OB32 SURPLUS WATER - HOMESTEAD CREEK WETTING FRONT AQUATIC FAUNA SURVEY 2021

Prepared for:

BHP Western Australian Iron Ore

125 St Georges Terrace

Perth, WA, 6000

Prepared by:

Indo-Pacific Environmental Pty Ltd

PO BOX 191

Duncraig East, WA, 6023

Phone: (08) 9444 1422

Fax: (08) 9444 1466

ACN 120 114 365

Project ID: 21006

Document Control

Revision	Version	Author	Date	Reviewer	Date
A	Internal Draft	Emma Thillainath, Dean Thorburn	23-12-2021	Dean Thorburn	11-01-2022
B	Client Draft	Dean Thorburn	07-02-2022	Jared Leigh	28-02-2022
0	Final to Client	Dean Thorburn	21-03-2022	Jared Leigh	28-03-2022
1	Revision to Client	James Keleher, Dean Thorburn	19-07-2022	Jared Leigh	01-08-2022
2	Revision to Client	Dean Thorburn	18-08-2022	Jared Leigh	02-09-2022
3	Revision to Client	Dean Thorburn	05-09-2022	Jared Leigh	07-09-2022
4	Final to Client	Dean Thorburn	28-09-2022		

EXECUTIVE SUMMARY

BHP Western Australian Iron Ore commissioned Indo-Pacific Environmental to undertake a two-season field assessment of aquatic fauna and habitats occurring within Homestead Creek, and a limited number of survey sites in the Fortescue River main channel (located downstream of the confluence), which may be influenced by a potential wetting front associated with future discharges of excess mine water. Aquatic fauna surveys were undertaken between the 18th and 26th of May 2021 (wet season) and the 25th of October and the 1st of November 2021 (dry season). A broad suite of survey methods was employed at 11 survey sites during the wet season, however, the lack of surface water during the dry season meant the full suite of survey methods were only employed at seven survey sites.

The aquatic habitat in Homestead Creek was found to be highly ephemeral with a majority of that catchment drying rapidly after the cessation of rain. Five sites in Homestead Creek were found to contain surface water during the wet season with these sites being small remnant pools. In contrast, only one site (HC2) was found to contain surface water during the dry season survey. As Homestead Creek was dry at this time it was considered possible that HC2 was maintained by groundwater. On occasion, values of several water quality parameters measured as part of the assessment were found to be outside relevant Default Guideline Values outlined by the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2018) during both seasons. However, this result was consistent with water quality analysis undertaken during previous surveys of aquatic habitats in the Fortescue River catchment being a function of rainfall and flow events, land use and catchment geology. As part of the current assessment, one site within the Eastern Ridge recharge ponds (referred to as the water storage dam – WS1) located to the west of Ophthalmia Dam was included in the survey. Of note during the current study was the higher electrical conductivity measured at this site in both seasons. In addition, nitrate levels were also vastly higher in the water storage dam than elsewhere. Assessment of discharge water coming into WS1 was not assessed as part of the current study.

No range restricted or significant species were recorded from microinvertebrate, sediment rehydration or macroinvertebrate samples collected from Homestead Creek, Ophthalmia Dam or main channel Fortescue River during the current study. The majority of species were considered to be common having widespread distributions across Northern Australia, Australia or Australasia. Of note was the presence of a juvenile syncarid (*Atopobathynella* `sp. Biologic-PBAT041') belonging to the family Parabathynellidae recorded from surface water at HC5 during the wet season survey. An additional syncarid was also collected from the Fortescue River (PB1) from the hyporheic zone in the dry season. Syncarids are stygobitic/stygal crustaceans which are typical of groundwater habitats. These crustaceans have a cryptic distribution across the Pilbara region, and are rarely collected from surface water samples. In light of this, additional taxonomic investigation of the specimens may be considered beneficial to assist in determining the species historical distribution in the region.

Three native fish species, *Leiopotherapon unicolor* (Spangled Perch), *Melanotaenia australis* (Western Rainbowfish) and *Neosilurus hyrtlii* (Hyrtl's Tandan), were recorded at sites within Homestead Creek, as well as Ophthalmia Dam and survey sites in the main channel Fortescue River during both seasons.

Chelodina steindachneri (Steindachner's Snake-necked Turtle) was also captured in Ophthalmia Dam and the main channel Fortescue River during the wet season, though not in Homestead Creek. These native fish species have commonly been recorded throughout Australian inland waters, whilst *C. steindachneri* has been recorded throughout the Pilbara and Midwest region. All these species have broad distributions and are not afforded protection under the EPBC Act or BC Act. The introduced *Cherax quadricarinatus* (Redclaw Crayfish) was recorded in high abundance in Ophthalmia Dam, the water storage dam and the main channel Fortescue River. *Cherax quadricarinatus* has become rapidly established in the catchment in recent years.

Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

1 INTRODUCTION

1.1 Background

BHP Western Australian Iron Ore (BHP WAIO) commissioned Indo-Pacific Environmental (IPE) to undertake a two-season field assessment of aquatic fauna and habitats occurring within Homestead Creek, and a limited number of survey sites in the Fortescue River main channel located downstream of the confluence, which may be influenced by a potential wetting front resulting from mine water discharge from the Ore Body 32 (OB32) project area. The 'study area' was considered to encompass that section of Homestead Creek originating ~4 km north-east of Newman (in the East Pilbara region of Western Australia) to its confluence with the upper Fortescue River and subsequently downstream 55 km along the main channel (Figure 1). This area is comprised of active/non-active Geoscience tenure, mining operational areas and pastoral leases. While the original survey request from BHP WAIO did not include Ophthalmia Dam, subsequent discussions on the potential addition of a discharge pipeline from the OB32 project area into the western arm of Ophthalmia Dam resulted in the inclusion of a limited number of survey sites in the dam as part of the current scope. Historically, BHP WAIO has used Ophthalmia Dam for the management and storage of excess mine water from surrounding mining operations, with dam infrastructure and water volumes managed by the Non-Process Infrastructure (NPI) division. Therefore, BHP WAIO also requested the inclusion of a site in the Eastern Ridge recharge ponds (herein referred to as the water storage dam WS1) in the study area due to the fact this infrastructure may also be utilised for the management of discharge water resulting from OB32 mining activity.

The current assessment aimed to collect information on the ecological condition of the study area in order to guide relevant future environmental approvals or the management of operations within the region. In addition, the assessment aimed to provide baseline information upon which an annual monitoring program could be based by cataloguing the broad range of aquatic taxa and habitat presents.

1.2 Project Aims and Objectives

The aquatic fauna baseline assessment aimed to document the current ecological condition of Homestead Creek, the Fortescue River located immediately downstream of the confluence, and at a limited number of sites within Ophthalmia Dam. The specific objectives for the current assessment were to:

- Determine the presence or likely presence of listed or threatened aquatic species or ecological communities through the review of previous surveys and relevant databases;
- Systematically sample aquatic fauna in the wet and dry seasons in the study area, with priority given to aquatic fauna which is considered to be of 'significance';
- Conduct habitat and water quality assessments at each sampling location;
- Provide an inventory of aquatic taxa collected; and
- Report the conservation status of recorded aquatic fauna.

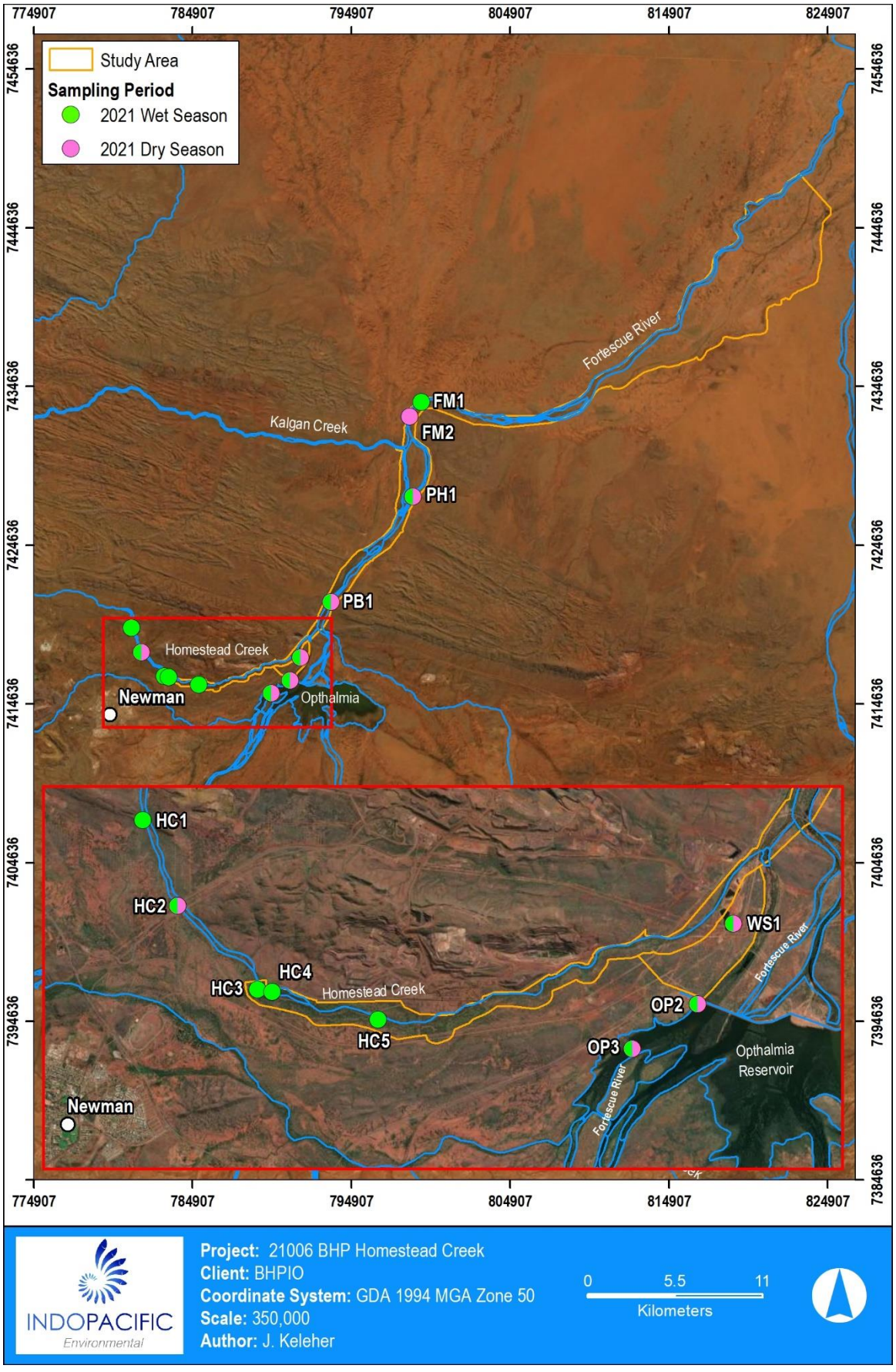


Figure 1. Extent of the study area and sites surveyed during the 2021 wet season and 2021 dry season.

