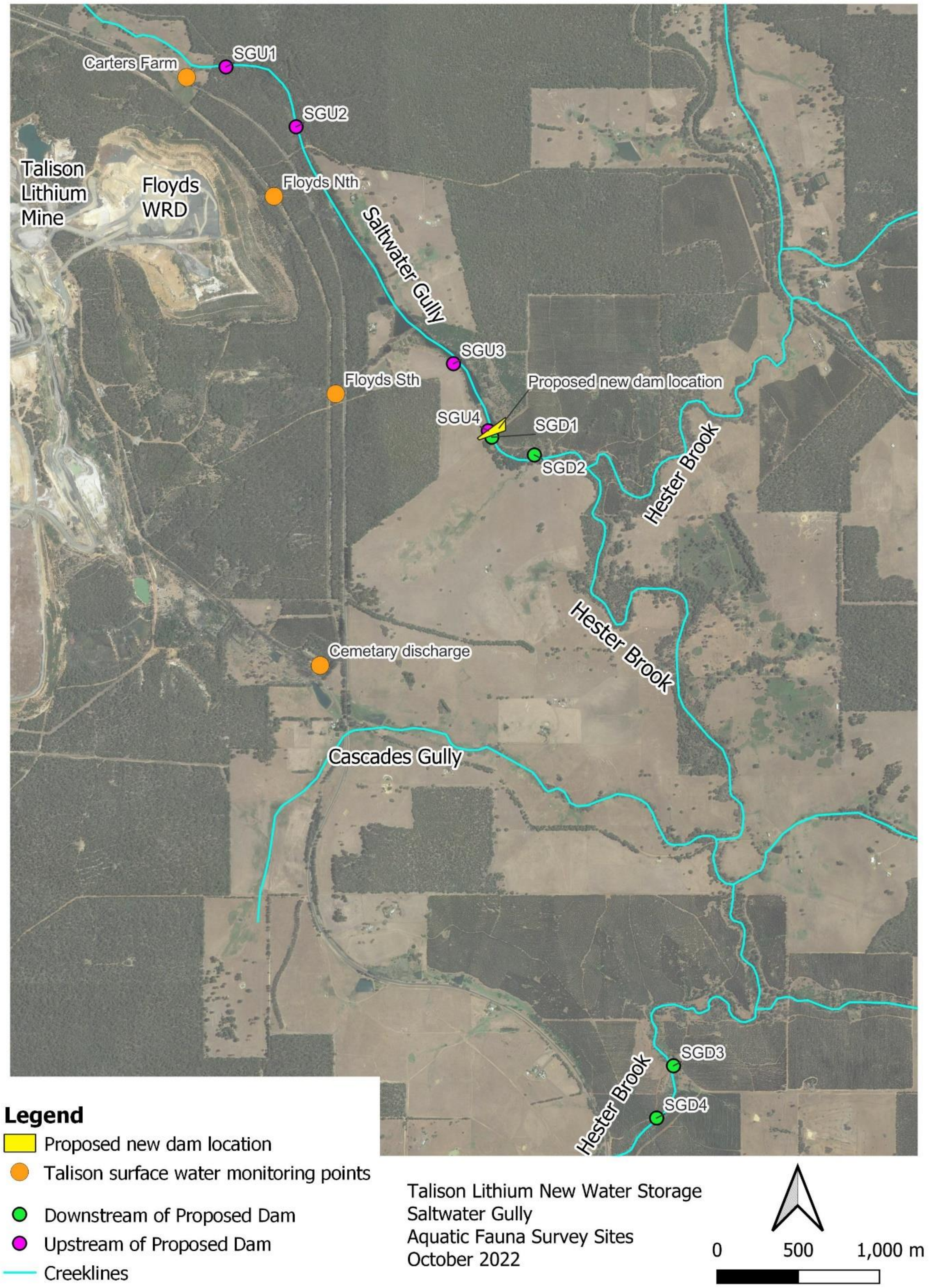

Figure 1. Aquatic ecological survey sites along a 10km stretch of Saltwater Gully, Greenbushes in relation to the location of the proposed new water storage (dam).

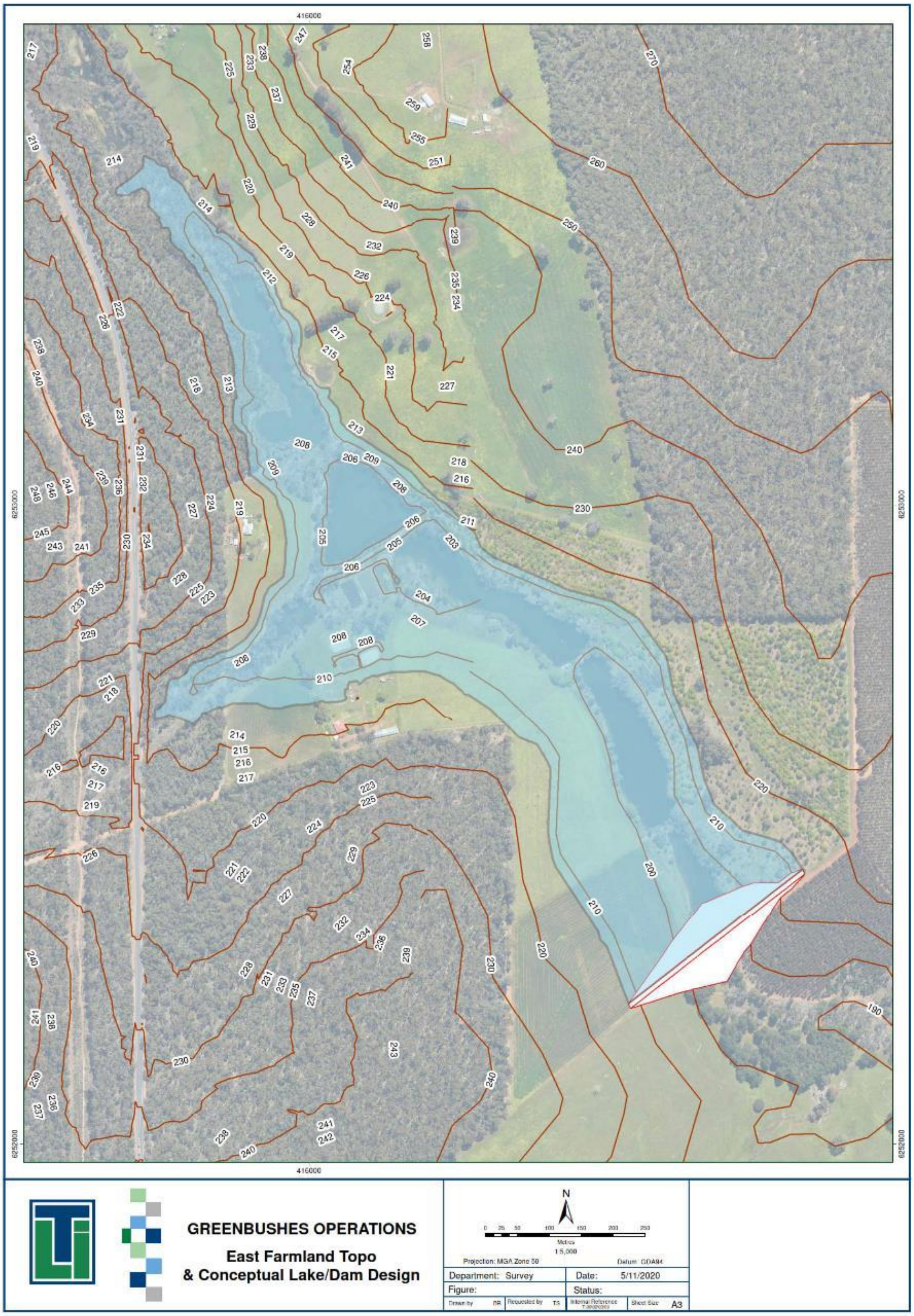

Figure 2. Conceptual design of the proposed Saltwater Gully Dam.

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). This includes monitoring of surface water emissions from the Floyds waste rock dump (WRD). Talison disposes of the waste rock from the mining of the pegmatite lithium ore body at the Floyds WRD, which was constructed prior to 1991 (GHD 2022). Wastewater drains easterly from Floyds WRD towards Saltwater Gully, entering upstream (emissions point Floyds North) and adjacent to (emissions point Floyds South) the existing series of dams (Figure 1).

SLR Consulting was engaged by Talison to conduct a field survey of aquatic ecological values of the existing dams and downstream environment in Saltwater Gully in October 2022, and a critical review of the ecotoxicology reports.

1.2 Scope of works

The scope of services for the field survey and the ecotoxicology report review.

- Identify any potential groundwater-dependent ecosystems (indicative vegetation communities) downstream of the new water storage dam.
- Conduct a field survey upstream, within and downstream of the existing Saltwater Gully dams including the following components:
    - Water quality, including *in situ* measurements (e.g., pH, dissolved oxygen, temperature, etc.), and gulp samples for general ions, nutrients and metals.
    - Sediment quality (metal concentrations and acid generating potential).
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- 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.

1.3 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 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 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 state WA's *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, and
- 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 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).

1.4 Study area environmental setting

The study area for the Spring 2022 Saltwater Gully Aquatic Fauna Survey comprised the inundated creekline between and inclusive of the surface water sampling locations detailed in Figure 1. 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 3). The active mining area, also referred to as mine development envelope (MDE), predominantly occurs within Greenbushes State Forest 20 (SF20) and withing 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. The landscape of Saltwater Gully, which is outside, but within 1 – 4 km of, the MDE, is highly modified due to a long history of disturbance, including dredging for tin alluvial deposits during the early 1900s (GHD 2021). The gully includes areas of native vegetation interspersed with water storages, agricultural land (cattle pasture), land previously used for aquaculture, timber plantations, power infrastructure and roads.

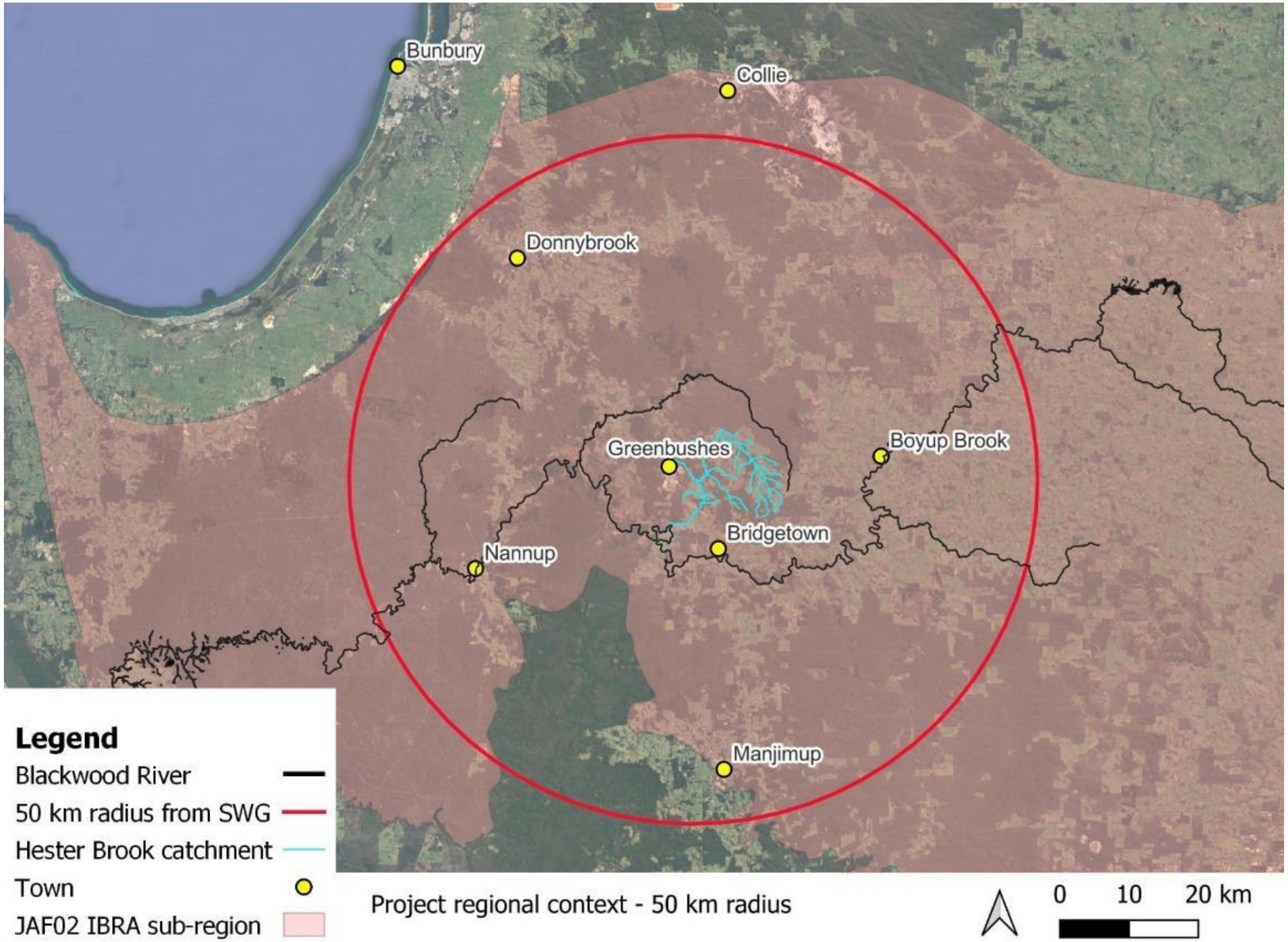

Figure 3. Project area regional context. SWG = Saltwater Gully

1.4.1 Climate

The study area experiences a Temperate climate of warm, dry summers and cold, wet winters (Australian Climate Averages - Climate classifications (bom.gov.au)) and is located within the Hardy Estuary-Blackwood River Catchment. Due to large gaps in rainfall data from the Greenbushes (009552) weather station over the past year, data from the surrounding Bridgetown (GS 009617, ~12.9km SE of Greenbushes), Kirup (GS 009714, ~22.1km NW of Greenbushes) and Ravenscliffe Alert (GS 009997, ~20.9km WNW of Greenbushes) weather stations were used to represent rainfall data in the region (Figure 4). Total average annual rainfall recorded from the Greenbushes weather station is 733.9 mm (1896-2021; BOM 2022), with the highest rainfall typically occurring between May and September (highest average monthly rainfall in July - 184.5mm) and the lowest rainfall occurring between October and April (lowest average monthly rainfall in February – 14.9mm). Monthly total rainfall volumes received in the wider Greenbushes/Kirup/Bridgetown area in the lead up to the October 2022 survey were generally lower than, or comparable to, the long-term monthly averages (Figure 4).