2 METHODS

2.1 Guidance and Sampling Approach

The field surveys were undertaken in accordance with BHP WAIO procedures and considered relevant Environmental Protection Authority (EPA) documentation. In addition, survey methods and general sampling approaches were aligned with aspects of the following documents:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018);
- BHPBIO Biological Survey Spatial Data Requirements, Version 11.0 (SPR-IEN-EMS-015) (BHPBIO 2020);
- BHPBIO Aquatic Fauna Assessment Methods, Version 2.0 (0098594) (BHPBIO 2020);
- EPA Guidance No. 20, Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (EPA 2009);
- EPA Position Statement No. 3, Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002); and
- EPA Technical Guidance – Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA 2020).

2.2 Database Searches and Literature Review

Information attained from searches of relevant databases and the review of published and grey literature has been collated over recent years as part of previous surveys undertaken for BHP WAIO within the Fortescue River catchment. This information aims to identify whether aquatic fauna species or habitats of significance occurred, or were likely to occur, within the study area. To ensure this information remained up to date, database searches were again undertaken to ascertain aquatic fauna records within a 15 km to 20 km radius of the 70 km long study area. This included searches of the following:

- Protected Matters Search Tool (PMST) - Department of Agriculture, Water and the Environment (DAWE);
- NatureMap - Western Australian Government Department of Parks and Wildlife and Western Australian Museum;
- Freshwater Fish Distribution in Western Australia - Western Australian Government Department of Primary Industry and Regional Development (DPIRD) – Fisheries;
- Threatened and Priority Ecological Communities - Western Australian Government Department of Parks and Wildlife; and
- Threatened and Priority Fauna List - Western Australian Government Department of Parks and Wildlife.

A search was also undertaken to identify whether any new information relating to aquatic fauna occurring within the upper Fortescue River had arisen to ensure compiled records remained up to date. Information on the aquatic fauna occurring throughout the upper Fortescue River was attained from technical reports; books; journals; and relevant government, university and regulatory publications.

2.3 Licences

The field survey was conducted under a Section 7 Exemption (No. 2799) obtained from DPIRD - Fisheries per Section 7 (1) and (2) (e) of the *Fish Resources Management Act 1994* (FRM Act).

2.4 Sampling Team, Design and Locations

The Pilbara region has a semi-arid climate typified by a dry season (~July to November) and a wet season (~December to June) with highly variable rainfall, generally associated with cyclonic events and isolated thunderstorms (Sudmeyer 2016). To undertake the requested two-season field assessment, wet season sampling was conducted by Dr Dean Thorburn and Emma Thillainath between the 18th and 26th of May 2021 with dry season sampling conducted by the same field team between the 25th of October and the 1st of November 2021. These fieldtrips were concurrently undertaken with an existing scope of work assessing the aquatic fauna in the Fortescue River. Consistent surveys methodologies were employed for both studies and closely followed those outlined in the BHP WAIO 'Aquatic Fauna Assessment Methods' (Document number: 0098594).

To address the project objectives, sampling was undertaken at five sites along Homestead Creek where water was found to be present in May 2021, as well as one site in the Eastern Ridge recharge basins. While it was originally proposed that five sites be assessed in the Fortescue River downstream of the confluence with Homestead Creek, the inclusion of Ophthalmia Dam in the study area resulted in three sites being surveyed in the Fortescue River main channel and two sites within the dam. These 11 sites were selected due to the fact surface water was present at the time of the May survey. Indeed, the majority of Homestead Creek was already dry at this time despite some recent rainfall. While the intention was to resurvey these same sites during the late dry season, the highly ephemeral nature of this section of the Fortescue River and Homestead Creek meant that several of those sites were found to be dry upon return in October 2022. As such, only seven sites were found to contain surface water during the dry season survey, with only one of these sites being located in Homestead Creek (Table 1, Appendix 1). While water was present at FM1 during October, access to survey this site was not granted by surrounding mine tenure holders. As a result, a comparable site was established approximately one kilometre upstream (i.e. FM2). As such, these sites have been analysed and presented separately.

Table 1. Summary of sites surveyed during the 2021 wet season and 2021 dry season and the ecological components sampled (Sed. = sediment for rehydration, AQI = Aquatic invertebrates, AQVC = Aquatic vertebrates and crustaceans, Hab = habitat assessment and WQ = water quality).