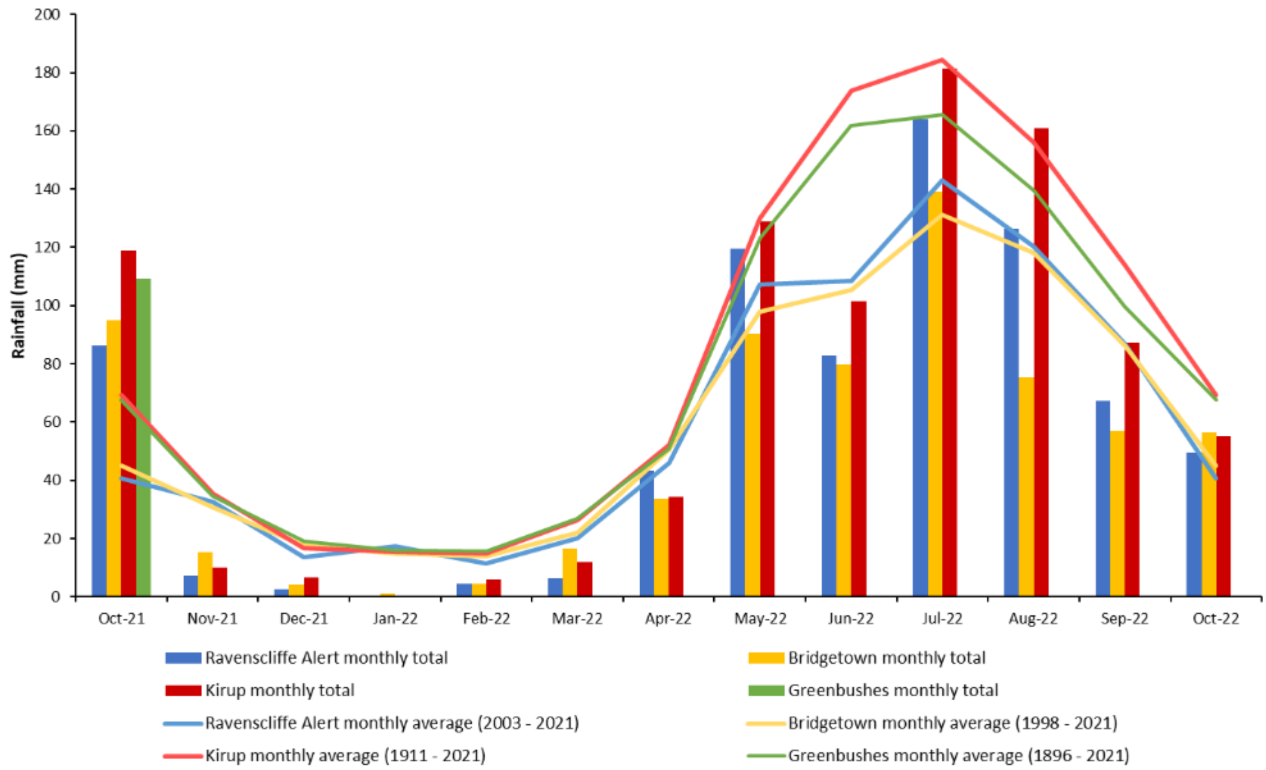

Figure 4. Total monthly rainfall recorded from October 2021 to October 2022 (inclusive) at Greenbushes and three nearby stations, compared to the long-term monthly average rainfall data.

1.4.2 Surface water hydrology

The Saltwater Gully study area is located within the middle Blackwood River catchment. It is a small headwater tributary starting near North Greenbushes and flowing for approximately 5 km before joining

Hester Brook, approximately 700 m downstream of the proposed new dam location (Figure 1). Hester Brook discharges to the Blackwood River approximately 14 km downstream of the proposed new dam location. The Saltwater Gully catchment drains the state forest and agricultural lands to the north/north-east of the study area and receives seepage and surface water generated at the Floyds WRD (GHD 2021). Approximately five historic water storage dams are located along the Saltwater Gully creekline, along with five or six smaller constructed ponds that would likely drain/overflow into one of the middle dams.

1.4.2.1 Discharge to SWG from Talison operations

Talison provided discharge volume data for three monitoring points that contribute water to Saltwater Gully (Figure 1). Monthly totals recorded during the 12-month period prior the 2022 survey were plotted (Figure 5). The data indicated that peak flow in Saltwater Gully likely occurred in August 2022, late winter, following the majority of winter rainfall recorded for the Greenbushes/surrounding area (see Figure 4).

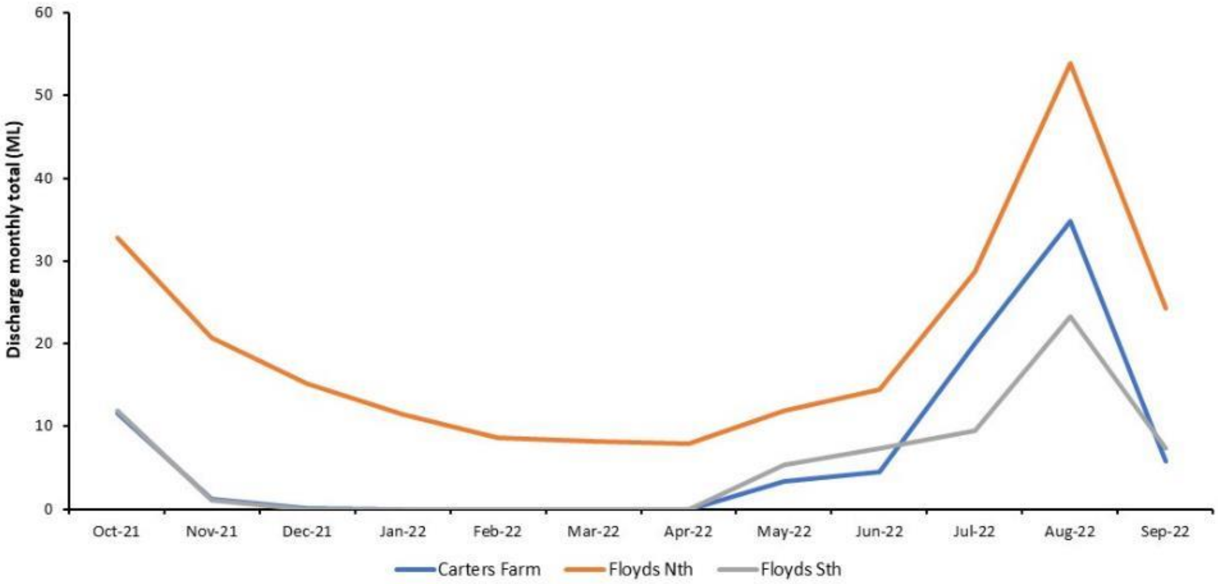

Figure 5. Total monthly discharge volumes recorded from October 2021 to September 2022 (inclusive) at Talison surface water monitoring locations.

1.4.3 Groundwater hydrology

The study area is located in the Karri subarea of the Karri Groundwater Area (GHD 2021). The Karri area is not a proclaimed groundwater area under the Rights in Water and Irrigation Act 1914 (GHD 2021). The groundwater flow system in the area is classified as 'local flow systems in Precambrian rocks' (GHD 2021). No significant groundwater flows have been noted within the clayey lateritic weathered profile, which occupies the upper 2 to 3 m below ground level (m bgl) (GHD 2021). The permeability of the clay was inferred as very low (GHD 2021). Groundwater was observed at depth between the boundary of the clays and fresh rock, hence between approximately 22 and 43 m bgl. The potentiometric measurements indicated the presence of a confined aquifer (GHD 2021).

2 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 waters up to 50 km from the proposed new dam location in Saltwater Gully (Figure 3).

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 1. Table 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 2022), listed as occurring in the "Southwest" and "Warren" regions, were cross-checked with other databases in Table 2 to determine the likelihood of these species occurring in Saltwater Gully and downstream Hester Brook.

Table 1. Aquatic biology reports relevant to the study area (50 km radius of SWG) 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 (Saltwater Gully)				
Unreported	Aug. 2013	Ecotoxicology of lithium	CENRM UWA	Consultancy report
Surveys within 50 km of the study area (Saltwater Gully)				
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

Field Survey Date	Report Date	Report Title	Author	Report Type
Metadata analysis	Jun. 2018	Identifying Priority Species Within the Southwestern Australian Aquatic Invertebrate Fauna	Pennifold	WA State government report
Desktop assessment	Jul. 2018	Greenbushes Vertebrate, SRE and Subterranean Fauna Desktop Assessment	Biologic	Consultancy report

Table 2. Database searches.

Database	Search Date	Authority	Area of Search/ Species
Protected Matters Search Tool	Search conducted by SLR on 11th January 2023	DAWE	50 km radius of Project area
Australian Wetlands Database	Search conducted by SLR on 11th January 2023	DAWE	50 km radius of Project area
Dandjoo Biodiversity Data Repository	Search conducted by SLR on 11th January 2023	DBCA	50 km radius of Project area
Freshwater Fish Distribution in Western Australia	Search conducted by SLR on 11th January 2023	DPIRD	Blackwood River Catchment
Wild Rivers (DWER-087)	Search conducted by SLR on 11th January 2023	DWER	Blackwood River Catchment
Threatened Ecological Communities (DBCA-038)	Search conducted by SLR on 11th January 2023	DBCA	50 km radius of Project area
Threatened and priority fauna list	Search conducted by SLR on 11th January 2023	DBCA	Southwest and Warren region
Groundwater Dependent Ecosystems Atlas	Search conducted by SLR on 11th January 2023	Bureau of Meteorology	Saltwater 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 11th January 2023. Utilised in assessing taxonomic status and distribution of aquatic fauna	Collaborative project between academic, private and community groups.	All relevant 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 in the immediate vicinity of the Project. The Peel Yalgorup Ramsar and EPP wetland system is located on the coast approximately 13 km west of the Project area and as such, is unlikely to 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 Saltwater Gully, or distribution ranges that included the Project area (Table 3). Of these eight species, only three were assessed as moderately likely to occur either in Saltwater Gully or in Hester Brook downstream of the Project area; the Carter's freshwater mussel, the minute freshwater snail, and the rakali (water rat). Further information on these three species is provided below.

Carter's Freshwater Mussel ("*Westralunio carteri*")

The current listing of *Westralunio carteri* is **Vulnerable** under the EPBC Act, **Vulnerable** under the BC Act, and as **Vulnerable** by 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 Kunzinger 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; *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. It prefers 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 mussels also appear intolerant of average salinity levels >1,500 mg/L (~3,000 µS/cm).

The nearest recent record of Carter's freshwater mussel to the study area is in St Johns Brook near Nannup, approximately 33 km west of Saltwater 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 Saltwater Gully/Hester Brook.

Minute Freshwater Snail (*Glacidorbis occidentalis*)

The current listing of *Glacidorbis occidentalis* as **P3** by DBCA (2022) and as **Vulnerable** by IUCN (Ponder & Slack-Smith 1996) is considered in need of revision (IUCN 2022). The original listing was based on the fact that this snail has only been rarely collected and even when present, only occurs in low numbers, making it vulnerable to disturbance. *G. occidentalis* occurs almost exclusively in gravel riffle habitats in less disturbed, vegetated, seasonal headwater tributaries of creeks arising from the Darling Scarp, where salinity is low (<500 µS/cm), turbidity is low (<5 NTU) and pH slightly acidic pH (5 - 7). While it appears to have once been widespread throughout the northern jarrah forest, climate change and declining stream flow are expected to have reduced habitat availability. Its former range included jarrah forest streams in the upper catchments of the Canning, Wungong, Serpentine, North Dandalup and Harris rivers on the edge of the Darling Scarp (Bunn & Stoddart 1983, Bunn et al. 1989). Pennifold (2018) reported an extent of distribution along the Darling Scarp from Perth to Muir (50 km south-east of Manjimup). The extent of its current distribution is unknown, however, given the study area occurs within the Southern Jarrah Forest sub-region on the Darling Plateau, this species was considered moderately-likely to occur in Saltwater Gully/Hester Brook.

Rakali (*Hydromys chrysogaster*)

Rakali, listed by DBCA (2022) as **P4,** have been recorded within 10 km of the Greenbushes lithium mine and there are numerous records within the broader 50 km radius of Saltwater Gully. 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 in Saltwater Gully and 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 Saltwater Gully, or distribution ranges that included the Project area (Table 3). Of these eight species, three were assessed as moderately likely to occur either in Saltwater 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 3. Likelihood of occurrence of conservation significant aquatic fauna within the Project area (Saltwater Gully)., based on presence of suitable habitat in Saltwater Gully/downstream Hester Brook and records of occurrence within a 50 km radius of Saltwater Gully, 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 Saltwater Gully did not detect the species (DWER Healthy Rivers distribution map, survey details not available). Nearest recent record ~33 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).
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 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).

Group	Scientific name	Common name	Cons. Status	Likelihood of occurrence within the Project area
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.
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		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).

Group	Scientific name	Common name	Cons. Status	Likelihood of occurrence within the Project area
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).
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 for Saltwater Gully that targeted aquatic fauna. CENRM UWA collected three species from Saltwater Gully/Hester Brook for the 2013 ecotoxicology investigation: the fish western pygmy perch (*Nannoperca vittata*), the freshwater crayfish koonac (*Cherax preissi*) and the waterboatman bug (*Diaprepocoris barycephalus*).

CENRM UWA conducted an aquatic biota survey in October 2013 along Norilup Brook, upstream and downstream of the Talison Greenbushes mine. Macroinvertebrate samples were collected and preserved using methodology comparable to the current 2022 survey (i.e., 250 µm dip net and heel-kick sweeping of habitat as described in section 3.2.4). Fish and crayfish were sampled using the 250 µm dip net and unspecified "fish traps". Three fish species (the native pygmy perch *N. vittata* and minnow *Galaxias occidentalis*, and the introduced *Gambusia* sp.), one crayfish (native koonac *C. preissi*), approximately 88 macroinvertebrate taxa and nine microinvertebrate taxa (Ostracoda and Copepoda) were collected from twelve study sites. No descriptions of habitat types present at the sampling sites were reported, and although flora was mentioned in the title of the report, no results for aquatic flora sampling or observations were reported. No aquatic species of confirmed conservation significance were recorded during the CENRM UWA October 2013 survey. One candidate-priority species, *Batrachomatus nannup* (previously named *Allomatus nannup*), was recorded.