Reach	Site	Site Code	Coordinates (UTM)			Samples Collected – Wet 2021					Samples Collected – Dry 2021				
			Zone	Easting	Northing	Sed.	AQI	AQVC	Hab.	WQ	Sed.	AQI	AQVC	Hab.	WQ
Homestead Creek	Homestead Creek 1	HC1	50	781082	7419421	✓	✓	✓	✓	✓	✓	No surface water present			
	Homestead Creek 2	HC2	50	781705	7417882	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Homestead Creek 3	HC3	50	783148	7416371	✓	✓	✓	✓	✓	✓	No surface water present			
	Homestead Creek 4	HC4	50	783405	7416331	✓	✓	✓	✓	✓	✓	No surface water present			
	Homestead Creek 5	HC5	50	785314	7415834	✓	✓	✓	✓	✓	✓	No surface water present			
Water Storage Dam	Water Storage Dam 1	WS1	50	791701	7417559	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ophthalmia Dam	Ophthalmia Dam 2	OP2	50	791061	7416115	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Ophthalmia Dam 3	OP3	50	789880	7415311	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fortescue River Downstream of Ophthalmia Dam	PB1	PB1	50	793627	7421050	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	PH1	PH1	50	798796	7427698	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Fortescue Mid 1	FM1	50	799331	7433652	✓	✓	✓	✓	✓	Inaccessible				
	Fortescue Mid 2	FM2	50	798603	7432739	Not visited					✓	✓	✓	✓	✓

2.5 Water Quality Assessment

When surface water was present, a range of physiochemical parameters were measured *in situ* using a portable hand-held Yellow Springs Instruments (YSI) field meter (Table 2). In addition, undisturbed water samples were collected for laboratory analysis per the Western Australian River Assessment System (AUSRIVAS) Sampling and Processing manual protocols (van Looij 2009). Water samples were kept on ice while in the field and refrigerated as soon as possible, before being transported to the NATA-accredited Australian Laboratory Services (ALS) in Perth, Western Australia. Water samples were subsequently analysed for a number of nutrient, anion and cation parameters. Water quality parameter values, for which Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018, ANZECC 2000) Default Guideline Values (DGVs) existed, were compared to values obtained from each site. For riverine sites, DGVs for lowland rivers in tropical Australia were adopted, whilst DGVs for Lakes, reservoirs and wetlands in tropical Australia were adopted for sites located within Ophthalmia Dam.

Table 2. Water quality parameters measured.

Physiochemical *in situ*	Laboratory Analysis	
pH (H^+)	Turbidity (NTU)	Hardness (as $CaCO_3$)
Temperature (°C)	Ammonia (N-NH_3)	Chloride (Cl)
Electrical conductivity (µS/cm)	Nitrogen oxides (N-NO_x)	Calcium (Ca)
Dissolved oxygen (%)	Nitrogen total (N-total)	Magnesium (Mg)
Dissolved oxygen (ppm)	Phosphorus total (P-total)	Sodium (Na)
Salinity (PSU)	Alkalinity (as $CaCO_3$)	Potassium (K)
	Total suspended solids (TSS)	

2.6 Qualitative Habitat Assessment

A qualitative habitat assessment was undertaken at all sites. This assessment was adapted from the Western Australia AUSRIVAS sampling and processing manual (van Looij 2009) and enabled consistent documentation of available instream habitat, substrate composition, bank structure and disturbances (Table 3). This information was incorporated into the Waters and Rivers Commissions habitat of rivers and creeks assessment (Water and Rivers Commission 2000) to rate the overall stream habitat of each site.

Table 3. Habitat characteristics recorded at each study site.

Site measurements	Habitat Area (% Cover)	Sediment Substrate (% Cover)	Disturbances (Ranked 0-3)
Habitat Type Site Length (m) Site Width (m) Depth (m) Velocity (cm/s)	Mineral Substrate Emergent Macro Submerged Macro Floating Macro Algal Cover Detritus Veg. draped in water Root mats Woody Debris >10cm	Bedrock Boulders (>256 mm) Cobbles (64-256 mm) Pebbles (16 - 64 mm) Gravel (4 - 16 mm) Sand (1 - 4 mm) (Silt (<1 mm) Clay	Pastoral Use Frequent Fire Mining Exploration Road/ Access Track Rubbish/ Litter Weed Invasion Other None Discernible Local Erosion

2.7 Sediment Collection and Rehydration of Invertebrates

At each sample site, regardless of whether water was present or not, at least 500 g of fluvial sediments was collected from the top 5-10 mm of the river or creek bed. Areas that appeared to have held water previously (i.e. indicated by a historic waterline and low elevation) with silty, fine sediments were targeted for collection. Samples were transported to the IPE laboratory, where 100 g of each sediment sample were rehydrated in a plastic container with 300 ml of deionised water. Rehydration occurred under controlled conditions, with the temperature maintained at 25ºC and a 12 hour light/12 hour dark light cycle implemented. Samples were examined for emerging fauna periodically for up to six weeks after rehydration. Emergent fauna collected were categorised and sent to Dr Russell Shiel (University of Adelaide) for additional identification to species level (where possible) under high-powered magnification. Abundances were recorded using a log10 abundance scale (i.e. 1 = 1 individual, 2 = 2 - 10 individuals, 3 = 11 – 100 individuals, 4 = 101-1,000 individuals, etc.) as outlined under the BHP WAIO aquatic fauna assessment methods document (0098594) and adapted from the Western Australia AUSRIVAS sampling and processing manual (van Looij 2009).

2.8 Microinvertebrate Fauna

Microinvertebrate samples were collected by gentle sweeping over an approximate 15 m distance with a 53 µm mesh plankton net. Samples were preserved in 70% ethanol and sent to Dr Russell Shiel (University of Adelaide) for identification and enumeration. The first 200-300 individuals obtained from an agitated sample decanted into a 125 mm^2 gridded plastic tray were identified to the lowest taxon possible. The tray was also scanned for additional taxa for identification and recorded as 'present'. This method is widely used and accepted (Shiel and Tan 2013; WRM 2009-2018) to determine the presence/absence of microcrustacean taxa in addition to determining the proportional microinvertebrate assemblage composition at each site.