CENRM UWA conducted another 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, habitats were not 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 may 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), approximately 73 macroinvertebrate taxa and 14 microinvertebrate taxa (Ostracoda, Cladocera and Copepoda) were collected from ten study sites. It is unclear from the report which species the crayfish belonged to, koonacs (*C. preissi*), or gilgies *C. quinquecarinatus*), as they are referred to as gilgies in the results section, and as koonacs in the appendix. It is possible that koonacs were the only crayfish species present, as per the previous aquatic fauna studies, and incorrect nomenclature was used in the result section. No aquatic species of confirmed conservation significance were recorded during the CENRM UWA October 2021 survey. One candidate-priority species, *Musculium kendricki*, was recorded; at Norilup Brook site 9.

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 oblonga*, 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.

2.2.3 Groundwater dependent ecosystems

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

3 Survey methods

3.1 Aquatic fauna sampling sites

Sampling for water quality, sediment quality and aquatic fauna, and qualitative assessments for macrophytes and habitat composition was conducted at the following eight site locations (Figure 1, Table 4):

a) Four sites upstream of the proposed new dam location in Saltwater Gully, including two sites upstream of the Floyds North emissions monitoring point, and two sites downstream of this point in the existing dams.
b) Four sites downstream of the proposed new dam location, including two sites upstream of the Saltwater Gully - Hester Brook confluence, and two sites downstream of the confluence.

Photographs of sites are provided in Appendix 1.

Table 4. Site locations for the 2022 survey. Coordinates are provided in UTM datum MGA94, zone 50. PD = proposed new dam.

Area	Code	Date Sampled	Easting	Northing
Upstream of PD and Floyds Nth monitoring point	SGU1	26-10-2022	414978	6254548
Upstream of PD and Floyds Nth monitoring point	SGU2	26-10-2022	415413	6254185
Upstream of PD, downstream of Floyds Nth monitoring point	SGU3	26-10-2022	416395	6252742
Upstream of PD, downstream of Floyds Nth monitoring point	SGU4	27-10-2022	416613	6252333
Downstream of PD	SGD1	27-10-2022	416635	6252294
Downstream of PD	SGD2	28-10-2022	416898	6252187
Downstream of PD	SGD3	27-10-2022	417787	6248453
Downstream of PD	SGD4	28-10-2022	417686	6248132

3.2 Sampling methods

3.2.1 Water quality

A number of general water quality variables were recorded *in situ* using 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 2018 (ANZG 2018), 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 2018 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 (2018) 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 (2018) 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, a composite 250 g sample of fine sediment was collected from the top 1-2 cm of substrate, targeting areas of fine sediment (sand/silt/clay), in shallow areas of each site (< 1 m). Sediments were scraped directly from the substrate with a nitrile-gloved hand using an inverted unused zip-lock bag to reduce incidental contamination. All sediment samples were kept cool in an esky while in the field, and transported to the laboratory. All laboratory analyses was conducted by the ChemCentre, Bentley, WA (a NATA accredited laboratory), sieved (63 µm) and extracted using a weak acid digest on the <63 um fraction to reflect the bioavailable fraction of metals (As, Cd, Cr,Cu, Fe, Hg, Li, Ni, Pb, Se, Zn). Sediment quality data were compared against the most recent ANZG (2018) sediment quality guideline values (GVs) for aquatic ecosystems. Two sets of GVs are provided, the default GVs (DGV), and the 'upper' guideline values (GV-high), which provide an indication of concentrations at which toxicity-related adverse effects might already be expected/observed. Acid generating potential of sediments was also determined. This indicates if exposure, drying, oxidation and rewetting of the sediments in the channel may result in acid generation and mobilisation (release) of potentially toxic metals, if present.

3.2.3 Habitat

Habitat condition assessments were conducted at all eight sites following the SWIRC methodology (Storer *et al*. 2020). General observations of channel morphology, connectivity, erosion fringing vegetation health and extent were made using DWER SW-WA River Health Assessment Field Sheets.

At least two photographs were taken at each site, one facing upstream and one facing downstream, along with any defining site features. Details of aquatic mineral substrate composition and in-stream habitat were recorded from each site. SLR also has specific worksheets for habitat assessment to ensure habitat recordings are as comparable as possible between sites and over time. Habitat characteristics assist in interpreting spatial and temporal differences in aquatic fauna. Parameters include percent cover by inorganic sediment, submerged macrophyte, floating macrophyte, emergent macrophyte, algae, large woody debris, detritus, roots and trailing vegetation. Details of substrate composition was also recorded and included percent cover by bedrock, boulders, cobbles, pebbles, gravel, sand, silt and clay.

3.2.4 Aquatic Biota

Macrophytes (aquatic plants)

Macrophyte species observed at each site were recorded to species level where possible, and (%) cover over the length of the site (100 m of channel) was estimated.

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 a 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 WRM. Taxa that could not be identified to species level generally were assigned a voucher number and lodged in the WRM voucher collection.

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 (Plate 1) 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[1] (SL mm, for fish) or carapace length (CL mm, for crayfish; Plate 1), health and reproductive status recorded, and released live 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 and turtles. Unbaited camera traps were also set at 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

[1]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.

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:

1. 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).
2. 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.
3. Bubble plots – “bubbles” of sizes representative of sediment or water quality values superimposed on the macroinvertebrate assemblage PCO ordination to visualise spatial differences in correlated analytes (as determined through BVSTEP).

3.4 Licences

The survey was carried out under a Department of Biodiversity, Conservation and Attractions (DBCA) Fauna Taking (Biological Assessment) Licence issued under Regulation 27 of the Biodiversity Conservation Regulations 2018 and the *Biodiversity Conservation Act 2016* (BA27000727), issued 28/09/2022. SLR Consulting (nee Wetland Research & Management) also hold a current Instrument of Exemption (EXEM 3407) under the *Fish Resources Management Act 1994* to undertake freshwater aquatic fauna surveys in major rivers and tributaries of southwest WA.

3.5 Survey limitations

Table 5 below summarises the potential limitations and constraints affecting the Saltwater Gully Aquatic Ecological survey.

Table 5. Survey limitations

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 7 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 3407) under the *Fish Resources Management Act 1994* to undertake freshwater aquatic fauna surveys.

Aspect	Constraint?	Comment
Scope	No	The scope was prepared by Talison and SLR, informed by the consultants knowledge of previous, similar assessments and limited to upstream and downstream of the proposed new dam 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 dam, therefore eight sites representative of habitat areas and locations present in upstream and downstream areas were selected and targeted for sampling to maximise species detection. 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.
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	No	There were restrictions on entering properties containing livestock due to biosecurity concerns, however, other suitable locations for aquatic sampling were found.

4 Results and discussion

4.1 Water quality

Saltwater Gully and downstream Hester Brook recorded generally neutral to basic pH (pH 7.14 - 8.82), fresh to brackish conductivity (EC; 655.4 - 3350 µS/cm)[2] and adequate to high dissolved oxygen (99 - 148.4 % saturation). Water quality analyte levels recorded from the study area in spring 2022 were generally below or within the ANZG (2018) DGVs (Table 6). Analytes which recorded exceedances of ANZG DGVs included:

- Dissolved Oxygen (DO) measured in the field exceeded the upper ANZG DGV (120%) at sites SGU2 (127.1%), SGU3 (143.1%) and SGU4 (148.4%).
- Conductivity (EC) measured in the field exceeded the ANZG DGV (300 µS/cm) at all sites (range 665.4 µs/cm at SGU2 to 3350 µS/cm at SGD2).
- Nitrogen (N-total) levels recorded through laboratory analysis exceeded the ANZG eutrophication DGV (0.3mg/L) at the majority of sites (range 0.31 mg/L at SGU2 to 0.51 mg/L SGD3), with the exception of SGU1 (0.25 mg/L).
- pH measured in the field exceeded the upper ANZG DGV (8.0) at sites SGU3 (8.82), SGU4 (8.56) and SGD4 (8.03).
- Sulfate (SO_4_S) and magnesium (Mg) concentrations recorded through laboratory analysis were at least two-times greater than upstream sites SGU1 and SGU2. Elevated SO_4_S and Mg may be indicative of acid mine drainage from the Floyds South emissions point located between SGU2 and SGU3 (see Figure 1), and may be detrimental to aquatic fauna from elevated osmotic stress.
- Vanadium (V) recorded through laboratory analysis exceeded the ANZG 95% (0.0006 mg/L) at sites SGD3 and SGD4 (both 0.0008 mg/L).

There were also spatial differences in water quality across the study area. Alkalinity, EC, TDS and concentrations of associated ions were generally lower in sites upstream of the Floyds north monitoring point, compared to SGU3, SGU4 and the SGD sites. Turbidity levels upstream of the proposed dam were generally low (≤ 2.57 NTU), compared with downstream sites (2.14 – 14.01 NTU). Total nitrogen concentrations tended to increase with distance downstream, with levels likely to be related to the greater extent of agricultural land further downstream in the catchment, compared to the greater extent of state forest in the upstream catchment area. Patterns in dissolved metals concentrations were highly variable. Cobalt (dCo), iron (dFe) concentrations were higher upstream of Floyds North monitoring point, while Arsenic (dAs), lithium (dLi), manganese (dMn) and uranium (dU) concentrations were higher in the middle dam sites (SGU3 and SGU4), compared with downstream sites. Concentrations of aluminium (dAl) and vanadium (dV) were higher in sites downstream of the proposed new dam location.

[2] Fresh defined as < 1500 µS/cm, Brackish = 1500 – 4500 µS/cm, Saline = 4500 – 50,000 µS/cm, Hypersaline > 50,000 µS/cm (DoE 2003). Classifications were presented as TDS (mg/L) in DoE (2003) so a conversion factor of 0.68 was used to convert to conductivity µS/cm as recommended by ANZG (2018).

Table 6. Water quality recorded at the aquatic fauna survey sites in spring 2022, compared with ANZG (2018) DGVs. Recorded values which exceeded (or fell outside the range of) the ANZG DGV are highlighted pale orange.

Analyte	ANZG (2018)	Upstream of Floyd's emission point		Upstream of proposed water storage area		Downstream of proposed water storage area			
	95% TV	SGU1	SGU2	SGU3	SGU4	SGD1	SGD2	SGD3	SGD4
aION_BAL	np	-3.9	-4.5	-0.9	-1.6	-5.3	-1.9	-5.1	-4
Al (pH > 6.5)	0.055	0.011	0.023	0.006	0.013	0.01	0.032	0.03	0.03
Alkalinity	np	46	34	76	75	79	76	102	103
dAs	np	<0.001	<0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001
Ca	np	34.5	16.4	99.7	86.2	79.3	60.1	39	40.7
dCd	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cl	np	185	124	234	210	207	216	1010	1000
dCo	np	0.0011	0.0006	0.0003	0.0002	0.0005	0.0003	0.0004	0.0006
dCr	np	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
dCu	0.0014	0.0005	0.0003	0.0002	0.0003	0.0003	0.0003	0.0005	0.0005
DO-field (% sat)	85-120	99.4	127.1	143.1	148.4	107.1	127.1	112.4	116.1
EC-field (µs/cm)	300	1072	655.4	1749	1542	1540	3350	1460	3050
dFe	np	0.23	0.34	0.067	0.072	0.1	0.12	0.32	0.37
Hardness	np	220	110	520	450	420	330	370	380
HCO3	np	56	42	86	91	96	93	124	126
dHg	0.0006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
K	np	1.9	1.1	4.5	4	3.6	2.9	4.4	4.5
dLi	np	0.022	0.0084	0.58	0.52	0.47	0.32	0.029	0.03
Mg	np	33.7	17.5	66.2	57.9	54	44.5	66.9	68.6
dMn	1.9	0.089	0.1	0.13	0.078	0.051	0.029	0.081	0.11
dMo	0.073	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
$N\text{-}NH_3$	0.9	0.02	0.02	0.01	0.02	0.02	<0.01	0.02	0.02
$N\text{-}NO_x$	np	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
$N\text{-}NO_2$	9.3	0.01	<0.01	0.01	0.09	0.09	0.13	0.04	0.04

Analyte	ANZG (2018)	Upstream of Floyd's emission point		Upstream of proposed water storage area		Downstream of proposed water storage area			
	95% TV	SGU1	SGU2	SGU3	SGU4	SGD1	SGD2	SGD3	SGD4
N-total	0.3	0.25	0.32	0.31	0.43	0.35	0.36	0.51	0.49
Na	np	112	73.6	154	139	133	138	492	499
dNi	0.011	<0.001	<0.001	0.002	0.002	0.002	0.001	0.001	0.002
P-total	0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
dPb	0.0034	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
pH-field (H^+)	6.5-8.0	7.14	7.36	8.82	8.56	7.82	7.78	7.95	8.03
dSe	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SO_4_S	np	196	86.9	453	399	406	269	79.6	76.8
TDS_calc	np	570	340	900	800	790	730	1700	1700
Temperature-field (ºC)	np	16	18.1	19.2	20.4	19.6	14.7	18.7	16.7
dTh	np	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
TSS	np	2	4	<1	1	2	3	5	7
Turbidity-field (NTU)	20	2.49	2.57	2.41	2.51	2.14	14.01	4.17	10.54
dU	0.005	<0.0001	<0.0001	0.0004	0.0004	0.0003	0.0003	0.0003	0.0004
dV	0.0006	0.0001	0.0003	0.0003	0.0006	0.0003	0.0004	0.0008	0.0008
dZn	0.008	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.002

4.2 Sediment quality

Sediment quality analyte levels recorded from the study area in spring 2022 were all below the ANZG (2018) DGVs (Table 7). The net acid generation results indicated that the submerged sediments in the study area are non-acid forming (NAG kg H2SO4/t = <0.05). Sediment pH (NAG) was generally lower in upstream sites, compared to downstream sites, and lower at sites upstream of the Floyds North monitoring point compared to sites downstream of this location.

Table 7. Sediment quality recorded at the aquatic fauna survey sites in spring 2022, compared with ANZG (2018) 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 are highlighted pale orange.

Analyte	Units	DGV	DGV – high	Upstream of Floyd's emission point		Upstream of proposed water storage area		Downstream of proposed water storage area			
				SGU1	SGU2	SGU3	SGU4	SGD1	SGD2	SGD3	SGD4
As	mg/kg	20	Np	1	0.4	2.2	0.9	0.4	0.4	0.6	0.4
Cd	mg/kg	2	25	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cr	mg/kg	80	370	11	13	35	11	18	25	25	18
Cu	mg/kg	65	270	2.7	6.1	1.3	1.9	3.3	2.9	1.5	3.3
Fe	mg/kg	np	Np	860	1700	1000	920	2000	2900	1900	2000
Hg	mg/kg	0.15	1	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Li	mg/kg	np	np	1	0.6	2.7	6.9	1.5	0.7	2.2	1.5
Ni	mg/kg	21	52	1	1.8	2.6	2.9	1.6	2.5	2.5	1.6
Pb	mg/kg	50	220	10	7.7	0.9	4.4	4.2	3.7	2.6	4.2
Se	mg/kg	np	np	<0.05	<0.05	<0.05	0.11	0.06	<0.05	<0.05	0.06
Zn	mg/kg	200	410	<10	<10	<10	<10	<10	<10	<10	<10
N	mg/kg	np	np	730	850	250	620	350	350	370	460
P	mg/kg	np	np	110	100	68	120	110	120	49	110
NAG	kgH2SO4/t	np	np	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
NAG<4.5	kgH2SO4/t	np	np	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
pH(NAG)		np	np	4.5	5.2	5.3	6.9	6.2	6.4	5.5	6.2

There were also spatial differences in sediment metals and nutrient concentrations across the study area. Sediments closest to the new proposed dam, at site SGU4, recorded higher concentrations of lithium (6.9 mg/kg) and selenium (0.11 mg/kg), compared to other sites upstream and downstream (Li ≤ 2.7 mg/kg, Se ≤ 0.6 mg/kg). Lead concentrations were higher at the sites upstream of Floyds North monitoring point (≥ 7.7 mg/kg), compared to all other sites (≤ 4.4 mg/kg). Sediment iron concentrations were greater downstream of the proposed new dam (≥ 1900 mg/kg) compared to the upstream sites (≤ 1700 mg/kg). Total nitrogen levels were also higher at the sites upstream of Floyds North monitoring point (≥ 730 mg/kg, and at site SGU4 (620 mg/kg), compared to the other sites (≤ 460 mg/kg). Total phosphorus concentrations were generally comparable between upstream and downstream areas. Variation in sediment concentrations of these analytes throughout the study area may be linked to the site locations in relation to potential sources (i.e., Floyds North and South emission points) and existing dam structures trapping sediments, and variation in sediment characteristics between sites. Different types of metals and nutrients vary in propensity to bind with sediments, depending on the organic matter, sand and clay content of the sediment (Gregory 2008).

4.3 Habitat

Recorded values for habitat variables are tabulated in Appendix 3 and photographs of each site provided in Appendix 1. In general, all sites upstream of the Floyds north monitoring point were in near pristine aquatic habitat condition, with no livestock access, very few weeds, and comparatively minor points of erosion. Sites located in the Saltwater Gully dams were categorised as degraded, due to reduced coverage and diversity of native understory vegetation, areas of weedy grass cover, and some erosion of banks, with sediment plumes observed. Downstream of the proposed dams, the aquatic habitat of lower Saltwater Gully was in slightly better condition than the 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 limited in-stream vegetation present, low visibility, weedy riparian zones and considerable bank erosion.

A summary of the habitat condition and composition assessment at each site is provided below.

<u>SGU1</u>

Site SGU1 is located approximately 2.24 km upstream of the proposed water storage area, in a forested area adjacent to livestock farmland. There was no flow present at this site, however there was also no evidence of connectivity issues. Water clarity was generally clear with no tannin staining or algae present throughout the site. Sediments observed at the site were a mixture of sand, silt and clay with no obvious sediment deposition. There was evidence of natural native tree and shrub recruitment, with the understorey dominated by rushes and sedges in the riparian zone. Vegetation in the streamside zone of both the left and right banks was comprised of mostly native shrubs and trees with a small proportion of blackberry bushes found on both banks. Bullrush was the only macrophyte observed at this site and account for only 5% of the total in-stream habitat area. There was no evidence of significant erosion or livestock damage present on either bank with the only visible sources of potential pollution being a dead kangaroo found in the water directly upstream of the site and the relative proximity to livestock farmland. However, this site may receive potential contaminants of concern in seepage from Floyds WRD, as it is located downstream of the furthest upstream monitoring location for Floyds WRD seepage (GHD 2021).

<u>SGU2</u>

Site SGU2 is located approximately 1.79 km upstream of the proposed water storage area and upstream of the Floyds North emission monitoring point, in a forested area with a sealed road crossing located directly downstream of the site. No significant flow was observed at this site and there was no evidence of loss of connectivity in the system. Water clarity was overall clear throughout the site although an oily sheen was present in some areas. Silt was the dominant type of sediment recorded, with some sediment deposition observed. Many crayfish burrows of varying sizes were observed to be densely scattered across the entire site. There was evidence of native shrub recruitment occurring naturally, with the understorey being dominated by native bushes and shrubs in the riparian zone. Vegetation in the streamside zone of both the left and right banks was comprised of mostly shrubs with trees, rushes and sedges also present to a lesser extent. No exotic vegetation or aquatic macrophytes were recorded at this site. There was no evidence of significant erosion or livestock damage present on either bank with the only visible source of potential pollution to this site being the sealed road crossing located downstream. However, this site may receive potential contaminants of concern in seepage from Floyds WRD, as it is located downstream of the furthest upstream monitoring location for Floyds WRD seepage (GHD 2021).

SGU3

Site SGU3 is located approximately 0.5km upstream of the proposed water storage area and downstream of the Floyds North emission monitoring point at the base of sloping livestock farmland. Flow was observed at the south-eastern corner of the pool passing through a culvert and continuing for approximately 15m down a series of small waterfalls which allows for the passage of fish during the wet months of the year. Water clarity was overall mostly clear with some slight tannin staining and algae (1-9%) being observed in the water column. Small to moderate sediment deposits were also recorded at this site. Charophyte[3] beds were observed covering a large area of the southern portion of the site. There was no evidence of any recruitment of native woody vegetation in the streamside zone of this site, with most of the vegetation being plantation trees, introduced weeds and grasses. Bare ground accounted for 50-74% of the streamside zone on both the left and right banks, with 1-9% being covered by large (>10m) plantation trees. Evidence of bank erosion of 5-19% was recorded on both the left and right banks. Although the site had no direct cattle access, due to the slope of the adjacent paddock there is a high chance for runoff to be a source of potential pollution in addition to any pollution caused by traffic travelling along the road bridge. This site is located downstream of potential WRD seepage sources.

SGU4

Site SGU4 is located approximately 0.20km upstream of the proposed water storage area adjacent to livestock farmland. Flow was observed at the southwestern corner passing through a culvert and continuing for approximately 10m downstream allowing for passage of fish during the wet months of the year. Water observed at this site was slightly turbid with a small amount of algae (1-9%) present in both the water column and on substrate. Moderate sediment plumes were also recorded at this site. Charophyte beds were observed covering approximately 30% of the site with isolated patches of various sedges also being recorded along the embankment. There was evidence of a limited amount of naturally occurring tree recruitment recorded in the streamside zone. Vegetation recorded in the streamside zone of the left bank was mostly grasses and sedges with a few shrubs and trees. Small trees (<10m) comprised most of the vegetation recorded on the right bank (50-74%). Both banks had a small proportion (1-9%) of exotic plantation trees, however most trees observed at this site were native. Evidence of bank erosion

[3] Charophytes are a group of freshwater green algae.

of 5-19% was seen on both the left and right banks. The primary visible source of disturbance to this site is the potential of livestock access and runoff from the adjacent paddock that is 5-10m away from the left embankment. This site is located downstream of potential WRD seepage sources.

SGD1

Site SGD1 is located approximately 0.15km downstream of the proposed water storage area in a low-lying area with dense grasses and weeds surrounded by sparse large native trees. Steady flow was observed at this site in very shallow water (approximately 0.3 m) originating from the bottom of the series of waterfalls originating from the culvert upstream at site SGU4. The water observed at this site was overall clear and free of tannins with no algae recorded in the water column or substrate. An oily sheen was recorded in the slower moving areas of the creek. Pugging holes (from cattle) were observed along the embankment. Approximately 10% of the total site area was covered by inundated sedges and rushes, however no other aquatic macrophytes were observed throughout the site. There was evidence of a moderate amount of natural recruitment of both trees and shrubs. Vegetation recorded in the streamside zone of both banks was comprised mostly of grasses, sedges, rushes and native trees. Both the left and right banks were dominated by exotic grasses and other weeds (75-100%). The left bank showed low-moderate amounts of erosion (5-19%) and the right bank showed evidence of high amounts of erosion (20-49%). There was evidence of direct livestock access to this site which was the primary visible source of disturbance observed at this site. This site is located downstream of potential WRD seepage sources.

SGD2

Site SGD2 is located approximately 0.81km downstream of the proposed water storage area in a very similar environment to SGD1. Steady flow was observed moving along the shallow water, originating from a series of small waterfalls spanning approximately eight meters located directly upstream. The water was clear and odourless with no significant algae or oils present at the time of the spring survey. Charophyte was the dominant aquatic primary producer recorded, though with only sparse patches observed throughout the site. Evidence of abundant natural recruitment of both native trees and shrubs was observed throughout the site. Vegetation recorded in the streamside zone was predominantly composed of ground cover, grasses, sedges and rushes (10-49%) on both banks with sparse shrubs and trees. Sparse blackberry bushes were recorded throughout the site along with many mature pine trees being present within 100 m of the bank. Both the left and right banks showed low-moderate levels of erosion and barbed wire fences had been installed to prevent cattle access. Historical livestock access, runoff, flow and wave action from the current were the predominant factors that have the potential to affect the bank's stability and pollute the creek. This site is located downstream of potential WRD seepage sources.

SGD3

Site SGD3 is located approximately 1.18km downstream of the proposed water storage area and is situated within an open area with minimal mature vegetation. A combination of very strong flow and soft sediment at this site during the spring 2022 survey prohibited the safe use of the electrofisher. The water at this site had a moderately anaerobic odour and was slightly turbid with moderate amounts of sediment plumes throughout. Algae and charophyte were absent from this site, likely due to the fast-flowing water. Bullrush *Typha* sp. was the dominant aquatic macrophyte present at this site, with stands present downstream of the road crossing. There was evidence of a moderate amount of natural recruitment of trees and shrubs throughout the site as well as signs of a fire event occurring in this area in recent years (likely the early 2022 bushfire). Vegetation in the streamside zone was predominantly comprised of exotic weeds, grasses and blackberry bushes on both the left and right banks. Both banks displayed moderate levels of erosion (5-19%) and poor overall structural integrity with the main factor affecting bank stability being the rate of flow passing through the site. The primary source of potential pollution impacting this site was the presence of a submerged road crossing approximately 15 m north of the sampling location. This site is located downstream of potential WRD seepage sources.

<u>SGD4</u>

Site SGD4 is located approximately 2.91km downstream of the proposed water storage area in a similar environment to SGD3, surrounded by plantation trees. Steady flow was observed at this site in approximately 0.5 - 1 m of water. The water at this site had a moderate level of turbidity with a light amount of sediment oils also being recorded. No macrophytes were observed throughout this site. Most of the vegetation within the streamside zone was exotic grasses and weeds and blackberry bushes. There was evidence of a limited amount of tree recruitment both natural and planted. There was also evidence of a fire event that had occurred in recent years (likely the early 2022 bushfire) resulting in minimal mature trees and significant amounts of exotic grasses. There was a low-moderate amount of erosion (5 - 19%) with both the left and right banks displaying good structural integrity. Main factors that could affect bank stability are the clearing of land as a result of the recent fire event and the fast flow moving through the site. There were no immediate point sources of pollution visible, however, the pine plantation surrounding this site could act as a non-point source of pollution.

4.4 Macrophytes

Macrophytes were present at six of the eight sites sampled in spring 2022 (Table 8). Taxa richness was low, with a total of four 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). Of note was the relatively high coverage of the bullrush *Typha* sp. At downstream site SGD3, and the relatively high coverage of charophyte algae (genera *Chara* sp. and *Nitella* sp.) at upstream site SGU4. As an emergent macrophyte, stands of *Typha* sp. provide habitat for macroinvertebrates (i.e., shelter, food), biofiltration (removal of nutrients and metals from the water column through plant uptake) and protection from flood washout to the aquatic fauna community. Charophyte algae are typically found in slow to zero flow aquatic environments and are morphologically and ecologically similar to aquatic vascular plants. Charophytes are beneficial to aquatic ecosystems, as they can absorb and store nutrients from the water into their biomass, improve sedimentation, reduce sediment suspension, and provide habitat for invertebrates and juvenile fish.

Table 8. Aquatic flora (macrophytes) recorded at the aquatic fauna survey sites in spring 2022.

Site	Emergent veg %	Submergent veg %	Algal cover %	Taxa
SGU1	5	0	0	Bullrushes *Typha* sp. and *Schoenoplectus* sp.
SGU2	0	0	5	Charophyte algae (genera *Chara* sp. and *Nitella* sp.)
SGU3	0	0	10	Charophyte algae (genera *Chara* sp. and *Nitella* sp.)
SGU4	2	0	23	Bullrush *Schoenoplectus* sp., Charophyte algae (genera *Chara* sp. and *Nitella* sp.)
SGD1	0	0	0	No macrophytes observed.
SGD2	2	0	3	Bullrush *Schoenoplectus* sp., Charophyte algae (genera *Chara* sp. and *Nitella* sp.)
SGD3	30	0	0	Bullrush *Typha* sp.
SGD4	2	0	0	No macrophytes observed.

4.5 Macroinvertebrates

A total of 133 macroinvertebrate taxa[4] were recorded during the spring survey, with 93 taxa recorded at sites upstream of the proposed water storage area and 84 taxa recorded downstream (Table 9; see Appendix 4 for taxa list and site abundance data). Insecta was the dominant group observed across all eight 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 2022 survey was the larval nonbiting midge *Tanytarsus* sp. (V6), with individuals recorded at every site. Taxa richness in Saltwater Gully and downstream Hester Brook in spring 2022 was generally comparable to the taxa richness found during CENRM UWA's spring 2013 and spring 2021 surveys of Norilup Brook and Hester Brook (range ~22 – 34 taxa per site), for Talison Greenbushes mine.