2.9 Hyporheic Fauna

Hyporheic sampling was conducted using the Karaman-Chappuis method (Delamare Deboutteville 1960). A hole ~20 cm deep and 40 cm in diameter was dug in the dry stream bed adjacent to the water's edge and left to infiltrate with water. Soon after infiltration, the water column was swept with a modified 110 µm mesh plankton net, with a follow-up sweep once again after approximately 30 minutes. Samples were not collected from sites where consolidated clay was present, due to the fact water did not inundate the hole. Samples were preserved in 70% ethanol and transported to the Indo-Pacific Environmental laboratory for identification and enumeration. Extracted macroinvertebrate specimens were identified to the lowest taxon possible. Microinvertebrate specimens were sent to Dr Russell Shiel (University of Adelaide) for identification to the lowest taxon possible. All taxa recorded from hyporheic samples were categorised, based on habitat affinity, using the functional classifications of Boulton (2001).

2.10 Macroinvertebrate Fauna

In alignment with AUSRIVAS methodologies (van Looij 2009), macroinvertebrates were collected using a 250 µm sweep net over a 10 m sampling area. Edge habitats and riffle habitats (when present) were targeted separately at each site to maximise the diversity of taxa collected. Each sample was washed and decanted to remove fine sediment, while debris was washed by hand in a 250 µm sieve to remove attached macroinvertebrates, and then discarded. Samples were preserved in 70% ethanol and transported to the Indo-Pacific Environmental laboratory for identification and enumeration. Macroinvertebrate fauna were identified to the lowest possible level and enumerated using a log10 abundance scale (i.e. 1 = 1 individual, 2 = 2 - 10 individuals, 3 = 11 – 100 individuals, 4 = 101-1,000 individuals, etc.). This method of reporting abundances has been adapted from the Western Australia AUSRIVAS sampling and processing manual (van Looij 2009) and is widely used in aquatic fauna assessments.

2.11 Large Aquatic Fauna

To comprehensively assess larger aquatic fauna within the study area, a broad sampling regime was used to account for the variable nature of the habitat present and to ensure the recording of all aquatic species present. Survey methods used at each site are presented in Table 4 and included electrofishing equipment, fyke nets, seine nets, baited opera house traps and visual records.

2.11.1 Electrofishing

To gather data on the presence and abundance of cryptic species or sample complex habitats, electrofishing was conducted using a Smith-Root Model LR24 battery-powered backpack electrofisher. While electrofishing, current and voltage settings were adjusted with the aim of stunning fish only. When used, transects were electrofished with the distance of each determined by GPS, from which the density (fish per metre) was calculated. Stunned fish were kept alive in a bucket of freshly collected water to recover before being identified, measured and released.

2.11.2 Fyke Nets

A pair of fyke nets (one facing upstream and one facing downstream) was deployed overnight to capture the dawn, dusk and nocturnal movement periods of both highly mobile and cryptic aquatic species including fish, decapod crustaceans, turtles, and amphibians. Each fyke net was 11.2 m total width (comprising two 5 m wings and one 1.2 m wide mouth), had a depth of 0.8 m and a length of 5 m, and was comprised of 2 mm woven mesh. Each fyke net was set to fish the entire water column. The mouth of the net is held open by a rigid aluminium frame, which was secured in place with the use of star pickets. The wings of each net were secured to the nearest bank in order to channel fauna into the mouth of the fyke net. In order to minimise the risk of drowning amphibians and aquatic reptiles, the end of the net (the bunt) was tied up above the waterline.

2.11.3 Seine Nets

At each site where waters were easily navigable by foot, and relatively free of large debris, seine nets of five or 15 m lengths comprising of 2 mm woven mesh were used to targ*et* all species and juveniles. Up to four seine net replicates were conducted at each site. In general, seine nets were walked out from the shore, stretched parallel to shore and hauled shoreward. The area over which the seine net is hauled was estimated and used to subsequently calculate the abundance of fish captured per square meter.

2.11.4 Baited Opera House Trap

To target nocturnal and cryptic species, particularly decapod crustaceans, a baited opera house trap was deployed in close proximity to each fyke net site overnight. The entry size into each trap is restricted to exclude larger air-breathing fauna (e.g. turtles) and mitigate the risk of drowning fauna.

2.11.5 Identification and Measurement

All specimens captured during the survey were identified to species level and counted in the field. At each site, a sub-sample of each species was measured to the nearest millimetre as total length (TL) for fish, orbital carapace length (OCL) for crustaceans and straight-line carapace length (SCL) for turtles. All native species were released alive at the site of capture. However, introduced fish or crustacean species captured were euthanised in accordance with DPIRD-Fisheries exemption conditions by placement in ice slurry as per Barker *et al*. (2009).

Table 4. Summary of fauna collection methods utilised at each site within the study area sampled during the wet and dry season (Micro = microinvertebrate sampling, Hypo = hyporheic sampling, Macro = macroinvertebrate sampling, Sed = rehydration sediment collection, E. = electrofishing, F = fyke nets, S = seine net, T = opera house traps and V = visual records). * Denotes site which corresponding macroinvertebrate riffle sample was also collected.