Upstream site SGU1 had the highest species richness of all sites, with 54 taxa recorded, while SGD3 had the lowest species richness, with 29 taxa recorded (Figure 6). Greater diversity of Coleoptera and Hemiptera (true bugs) were recorded in the upstream sites, compared to the downstream sites. This would be due to the difference in flow status between the areas, with these taxa known to prefer slow/low flow areas such as the Saltwater Gully dams, instead of the faster flowing channel sites SGD3 and SGD4.

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

[4] 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.

Hester Brook catchment (molluscs *Westralunio carteri/inbisi* and *Glacidorbis occidentalis*), however, neither species were recorded in spring 2022.

Fourteen southwest WA endemic species were recorded in the macroinvertebrate samples, including the bivalve *Musculium kendricki*, amphipod *Perthia acutitelson*, aquatic beetles *Limbodessus inornatus*, *L. shuckardii*, *Sternopriscus browni* and *S. marginatus*, the non-biting midge *Rheotanytarsus underwoodi*, the damselfly *Archiargiolestes* sp., the dragonflies *Archaeosynthemis leachii*, *Austrogomphus collaris*, *Austroaeschna anacantha*, toad bug *Nerthra tuberculata*, the caddisfly *Notoperata tenax* and the stonefly *Newmanoperla exigua*.

The bivalve *Musculium kendricki*, collected from SGU1 in spring 2022, was identified as a candidate for priority listing by Pennifold (2018). The basis for the inclusion of this species as a candidate was the paucity of records made since 1999. SLR have a recent (2022) record of this species in the Harvey River catchment, and CENRM recorded it within 10 km of the Project area, in Norilup Brook in 2021. The lack of records may be due to low sampling effort for aquatic fauna across the southwest region (aquatic invertebrates in particular, have historically been under-studied in this region), with taxonomy often not undertaken to species-level, and the inefficiencies in data sharing between private and government institutions.

The damselfly larvae of the *Archiargiolestes* genus, recorded at SGD4, cannot currently be distinguished to species level on morphological characteristics. However, the species *Archiargiolestes pusillissimus* was also identified as a candidate for priority listing by Pennifold (2018), due to a lack of records post-1978. Distribution information in Pinder and Pennifold (2011) indicate the *Archiargiolestes* sp. recorded in Saltwater Gully during the current study is likely to be the more widespread species, *Archiargiolestes pusillus*.

Table 9. Summary of higher-order macroinvertebrate taxa composition recorded from the study area in spring 2022. Refer Appendix 4 for full species list.

Macroinvertebrates		Number of Taxa	
Scientific Name	**Common name**	**Upstream sites**	**Downstream sites**
Cnidaria	Hydra	0	1
Nematoda	Nematodes	0	1
Mollusca	Freshwater Snails	5	5
Annelida	Aquatic worms and Leeches	2	1
Amphipoda	Amphipods	3	3
Arachnida	Water Mites	2	2
Collembola	Springtails	2	3
Diptera	Two-winged flies	26	31
Odonata	Dragonflies and Damselflies	7	7
Plecoptera	Stoneflies	0	1
Trichoptera	Caddisflies	9	10
Ephemeroptera	Mayflies	4	4
Hemiptera	True Bugs	9	3
Coleoptera	Aquatic Beetles	24	12
	Total taxa richness	93	84

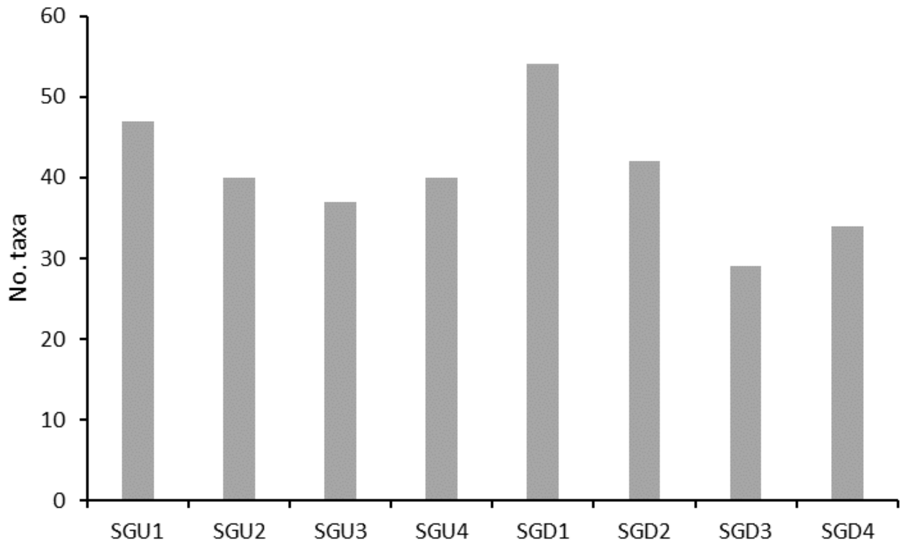

Figure 6. Macroinvertebrate taxa richness recorded at each Saltwater Gully/downstream Hester Brook site, spring 2022.

4.5.1 Relationships between macroinvertebrate assemblages and environmental data

Spatial patterns across the study area were evident in the macroinvertebrate assemblage PCO ordination (Figure 7). A total of 60.6% of the variation between sites was explained by two PCO axes. Upstream and downstream sites separated along PCO1, which explained 34.6% of the total variation in assemblages between sites. The separation of upstream sites was correlated with greater abundances of non-biting midge taxa *Corynoneura* sp., *Parakiefferiella* sp., *Paralimnophyes pullulus*, *Procladius paludicola*, and *Tanytarsus* sp., mosquito larvae *Culex* sp., immature water boatmen Corixoidea spp., and diving beetle *Hyphydrus elegans*. The separation of downstream sites was correlated with greater abundances of non-biting midge larvae *Cricotopus parbicinctus* and *Thienemanniella* sp., black fly larvae Simuliidae spp. (indicative of flowing water, rather than still water), crane fly larvae Tipulidae spp., biting midge larvae Ceratopogoninae spp., and the southwest endemic stonefly larvae *Newmanoperla exigua*.

Sites SGU1, SGD3 and SGD4 separated from the other sites along PCO2, which explained 26% of the total variation in assemblages between sites. Taxa correlated with this separation that recorded greater abundances at these sites included the snails *Glyptophysa* sp. and *Ferrissia petterdi*, southwest endemic amphipod *Perthia acutitelson* and the non-biting midge larva *Paramerina ?levidensis*. Taxa that recorded lower abundances or were absent from SGU1, SGD3 and SGD4, and more abundant at the other sites, included dragonfly nymph *Orthetrum caledonicum*, mayfly nymph *Cloeon fluviatile*, caddisfly larva *Hellyethira* sp. and water mite Oribatida sp..

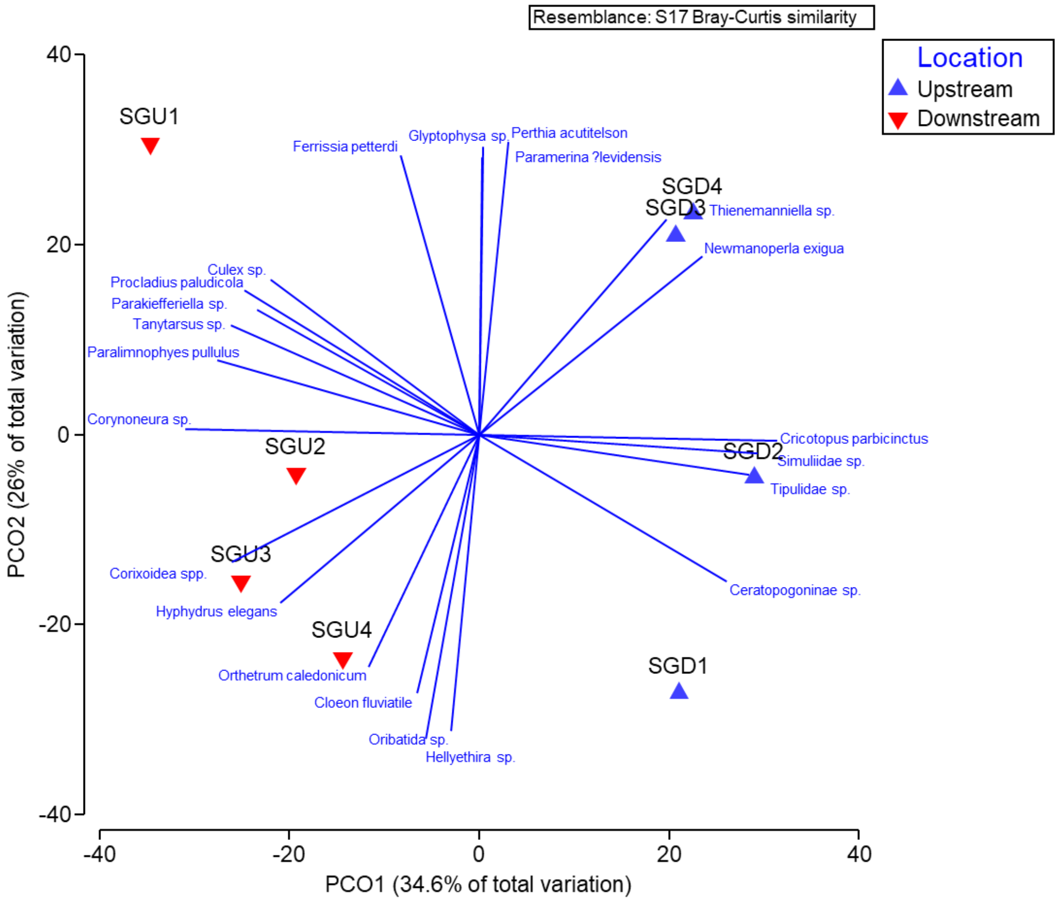

Figure 7. Saltwater Gully macroinvertebrate assemblage PCO ordination in two dimensions, log_{10} abundance data, Spring 2022. Macroinvertebrate taxa with correlations r > 0.85 with the separation of sites are overlaid.

PERMANOVA confirmed the macroinvertebrate assemblage composition at sites upstream of the proposed new dam were significantly different from downstream sites (One-way PERMANOVA df = 1, pseudo-F = 3.01, p = 0.025), at only 33.5% similarity between the two areas. Assemblage composition similarity was slightly higher within the upstream site group (47.5%), compared to the downstream site group (45.1%).

Linear correlations of sediment and water quality variables (r > 0.7) were overlaid on the macroinvertebrate assemblage PCO (Figure 8). The separation of SGU3 and SGD4 assemblages were correlated with greater SO4 concentrations, and SGD3 and SGD4 assemblages were correlated with greater levels of Na and Cl (major ions contributing to EC) dFe, dCu, dAl, TSS and turbidity. The separation of SGU3, SGU4 and SGD1 assemblages was correlated with greater dLi concentrations, with SGD1 also correlating with greater sediment Ni (Figure 8). The SGD2 assemblage correlated with greater sediment Fe, nitrate-nitrogen ($N\text{-}NO_2$; also correlated with SGD1 assemblage) and the ion HCO_3.

There was a significant, strong non-linear correlation between macroinvertebrate assemblage composition and a similar, though slightly different suite of sediment and water quality variables in Saltwater Gully (BVSTEP; Rho = 0.88, p = 0.003). The suite of variables found through BVSTEP to have the greatest correlation with the differences in macroinvertebrate assemblage composition were concentrations of iron and nickel in sediment, and dissolved aluminium, dissolved copper, dissolved vanadium, nitrite-nitrogen and electrical conductivity in water. Sediment iron concentrations were higher in the downstream sites, compared to upstream sites, while sediment nickel concentrations were higher in the dam sites SGU3 and SGU4, and immediately downstream of the proposed new dam at SGD1 (Figure 9). In water, dissolved aluminium concentrations were greater at downstream sites SGD2, SGD3 and SGD4, while dissolved copper was greater at SGU1, SGD3 and SGD4 (Figure 9). Concentrations of dissolved vanadium were higher in the dam site SGU4 and downstream sites SGD3 and SGD4, while greater nitrite-nitrogen concentrations were recorded at SGU4, SGD1 and SDG2 (Figure 10). Electrical conductivity was greater at SGD2 and SGD4 (Figure 10, see Table 6).

While sediment and water quality analytes were correlated with the macroinvertebrate assemblage variation in the study area, this correlation does not necessarily indicate causation. Rather, the differences between sites in habitat composition and condition, flow status (still water in the dam and upstream sites; flowing water in the downstream sites) 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.

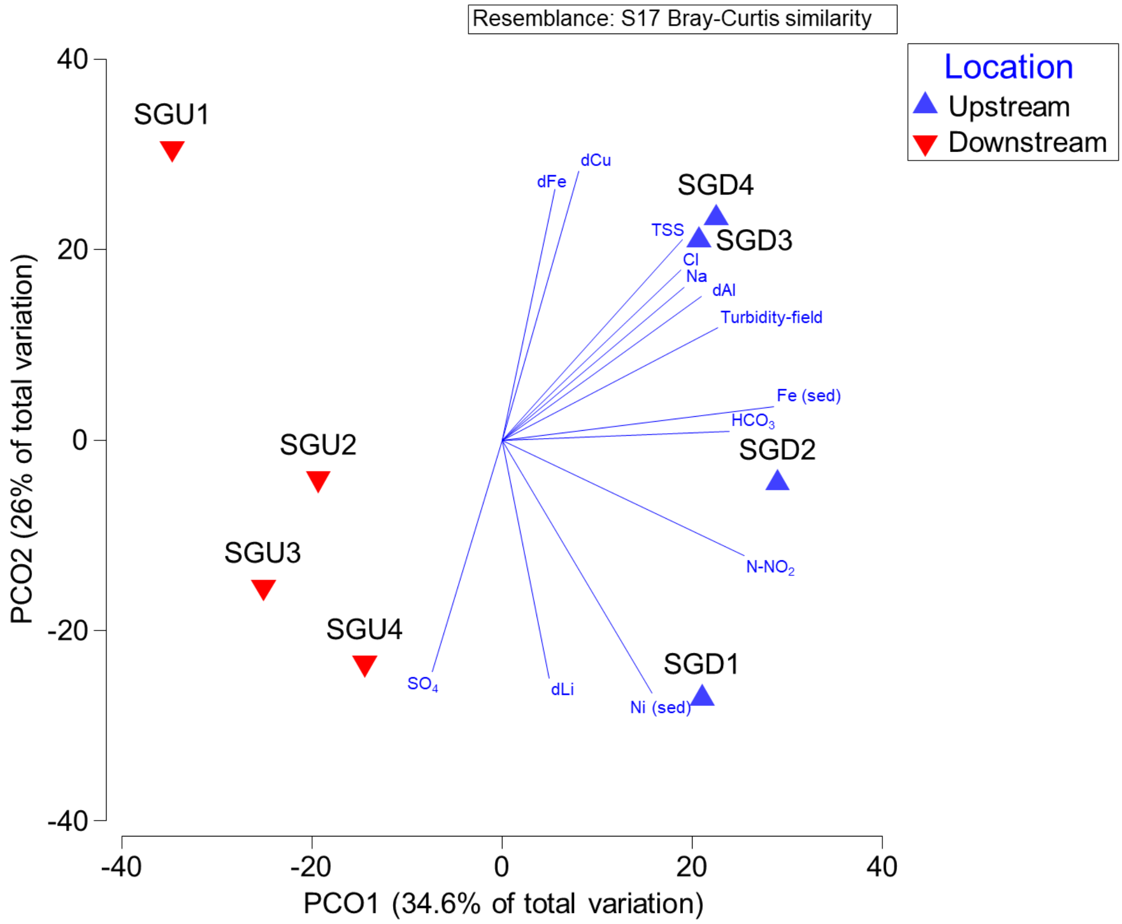

Figure 8. Macroinvertebrate assemblage PCO with environmental variables of correlations r > 0.7 with the separation of sites are overlaid.

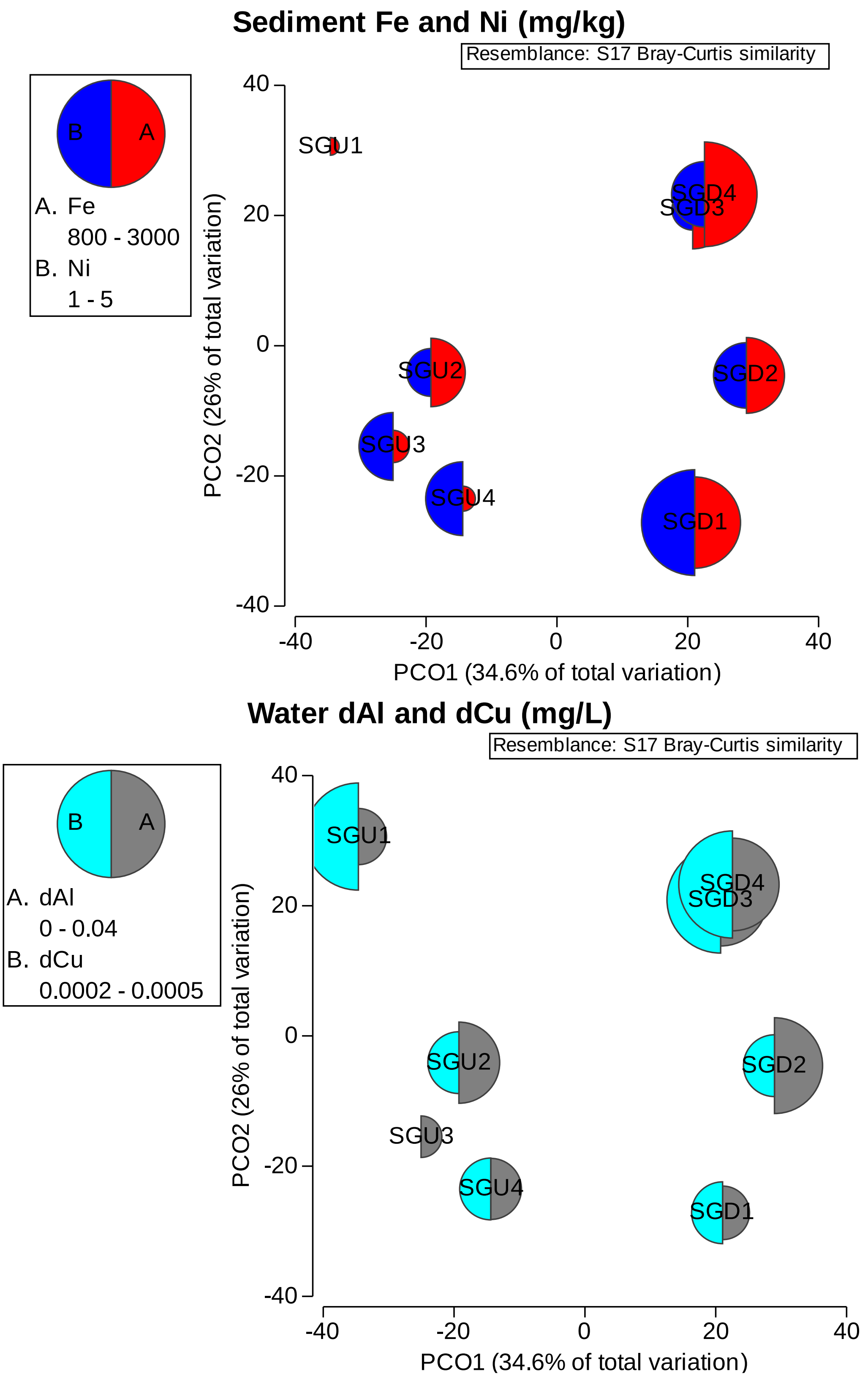

Figure 9. Saltwater Gully macroinvertebrate PCO overlaid with sediment Fe, Ni and water dAl and dCu bubble plots.

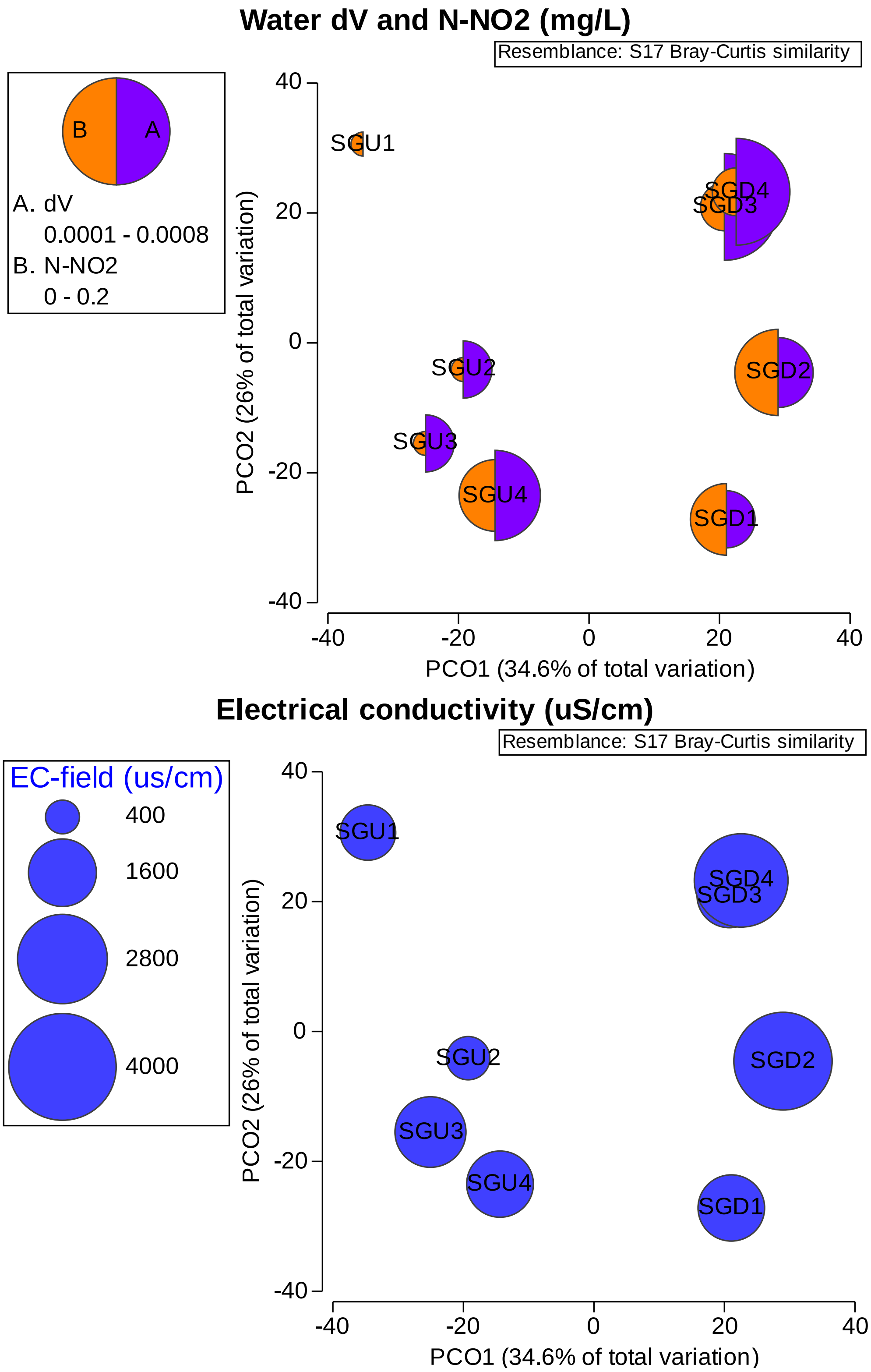

Figure 10. Saltwater Gully macroinvertebrate PCO overlaid with water dV, N-NO_2 and EC bubble plots.

4.6 Fish, Crayfish and Turtles

The spring 2022 survey of Saltwater Gully recorded two native fish species, two introduced fish species, two native crayfish species and one introduced crayfish species. Photographs of fauna are presented in Plate 1. CENRM (2014) and CENRM (2021) recorded most of the same species in Norilup Brook and Hester Brook, with the exception of the native smooth marron, and introduced redfin perch and yabby. The most commonly recorded species of fish was the native Western Pygmy Perch (738 individuals collected), followed by the introduced Gambusia (216 individuals collected). All the species captured are widespread throughout the southwest WA region, and all the native species captured are endemic to this region. No conservation significant fish or crayfish were recorded during the surveys. Records on DWER Healthy Rivers website (DWER 2023) indicate the only other species found in southwest WA that may inhabit Saltwater Gully, but was not detected in the current study, is the nightfish (*Bostokia porosa*).

The native the Southwestern Snake-Necked Turtle *Chelodina oblonga* was recorded as by-catch of fishing activities at SGU1, SGU2 and SGU4. This species is endemic to the south-west of Western Australia, inhabiting both permanent and seasonal waterbodies in fresh and saline systems. *C. oblonga* 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 and richness was generally highest in the sites upstream of the proposed new dam. The greatest species richness was recorded at SGU2, with eight species in total collected at this site. The highest abundance of crayfish was also recorded at this site (29), with numerous crayfish burrows observed in the stream bank. The highest fish abundance was recorded at SGU4 (653). Species richness and abundance was lowest at SGU1, where only one juvenile crayfish and one turtle were recorded.

Of the three introduced species recorded, the redfin perch may pose the highest risk to native fauna in Saltwater Gully. A single redfin perch was recorded at SGU2 at a length of 9 cm. 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). The small size of the individual and a known rapid growth and maturity rate indicate that there is likely to be more redfin perch present in the gully (DWER 2023). Redfin perch may impact native fish, crayfish and macroinvertebrate species through predation (DWER 2023). A study by Beatty and Morgan (2017) found a dramatic increase in the abundance of the smaller native western minnow (a species recorded at most Saltwater Gully/Hester Brook sites, except SGU1 and SGU2) following eradication of redfin perch from a water reservoir. An increase in the area of inundation in Saltwater Gully, following the construction of the new dam, could promote the proliferation and dispersal of redfin perch in Saltwater Gully and place pressure on the smaller-bodied native fish species (western minnow and pygmy perch).

Table 10. Fish, crayfish and turtle species recorded in Saltwater Gully and downstream Hester Brook, spring 2022.

Fauna group / species name	Common Name	Upstream of Floyds emission monitoring point		Upstream of proposed dam		Downstream of proposed dam				TOTAL
		SGU1	SGU2	SGU3	SGU4	SGD1	SGD2	SGD3	SGD4	
Reptilia (reptiles)										
Chelodina oblonga	Southwestern Snake-Necked Turtle	1	2	0	4	0	0	0	0	**7**
Crustacea (crayfish)										
Cherax sp. (j)	Juvenile crayfish	5	16	0	0	1	0	0	3	**25**
Cherax preissii	Koonac	0	7	3	1	0	0	0	0	**11**
Cherax cainii	Smooth Marron	0	2	5	3	0	2	0	1	**13**
Cherax destructor	Yabby*	0	4	0	2	1	6	1	1	**15**
Osteichthyes (bony fish)										
Gambusia sp.	Gambusia/Mosquitofish*	0	117	2	75	17	1	0	4	**216**
Perca fluviatilis	Redfin Perch*	0	1	0	0	0	0	0	0	**1**
Galaxias occidentalis	Western Minnow	0	0	17	4	4	4	41	27	**97**
Nannoperca vittata	Western Pygmy Perch	0	2	7	574	65	26	36	28	**738**
	Total abundance	**6**	**151**	**34**	**663**	**88**	**39**	**78**	**64**	**1123**
	Total species richness	**2**	**8**	**5**	**7**	**5**	**5**	**3**	**6**	**9**

* = exotic species

Cherax preissii Koonac

Nannoperca vittata Western Pygmy Perch

Galaxias occidentalis Western Minnow

Perca fluviatilis Redfin Perch

Cherax cainii Smooth Marron

Chelodina oblonga Southwestern Snake-Necked Turtle

Plate 1. A selection of photographs of aquatic fauna recorded in the study area, spring 2022

4.7 Other fauna

The water bird species white-faced heron (*Egretta novaehollandiae*), Western swamphen (*Porphyrio porphyrio*), Eurasian coot (*Fulica atra*) and Pacific black duck (*Anas superciliosa*) passed by the trail camera set at dam site SGU3. All of these species are widespread and occur beyond the southwest WA region. A motorbike frog (*Litoria moorei*) was recorded as fishing by-catch at SGU1 and released unharmed. This species is endemic to southwest WA. No other water birds, frogs or rakali were observed at any of the other study sites.

Litoria moorei Motorbike frog

Egretta novaehollandiae White-faced heron

Anas superciliosa Pacific black duck

Porphyrio Western swamphen

Plate 2. A selection of photographs of frogs and waterbirds recorded in the study area, spring 2022.