Site Code	2021 Wet Season									2021 Dry Season								
	Sed	Micro	Hypo	Macro	E	F	S	T	V	Sed	Micro	Hypo	Macro	E	F	S	T	V
HC1	✓	✓	✓	✓		✓	✓	✓		✓	No Surface Water Present							
HC2	✓	✓	✓	✓	✓		✓			✓	✓	✓	✓			✓		✓
HC3	✓	✓	✓	✓		✓	✓	✓		✓	No Surface Water Present							
HC4	✓	✓	✓	✓						✓	No Surface Water Present							
HC5	✓	✓	✓	✓			✓			✓	No Surface Water Present							
WS1	✓	✓		✓		✓		✓		✓	✓		✓		✓		✓	
OP2	✓	✓		✓		✓		✓		✓	✓		✓		✓		✓	
OP3	✓	✓	✓	✓		✓		✓		✓	✓		✓		✓		✓	
PB1	✓	✓	✓	✓*	✓	✓		✓		✓	✓	✓	✓		✓		✓	
PH1	✓	✓	✓	✓*	✓	✓		✓		✓	✓	✓	✓		✓		✓	
FM1	✓	✓	✓	✓	✓	✓		✓		Inaccessible								
FM2	Not Visited									✓	✓	✓	✓		✓		✓	

2.12 Survey Limitations

The EPA (2020) outlines several potential limitations to fauna surveys. The current assessment provides a snapshot of water quality, habitat and faunal condition within the study area over a wet and dry season. While the assessment allows for a seasonal comparison, noting the dynamic and ephemeral nature of the system, temporal comparisons should consider influential factors outside the scope of this assessment (e.g. historic flows and external impacts from other operations).

With the identification of invertebrates, the total number of taxa recorded usually contains groups of taxa that cannot be taken to species level due to the absence of available and published taxonomic keys, damaged organisms or the maturity of some specimens. Therefore, the total number of taxa recorded during the current assessment will likely be marginally underestimated. Furthermore, results of hyporheic taxa categorised using the functional classifications of Boulton (2001) should be treated with a degree of caution as they are likely affected by available life history information, taxonomic resolution, and interpretation of classification categories. With respect to rehydrating sediments, caution must also be taken when interpreting results and making comparisons. This is due to the fact that not all taxa are likely to emerge during laboratory rehydration, as specific environmental cues are unable to be replicated under laboratory conditions. A complete summary of the survey limitations encountered during the current assessment are presented in Table 5.

Table 5. Survey limitations and constraints.

Limitation	Applicability to this survey
Availability of data and information	Taxonomy of aquatic fauna (macroinvertebrate fauna, fish etc.) throughout the region is relatively well documented, with a number of survey results and data available. While microinvertebrate fauna and taxonomic resolution remains a constraint of the current study to some degree, engagement of a taxonomic expert (Dr Russell Shiel) meant that relatively few taxa remained unidentified and as such this was considered a minor limitation.
Timing, weather and season	The timing of the wet season survey was adequate, with sampling in the wet season capturing wet season flows and discharge from Ophthalmia Dam. While flow was not present in Homestead Creek, remnant pools were present. Homestead Creek is highly ephemeral and likely to dry rapidly after the cessation of rain. As such sampling of the remnant pools was considered adequate and representative of wet season conditions. In relation to the dry season sampling in 2021, flow was present in the Fortescue River as a result of water being actively released from the Ophthalmia Dam by NPI. This section of the river would typically be dry, with some small remnant pools potentially remaining, and as such would not be considered typical of dry season conditions. Although the timing of the dry season sampling wasn't ideal to capture baseline conditions, releases from the dam are irregular, and represented similar conditions to the wet season in most Fortescue River main channel sites. No adverse weather was encountered in either season. These factors were considered to represent a minor limitation of the study, noting that dry season conditions in Homestead Creek and the Fortescue River would typically be dry.
The proportion of fauna identified/recorded/collected	An adequate snapshot of faunal assemblage composition across the study area was derived from the current assessment, with both cosmopolitan as well as regionally endemic species recorded from across the study area.

Limitation	Applicability to this survey
Access issues and remoteness	During the dry season, field personnel were unable to access certain sites (see Table 1) due to tenure and heritage restrictions, however alternative sites to complete the sampling design requirements were sampled in place of these inaccessible sites. The use of an appropriate alternative survey site was not considered to be a limitation of the current study.
Completeness of the survey	Both field surveys (wet season 2021 and dry season 2021) were completed, with a good spread of sites across both seasons being sampled successfully.

3 RESULTS AND DISCUSSION

3.1 Database Searches and Literature Review

Database searches for significant communities occurring within the vicinity of the study area identified one Threatened Ecological Community (TEC) (Figure 2). The TEC identified was the Ethel Gorge aquifer stygobiont community, which occurs within the southern section of the study area (DBCA 2021). This TEC is categorised as "endangered" and has been endorsed by the Western Australian (WA) Minister for Environment as the following WA criteria for TECs have been met (DEC 2013; DBCA 2018):

(B) Current distribution is limited

(ii) There are few occurrences, each of which is small and/or isolated and all or most occurrences are very vulnerable to known threatening processes.

While Ethel Gorge is known to support a diverse, locally endemic stygofauna community, there is no direct or indirect interaction with the study area.

The PMST and NatureMap Database searches found no records of aquatic vertebrates or larger invertebrate species of significance within the 70 km long study area or its vicinity (15 km to 20 km). A list of the aquatic fauna studies, identified during the literature review, which have been conducted in the waters of the upper Fortescue River and in the vicinity of the current study area and their key findings are provided in Table 6. Numerous studies have been undertaken within the upper Fortescue River, resulting in several Pilbara endemic taxa or potentially significant taxa (i.e. macroinvertebrate species which have limited geographical distribution or about which little is known) being recorded. Although *Leiopotherapon aheneus* (Fortescue Grunter), a significant species (listed as Priority 4), is known to occur within the Fortescue River catchment (Morgan *et al.* 2004, Morgan *et al.* 2014), it has not been recorded within the upper Fortescue River catchment or the study area despite numerous surveys occurring in the region (Table 6). As such, no aquatic fauna species of conservation significance afforded protection under either the Federal EPBC Act or Western Australian BC Act have been recorded within the upper Fortescue River or the study area.

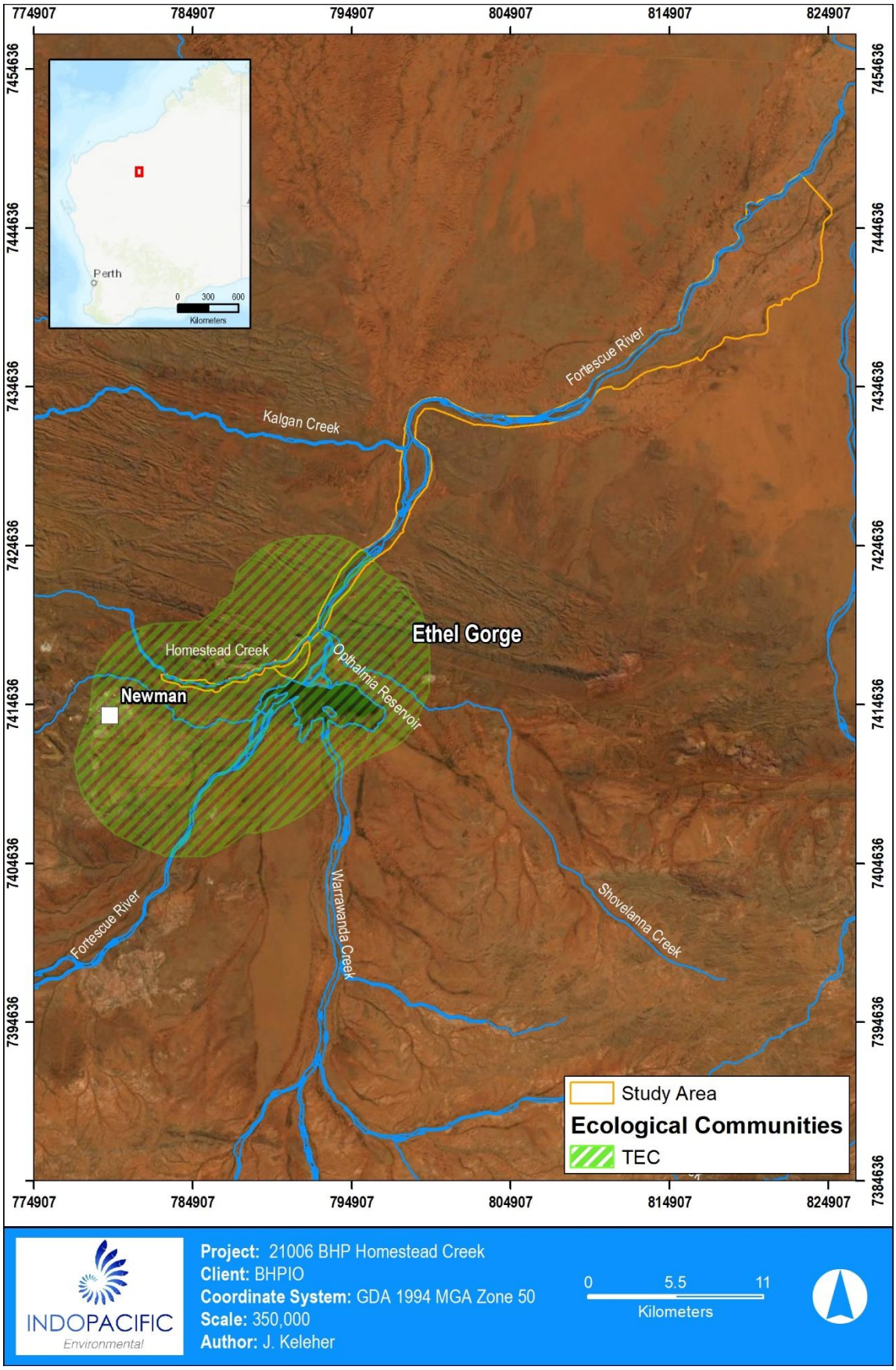


Figure 2. Extent of the study area in addition to identified Threatened Ecological Communities.

Table 6. Summary of publicly available aquatic fauna studies in Homestead Creek and the upper Fortescue River catchment, including aquatic vertebrate studies.