5 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 Saltwater Gully aquatic fauna from the Project, which involves increasing the height of the dam wall to increase the water storage area, include:

Decreased water supply to downstream aquatic fauna habitat and riparian zone flora

Reduced flow to downstream reaches may reduce the coverage of aquatic fauna habitat and the integrity of the riparian zone, leading to erosion and sedimentation and therefore degradation of in-channel habitat. Reduced flow period downstream of the dam, due to greater capture by the proposed new dam, coupled with overall declines in total rainfall in the southwest WA region with climate change, may adversely affect aquatic fauna and riparian zone flora depending on their environmental flow requirements. DWER may request hydrological investigations to determine whether the increased retention of water in Saltwater Gully will have a significant impact on environmental flows in Hester Brook.

A potential increased barrier for fish species moving upstream to breed

The survey results indicate that the native fish species Western pygmy perch and Western minnow were present both upstream and downstream of the proposed new dam and the Saltwater Gully/Hester Brook confluence. Western pygmy perch appear capable of breeding and sustaining populations within “closed” dam environments (Bonita Clark, SLR Consulting, pers. obs.). If the proposed new dam presents a barrier to fish passage upstream, the populations in downstream Hester Brook may still move into habitat upstream along Hester Brook (upstream of Saltwater Gully) for breeding purposes.

Mobilisation of sediments which may increase turbidity levels and concentrations of PCOCs in Saltwater 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.

Water and sediment quality changes

Water and sediment quality within Saltwater Gully after the proposed new dam creates a larger area of inundation is unlikely to change in any way that may increase the risk to aquatic biota in the near future, and is expected to remain similar to current levels, if emissions from Floyds WRD remain consistent. However, a net build-up of PCOCs in dam water and/or sediment may occur over time, causing water quality to deteriorate. PCOCs may also seep downstream through the dam wall and move downstream along Hester Brook, causing a decline in water quality in this area.

Changed habitat conditions favouring invasive species

The presence of the invasive redfin perch upstream of the proposed dam location may adversely affect native fish, crayfish and macroinvertebrate populations when the dam height is increased. It is likely establishment of a large, permanent waterbody on Saltwater Gully will favour redfin perch population increase and place greater predation pressure on native aquatic fauna. However, it may reduce the diversity of habitat within the inundated area, reducing the coverage of narrower, shallower channel areas between the existing series of dams along Saltwater Gully, where the smaller-bodies native fish and macroinvertebrates may find refuge from redfin perch predation. Additionally, there are what could be, based on aerial imagery, aquaculture ponds in Saltwater Gully that would fall into the area of inundation following the dam construction. These ponds may also hold exotic species that could then mix with the existing aquatic fauna assemblage, and potentially further increasing the risk to native biota. These pondages should be surveyed, and if they hold non-native species, they should be drained and species eradicated before being inundated by the new waterbody.

6 Summary and conclusions

The Saltwater Gully New Water Storage Aquatic Ecological Assessment was successfully completed between 26th – 28th October 2022. Aquatic biota, water and sediment quality sampling was conducted at eight sites; four upstream and four downstream of the proposed new dam location. The study area is located in the Southern Jarrah Forest IBRA sub-region (JAF02). The landscape of Saltwater Gully is highly modified due to a long history of post-European settlement disturbance. The gully includes areas of native vegetation interspersed with water storages, cattle pasture, timber plantations, power infrastructure and roads. No groundwater dependent ecosystems were identified in Saltwater Gully or along Hester Brook downstream of the proposed new dam location (Bureau of Meteorology's Groundwater Dependent Ecosystems Atlas).

Water and sediment quality

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. Metal (arsenic, lithium, manganese and uranium) concentrations were higher in the middle dam sites (SGU3 and SGU4), compared with downstream sites, which may indicate an accumulation of these metals in the Saltwater Gully dams downstream of the Floyds WRD. Sulfate and magnesium concentrations recorded through laboratory analysis were at least two-times greater than upstream sites SGU1 and SGU2. This may be indicative of acid mine drainage from the Floyds South emissions point located between SGU2 and SGU3.

Sediment quality analyte levels recorded from the study area in spring 2022 were all below the ANZG (2018) 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 were in near pristine aquatic habitat 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. 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* sp. at downstream site SGD3, and the relatively high coverage of charophyte algae (genera *Chara* sp. and *Nitella* sp.) at upstream site SGU4. Both *Typha* sp. 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 SGU1 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.

There was a strong correlation between macroinvertebrate assemblage composition and sediment and water quality variables in Saltwater 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, as the factors that influence macroinvertebrate habitat composition (i.e., the still water areas behind the existing dam walls, compared to flowing areas downstream) are also likely to be influencing where the PCOCs might accumulate downstream of the Floyds emission points.

Conclusions

Saltwater 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 Saltwater Gully was generally within the default and/or site-specific guidelines, emissions from Floyds WRD are the likely source of higher concentrations of several PCOCs in the existing dams. 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 construction of a new water storage, through raising the height of the existing dam, and the resulting increased area of inundation may be unlikely to increase the risk to aquatic biota from PCOCs within this area, and in downstream aquatic environments, in the immediate future. However, a net build-up of PCOCs in dam water and/or sediment may occur over time, causing water quality to deteriorate. PCOCs may also seep downstream through the dam wall and move downstream along Hester Brook, causing a decline in water quality in this area.

Mobilisation of sediment to downstream aquatic environments during earthworks for the new dam poses a risk to receiving biota but this may be mitigated through appropriate site management. Hydrological investigations may also be required to determine whether the increased retention of water in Saltwater Gully will have a significant impact on environmental flows in Hester Brook. It is also possible that the alterations to habitat within Saltwater Gully, through increasing the area of inundation, may favour the proliferation of invasive species (in particular, the redfin perch) to the detriment of the suite of native species, all of which are likely or known to be common throughout the southwest WA region.

In summary, while the construction and inundation of the new water storage area may pose some risks to resident aquatic fauna, none of these potential risks are likely to threaten the survival of these species at a regional level, given the high level of disturbance that has already occurred in Saltwater Gully in the last one hundred years.

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8 Feedback

At SLR, we are committed to delivering professional quality service to our clients. We are constantly looking for ways to improve the quality of our deliverables and our service to our clients. Client feedback is a valuable tool in helping us prioritise services and resources according to our client needs.

To achieve this, your feedback on the team's performance, deliverables and service are valuable and SLR welcome all feedback via https://www.slrconsulting.com/en/feedback. We recognise the value of your time and we will make a $10 donation to our 2022 Charity Partner – Lifeline, for every completed form.

APPENDICES

Appendix 1. Site photographs – Spring 2022

SGU1 Upstream

SGU1 Downstream

SGU2 Upstream

SGU2 Downstream

SGU3 Upstream

SGU3 Downstream

SGU4 Upstream

SGU4 Downstream

SGD1 Upstream

SGD1 Downstream

SGD2 Upstream

SGD2 Downstream

SGD3 Upstream

SGD3 Downstream

SGD4 Upstream

SGD4 Downstream

Appendix 2. ANZG (2018) default guideline values

Table A2-1. 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* ($\mu g\ L^{-1}$)	TP ($\mu g\ P\ L^{-1}$)	FRP ($\mu g\ P\ L^{-1}$)	TN ($\mu g\ N\ L^{-1}$)	NO_x ($\mu g\ N\ L^{-1}$)	NH_4^+ ($\mu g\ N\ L^{-1}$)	DO (% saturation)[i]		pH	
								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 $\mu g\ P\ L^{-1}$), FRP (10 $\mu g\ P\ L^{-1}$);

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 A2-2. 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

Note: several new (proposed) toxicant default guideline values are soon to be released and are denoted as [R].

Table A2-3. Recommended toxicant default guideline values for sediment quality.

Type of toxicant	Toxicant	DGV	GV-high
Metals (mg/kg dry weight)[a]	Antimony	2.0	25
	Cadmium	1.5	10
	Chromium	80	370
	Copper	65	270

Type of toxicant	Toxicant	DGV	GV-high
	Lead	50	220
	Mercury	0.15	1.0
	Nickel	21	52
	Silver	1.0	4.0
	Zinc	200	410

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

Appendix 3. Habitat assessments

Table A3-1. Habitat characteristics – river health assessment for each site, October 2022 (LWD – Large Woody Debris, LB – Left Bank, RB – Right Bank).

SITE	SGU1	SGU2	SGU3	SGU4	SGD1	SGD2	SGD3	SGD4
DATE	26-10-2022	26-10-2022	26-10-2022	27-10-2022	27-10-2022	28-10-2022	27-10-2022	28-10-2022
STREAM HABITAT DIVERSITY								
Channel (%)	100	70	0	5	0	40	80	100
Pool (%)	0	30	90	95	0	20	10	0
Riffle (%)	0	0	5	0	80	40	10	0
Run (%)	0	0	5	0	20	0	0	0
Aquatic plant and macroalgae (%)		100	20	32	10	2	30	0
LWD Diversity	2-3 different sizes	Wood of similar size	None	Wood of similar size	2-3 different sizes	2-3 different sizes	Wood of similar size	Variety of sizes
LWD Abundance	Dense (throughout most of site)	Sparse (few pieces)	None	Sparse (few pieces)	Moderate	Moderate	Sparse (few pieces)	Dense (throughout most of site)
Roots overhanging (%)		None	1-9	None	1-9	10-49	None	1-9
Banks overhanging (%)		None	None	None	1-9	10-49	None	10-49
Draped bank vegetation (%)		1-9	1-9	None	1-9	1-9		1-9
Depth	Varied	Moderately Varied	Moderately Varied	Moderately Varied	Uniform	Varied	Moderately Varied	Moderately Varied
Tree overhanging (%)	30 (LB), 10 (RB)	5 (LB), 5 (RB)	5 (LB), 5 (RB)	2 (LB), 5 (RB)	10 (LB), 15 (RB)	10 (LB), 5 (RB)	0	5 (LB), 2 (RB)
Shrub overhanging (%)	10 (LB), 5 (RB)	70 (LB), 96 (RB)	0	0	0	5 (LB), 10 (RB)	10 (LB), 70 (RB)	0
Grass overhanging (%)	0	5 (LB), 0 (RB)	0	0	0 (LB), 5 (RB)	5 (LB), 5 (RB)	90 (LB), 30 (RB)	40 (LB), 40 (RB)
Physical substrate diversity	Pebble, Gravel, Sand, Silt, Clay	Cobble, Pebble, Gravel, Sand, Silt, Clay	Boulders, Sand, Silt, Clay	Boulders, Gravel, Sand, Silt and Clay	Gravel, Sand, Silt, Clay	Bedrock, Boulders, Cobble, Pebble, Gravel, Sand, Silt, Clay	Gravel, Sand, Silt, Clay	Gravel, Sand, Silt, Clay
Sediment deposition	Not Obvious	Not Obvious	Obvious	Obvious	Obvious	Not Obvious	Obvious	Obvious
Water odours	Normal/None	Normal/None	Normal/None	Normal/None	Normal/None	Normal/None	Normal/None - Anaerobic	Normal/None
Water oils	None	Sheen	None	None	Sheen	None	None	None
Turbidity	Clear	Clear	Clear	Slight	Clear	Clear	Slight	Turbid
Tannin staining	Clear	Clear	Slight	Clear	Clear	Clear	Clear	Clear
Algae in water column (%)	0	0	1-9	1-9	0	0	0	0
Algae on substrate (%)	0	0	0	1-9	0	0	0	0
Sediment plume		Large	Small-Moderate	Moderate	Small	Small	Moderate	Moderate
Sediment oils	Absent	Light	Absent	Absent	Light	Absent	Absent	Light
Sediment odours	Normal/None	Normal/None	Normal/None	Normal/None	Normal/None	Normal/None	Anaerobic	Normal/None
VEGETATION ASSESSMENT								

Riparian Vegetation								
Riparian zone present	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ground layer	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Shrub layer	Yes	Yes	No	Reduced	Yes	Yes	Yes	No
Tree layer	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Streamside Vege All								
Bare ground (%)	0	1-9 (LB), 0 (RB)	50 -74 (LB & RB)	10-49 (LB & RB)	0	1-9 (LB & RB)	0	0
Ground cover (%)	1-9 (LB & RB)	1-9 (LB & RB)	0	10-49 (LB & RB)	10-49 (LB & RB)	10-49 (LB & RB)	75-100 (LB), 50-74 (RB)	50-74 (LB & RB)
Shrubs (%)	50-74 (LB & RB)	50-74 (LB & RB)	0	1-9 (LB & RB)	1-9 (LB & RB)	1-9 (LB & RB)	50-74 (LB), 75-100 (RB)	0
Trees <10m (%)	10-49 (LB & RB)	1-9 (LB), 10-49 (RB)	0	1-9 (LB), '50-74 (RB)	10-49 (LB), 50-74 (RB)	1-9 (LB & RB)	0 (LB), 1-9 (RB)	0
Trees >10m (%)	0	0	1-9 (LB & RB)	1-9 (LB), 10-49 (RB)	10-49 (LB), 1-9 (RB)	1-9 (LB & RB)	1-9 (LB), 0 (RB)	1-9 (LB & RB)
Streamside Vege Exotic								
Ground cover (%)	0	0	50-74 (LB & RB)	0	75-100 (LB & RB)	75-100 (LB & RB)	75-100 (LB & RB)	75-100 (LB & RB)
Shrubs (%)	1-9	0	0	0	0	0	75-100 (LB & RB)	0
Trees <10m (%)	0	0	0	1-9 (LB & RB)	0	1-9 (LB), 10-49 (RB)	0	0
Trees >10m (%)	0	0	1-9 (LB & RB)	1-9 (LB & RB)	0	0	0	50-74 (LB & RB)
Exotic species	Blackberry	None	Plantation trees	Some non-native plantation trees	Non-native grasses	Pine tree, some Blackberry (sparse)	Grasses, Weeds, dense Blackberry	Grasses, Blackberry, Plantation trees
Streamside Vege Native.								
Recruitment evidence	Natural	Natural	None	Natural	Natural	Natural	Natural	Natural and Planted
Recruitment type	Trees and Shrubs	Shrubs		Trees	Trees and Shrubs	Both	Trees and Shrubs	Trees
Extent of recruitment		Moderate		Limited	Moderate	Abundant	Moderate	Limited
Recruitment Health		Moderate		Moderate / Healthy	Moderate	Healthy	Moderate	Poor
Organic Litter								
Total organic litter (% cover)		10-49		1-9	1-9	1-9	10-49	1-9
Native (% cover)		10-49			75-100	75-100	1-9	1-9
PHYSICAL FORM								
Banks & Physical Form								
Erosion (%)	0-4 (LB & RB)	0-4 (LB & RB)	5-19 (LB & RB)	5-19 (LB & RB)	5-19 (LB), 20-49 (RB)	0-4 (LB & RB)	5-19 (LB & RB)	5-19 (LB & RB)
Erosion Severity	Minor (LB & RB)	Minor (LB & RB)	Minor (LB & RB)	Minor (LB & RB)	Low-Moderate (LB), High (RB)	Low-Moderate (LB & RB)	High (LB & RB)	Low-Moderate (LB & RB)
Bank Stability Factors	None	None	None (LB), Culvert, bridge, dam (RB)	Livestock access, Culvert, bridge, dam (LB & RB)	Livestock access, Runoff (LB & RB)	Livestock access, Flow and waves (LB & RB), Runoff (RB)	Flow and waves (LB & RB)	Cleared vegetation, Flow and waves (LB & RB)
Stabilisation works	None	None	None	None	None	Fenced livestock access (deterrent)	None	None

Livestock Impact Vege	None	None	None	None	Minor	None	None	None
Livestock Impact Bank	None	None	None	None	Minor	None	None	None
Livestock Pugging	None	None	None	None	Major	Minor	None	None
Livestock Manure	None	None	None	None	None	None	None	None
LlivestockTracks	None	None	None	None	Minor	Minor	None	None
FORESHORE CONDITION								
Bank and Channel Shape								
Bank Shape	Stepped	Concave	Concave	Concave	Wide lower bench	Concave (LB), Convex (RB)	Wide lower bench	Stepped
Slope	Low (10-30%)	Flat (<10%)	Moderate (30-60%)	Low (10-30%)	Moderate (30-60%)	Low (10-30%) (RB), Steep (60-80%) (RB)	Flat (<10%)	Steep (60-80%)
Channel Shape	Flat	Flat (<10%)	Flat	Flat	Flat	U-Shaped	U-Shaped	Box

Appendix 4. Macroinvertebrates

Values are log10 abundance categories, where 1 = 1 individual, 2 = 2-10 individuals, 3 = 11-100, 4 = 101-1000, and so on.

Phylum/Class/ Order	Family	Lowest taxon	SGU1	SGU2	SGU3	SGU4	SGD1	SGD2	SGD3	SGD4
CNIDARIA										
Hydrozoa										
Anthoathecata	Hydridae	*Hydra* sp.	0	0	0	0	3	2	0	0
NEMATODA		*Nematoda* sp.	0	0	0	0	0	2	0	0
MOLLUSCA										
Bivalvia										
Veneroida	Sphaeriidae	*Musculium kendricki*	0	0	0	0	2	0	0	0
Gastropoda		*Gastropoda* sp. (imm/dam)	0	3	0	0	0	0	0	0
Hygrophila	Lymnaeidae	*Bullastra lessoni*	0	0	0	0	1	0	0	0
	Physidae	*Physella acuta*	3	2	4	4	4	0	2	0
	Planorbidae	*Bayardella* sp.	0	3	0	3	0	0	0	0
		Ferrissia petterdi	3	2	0	0	0	0	2	2
		Glyptophysa sp.	3	0	0	0	0	0	3	2
ANNELIDA										
Hirudinida										
Arhynchobdellida	Hirudinidae	*Hirudinidae* sp.	2	0	0	1	0	0	0	0
Oligochaeta		*Oligochaeta* sp.	1	2	4	3	3	2	3	3
ARTHROPODA										
Malacostraca										
Amphipoda		*Amphipoda* spp. (imm/dam)	0	2	0	3	2	2	0	0
	Chiltoniidae	*Austrochiltonia subtenuis*	4	2	4	3	2	2	4	3
	Perthiidae	*Perthia acutitelson*	3	0	0	0	0	0	3	3
ARACHNIDA										
Sarcoptiformes		*Acarina* spp. (imm/dam)	2	3	3	3	2	3	2	2
		Oribatida sp.	0	2	2	3	3	1	1	0
COLLEMBOLA										

Phylum/Class/ Order	Family	Lowest taxon	SGU1	SGU2	SGU3	SGU4	SGD1	SGD2	SGD3	SGD4
Entomobryomorpha		*Entomobryoidea* sp.	1	0	0	0	3	0	0	0
Poduromorpha		*Poduroidea* sp.	0	0	2	0	0	3	2	0
Symphypleona		*Symphypleona* sp.	0	0	0	0	0	0	3	0
INSECTA										
Diptera	Ceratopogonidae	*Ceratopogoninae* sp.	0	2	2	2	3	3	3	2
		Ceratopogonidae sp. (P)	0	2	0	1	2	1	0	2
		Dasyheleinae sp.	0	1	2	3	2	0	2	0
		Forcipomyiinae sp.	0	0	0	0	2	2	0	0
	Chironomidae	*Chironomidae* sp. (P)	2	1	1	2	2	1	2	3
	Chironomini	*Chironomus aff. alternans*	0	0	0	0	0	2	1	0
		Chironomus occidentalis	0	0	0	0	0	2	0	0
		Chironomus tepperi	1	0	0	0	0	0	0	0
		Dicrotendipes sp. (V47)	0	0	0	0	0	2	0	2
		Kiefferulus intertinctus	0	0	0	0	0	0	0	2
		Polypedilum nubifer	0	0	2	0	0	0	0	0
		Stenochironomus sp.	0	0	0	3	0	0	0	0
		Stenochironomus sp. 1	2	0	0	0	0	0	0	0
	Tanytarsini	*Cladotanytarsus* sp.	0	2	0	0	2	0	0	0
		Cladotanytarsus sp. (VSC12)	0	0	0	3	0	2	0	1
		Paratanytarsus sp.	0	0	0	0	1	0	0	0
		Rheotanytarsus underwoodi	0	0	0	0	2	3	0	0
		Tanytarsus sp. (V6)	4	4	4	3	2	3	3	3
	Orthocladiinae	*Corynoneura* sp. (V49)	4	4	2	3	0	0	0	0
		Corynoneura sp. (WWO5)	0	0	0	0	3	0	0	0
		Cricotopus parbicinctus	0	2	0	1	4	4	4	3
		Nanocladius sp. (VCD7)	0	0	2	2	0	0	0	0
		Parakiefferiella sp. (VCD2)	2	0	1	0	0	0	0	0
		Paralimnophyes pullulus (V42)	3	3	2	2	0	0	0	2
		Thienemanniella sp. (V19)	2	0	0	0	0	4	4	3
		Thienemanniella sp. (WWO4)	0	0	0	0	4	0	0	0

Phylum/Class/ Order	Family	Lowest taxon	SGU1	SGU2	SGU3	SGU4	SGD1	SGD2	SGD3	SGD4
	Tanypodinae	*Paramerina ?levidensis*	3	2	0	0	0	2	2	2
		Pentaneurini genus C	0	1	0	0	0	0	0	0
		Procladius paludicola	3	1	2	0	0	0	0	1
	Culicidae	*Culicidae* sp. (P)	1	0	0	0	0	0	0	0
		Anopheles sp.	2	0	1	0	0	1	0	0
		Culex sp.	2	1	0	0	0	0	0	0
	Dolichopodidae	*Dolichopodidae* sp.	0	0	0	0	2	1	0	0
	Empididae	*Empididae* sp.	0	0	0	0	2	0	1	1
	Ephydridae	*Ephydridae* sp.	0	0	0	0	1	2	0	0
	Muscidae	*Muscidae* sp.	0	0	0	0	1	0	0	0
	Psychodidae	*Psychodidae* sp.	0	0	2	0	0	0	0	0
	Sciomyzidae	*Sciomyzidae* sp.	0	0	0	0	2	0	0	0
	Simuliidae	*Simuliidae* sp.	0	0	0	3	3	4	4	3
		Simuliidae sp. (P)	0	0	0	0	0	1	0	2
	Syrphidae	*Syrphidae* sp.	0	0	0	1	0	0	1	0
	Tipulidae	*Tipulidae* sp.	0	0	0	0	2	1	1	1
Odonata										
Anisoptera		*Anisoptera* sp. (imm/dam)	0	0	0	0	1	0	0	0
	Gomphidae	*Austrogomphus collaris*	0	2	0	0	0	0	0	0
	Libellulidae	*Orthetrum caledonicum*	0	0	2	2	1	0	0	0
	Corduliidae	*Hemicordulia australiae*	0	0	1	1	0	0	0	0
		Hemicordulia tau	0	1	0	0	1	0	2	2
	Synthemistidae	*Archaeosynthemis leachii*	0	0	0	0	1	0	0	0
		Austroaeschna anacantha	0	0	0	0	3	3	0	3
Zygoptera		*Zygoptera* spp. (imm/dam)	0	2	2	0	0	0	2	0
	Coenagrionidae	*Ischnura heterosticta*	0	0	1	0	0	0	0	0
	Lestidae	*Austrolestes analis*	2	0	0	0	0	0	0	0
	Megapodagrionidae	*Archiargiolestes* sp.	0	0	0	0	0	0	0	1
Plecoptera	Gripopterygidae	*Newmanoperla exigua*	0	0	0	0	0	2	4	3
Trichoptera		*Trichoptera* sp. (imm/dam)	0	0	0	0	3	0	0	0
	Hydropsychidae	*Hydropsychidae* sp.	0	0	0	0	2	3	0	0

Phylum/Class/ Order	Family	Lowest taxon	SGU1	SGU2	SGU3	SGU4	SGD1	SGD2	SGD3	SGD4
		Cheumatopsyche sp. AV2	0	0	0	2	2	3	2	0
	Hydroptilidae	*Hydroptilidae* spp. (imm/dam)	0	2	0	0	2	0	0	0
		Hellyethira sp.	0	2	2	3	3	1	0	0
	Leptoceridae	*Leptoceridae* spp. (imm/dam)	2	0	2	2	3	2	0	1
		Notalina spira	0	0	2	1	1	0	0	0
		Notoperata ?tenax	0	0	0	0	2	1	0	0
		Oecetis sp.	0	0	0	1	0	0	0	0
		Triplectides australicus	0	0	1	0	0	0	0	1
		Triplectides australis	0	0	2	0	0	0	0	1
		Triplectides sp. AV21	1	0	0	0	0	0	0	0
Ephemeroptera	Baetidae	*Cloeon fluviatile*	0	0	2	2	2	0	0	0
	Caenidae	*Caenidae* sp. (imm/dam)	0	0	0	0	0	0	3	0
		Tasmanocoenis tillyardi	0	2	4	4	3	4	2	3
	Leptophlebiidae	*Leptophlebiidae* sp. (imm/dam)	0	0	1	0	0	0	0	0
		Atalophlebia sp. AV17	0	0	2	0	0	0	0	1
Hemiptera	Corixoidea	*Corixoidea* spp. (imm/dam)	2	1	2	2	1	1	0	0
	Gelastocoridae	*Nerthra turberculata*	0	2	0	0	0	0	0	0
	Micronectidae	*Micronecta* sp.	2	0	0	0	0	0	0	0
		Micronecta annae	2	0	0	0	0	0	0	0
	Nepidae	*Laccotrephes tristis*	0	1	0	1	0	0	0	0
		Ranatra dispar	2	0	0	0	0	0	0	0
	Notonectidae	*Notonectidae* sp. (imm/dam)	2	0	0	0	0	0	0	0
		Anisops hackeri	2	0	0	0	0	0	0	0
		Anisops sp.	1	0	0	0	0	0	0	0
	Veliidae	*Veliidae* spp. (imm/dam)	0	0	0	0	2	1	0	0
		Nesidovelia peramoena	0	0	0	0	1	0	0	0
Coleoptera	Dytiscidae	*Antiporus femoralis*	1	0	0	1	0	0	0	0
		Hydrovatus sp.	0	2	0	0	0	0	0	0
		Hyphydrus elegans	0	2	2	2	0	0	0	0
		Hyphydrus sp. (L)	0	0	2	2	0	0	0	0

Phylum/Class/ Order	Family	Lowest taxon	SGU1	SGU2	SGU3	SGU4	SGD1	SGD2	SGD3	SGD4
		Lancetes lanceolatus	1	0	0	0	0	0	0	0
		Limbodessus inornatus	2	0	0	0	0	0	0	0
		Limbodessus shuckardii	0	1	0	0	0	0	0	0
		Megaporus solidus	1	0	0	0	0	0	0	0
		Megaporus sp.	0	1	0	0	0	0	0	0
		Necterosoma darwini	2	0	0	1	0	0	0	0
		Necterosoma regulare	0	0	0	1	1	0	0	0
		Necterosoma sp. (L)	3	0	3	3	2	0	0	0
		Onychohydrus scutellaris	2	2	0	0	0	0	0	0
		Onychohydrus sp. (L)	1	0	0	0	0	0	0	0
		Platynectes decempunctatus var. polygrammus	0	0	0	0	0	0	0	1
		Platynectes sp. (L)	0	0	0	0	2	0	3	2
		Rhantus suturalis	1	0	0	0	0	0	0	0
		Sternopriscus browni	2	0	0	0	0	0	0	0
		Sternopriscus marginatus	0	0	0	0	0	2	0	0
		Sternopriscus sp. (L)	3	3	4	2	0	3	0	0
	Gyrinidae	*Aulonogyrus strigosus*	0	0	0	0	0	1	0	0
		Macrogyrus angustatus	0	1	0	0	0	0	0	0
		Macrogyrus sp. (L)	2	0	0	0	0	0	0	0
	Haliplidae	*Haliplus* sp. (L)	0	0	0	1	0	0	0	0
	Hydrochidae	*Hydrochus* sp.	2	0	0	0	0	0	0	0
	Hydrophilidae	*Berosus* sp. (L)	2	3	1	0	0	0	0	0
		Enochrus mastersii	0	0	0	0	1	0	0	0
		Helochares sp. (L)	1	0	0	0	0	0	0	0
		Limnoxenus zealandicus	0	1	0	0	1	0	0	0
		Limnoxenus zealandicus (L)	0	0	0	0	2	0	0	0
		Paracymus sp. (L)	0	0	0	0	0	2	0	0
	Scirtidae	*Scirtidae* sp. (L)	0	0	0	0	1	3	0	1
		Taxa richness	47	40	37	40	54	42	29	34

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