Reference	Survey name	Sites	Sampling Components	Seasonal Conditions	Key Biological findings	Significant / Restricted Fauna
Morgan and Gill (2004)	Fish fauna in inland waters of the Pilbara (Indian Ocean) Drainage Division of Western Australia — Evidence for three subprovinces.	16 sites on the Fortescue River with one site in the upper Fortescue	Water quality, fish	Between December 2000 and November 2002	Species diversity was higher within the lower reaches of the Fortescue River. The listed *Leiopotherapon aheneus* was only recorded from the lower reaches whilst two common species were recorded from the upper Fortescue site.	No conservation significant fauna was recorded in the upper reaches of the Fortescue River.
Streamtec (2004)	Aquatic Ecosystems of the Upper Fortescue River Catchment for BHP Billiton Iron Ore.	12 sites in the upper Fortescue River catchment	Water quality, aquatic invertebrates, fish, turtles	Dry season and wet season	125 macroinvertebrates, three fish species and one turtle species were recorded.	Two undescribed aquatic invertebrate species; *Boongurrus* sp. (dytiscid beetle) and *Haliplus* sp. (haliplid beetle).
WRM (2009)	Hope Downs 4 Aquatic Ecosystem Surveys Dry Season Sampling 2008.	24 sites in Coondiner Creek, Mindy Mindy Creek, Kalgan Creek	Water quality, aquatic invertebrates, fish	Dry season	Three fish species, 102 microinvertebrate taxa and 188 macroinvertebrate taxa.	*Nosostica pilbara (*Pilbara threadtail) is listed as a Priority 2, located ~35 NE of Ophthalmia Dam.
Pinder *et al*. (2010)	An Arid Zone Awash with Diversity: Patterns in the Distribution of Aquatic Invertebrates in the Pilbara Region of Western Australia.	100 waterbodies throughout the Pilbara region including Innawally Pool	Water quality, aquatic invertebrates, macrophytes	Autumn and spring with a few ephemeral sites sampled in late summer after flooding.	High diversity of invertebrate species (>1000), most of which were widespread.	Flowing springs (Millstream/Karijini National Parks), ephemeral wetlands (Fortescue Marsh) and freshwater claypans supported rare and/or restricted elements.
WRM (2011)	Yandicoogina: Aquatic Management Report. Unpublished report by Wetland Research and Management Iron Ore.	Desktop review of studies conducted throughout the Upper Fortescue catchment.	Water quality, aquatic invertebrates, fish	Dry season and wet season	27 microinvertebrate taxa, 115 macroinvertebrate taxa, three fish species and one turtle species recorded	No conservation significance species recorded.

Reference	Survey name	Sites	Sampling Components	Seasonal Conditions	Key Biological findings	Significant / Restricted Fauna
WRM (2013)	Baseline Aquatic Survey of the Fortescue Marsh Wet Season 2012.	11 sites within the Fortescue Marsh, three within the lower extent of the study area	Water quality, aquatic invertebrates, fish	wet season	Two fish species, 109 microinvertebrate and 98 macroinvertebrate taxa recorded. The majority of macroinvertebrates were common.	A limited number of potential conservation significant (at the time) microinvertebrates as only known from the Fortescue Marsh, however, none were listed.
Morgan *et al.* (2014)	Field Guide to the Freshwater Fishes of Western Australia's Pilbara Province.	Summation of publications and unpublished data of sites throughout the "Pilbara Province", including a number of sites on the Fortescue River		Dry season and wet season	16 native freshwater fish species are known from the "Pilbara Province", nine of which are endemic. Four introduced fish and three introduced freshwater crayfish are known from the "Pilbara Province".	No conservation significant species known for the upper Fortescue River.
MWH (2016)	Ophthalmia Dam Aquatic Fauna Survey Aquatic Ecology.	16 aquatic sites within Ophthalmia Dam and eight sites within the upper Fortescue River Catchment	Water quality, algae, macrophytes aquatic invertebrates, fish, frogs, turtles	Dry season and wet season	The total number of species recorded comprised 46 algae, nine macrophytes, 146 aquatic invertebrates, 27 hyporheic fauna, two fish, three frog and one turtle species.	Five potentially conservation significant aquatic invertebrate taxa were identified however rare or restricted elements of Pilbara invertebrate communities are typically associated with permanent springs, ephemeral wetlands and freshwater claypans.
Ecologia and Indo-Pacific Environmental (2017a)	Fortescue River Aquatic Fauna Survey BHPBIO.	Seven aquatic sites, including five downstream of Ophthalmia Dam and two upstream	Water quality, habitat characterisation, aquatic invertebrates, Fish, frogs, turtles.	Wet season only (March 2017)	A total of 1777 individual macroinvertebrates collected from 99 taxa, three native and one introduced fish species, two amphibians and a reptile were recorded.	No conservation significant or restricted fauna was recorded.

Reference	Survey name	Sites	Sampling Components	Seasonal Conditions	Key Biological findings	Significant / Restricted Fauna
Ecologia and Indo-Pacific Environmental (2017b)	Innawally Pool Aquatic Survey BHPBIO.	Seven aquatic sites, including five downstream of Ophthalmia Dam and two upstream	Water quality, habitat characterisation, aquatic invertebrates, fish, frogs, turtles	Dry season and wet season	A total of 4000 individual macroinvertebrates collected from 110 taxa, three native and one introduced fish species, three amphibians and a reptile were recorded.	No conservation significant or restricted fauna was recorded.
Pinder *et al*. (2017)	Wetland biodiversity patterning along the middle to upper Fortescue valley(Pilbara: Western Australia) to inform conservation planning.	Invertebrate sampling within the middle and upper Fortescue valley	Water quality, habitat characterisation, aquatic invertebrates	Dry season and wet season	No large aquatic fauna of conservation significance or introduced species were identified within the upper Fortescue. Notes a recent record an introduced freshwater crayfish (*Cherax quadricarinatus*) from a tributary of the lower Fortescue River (Weelumurra Creek).	No conservation significant species recorded.
WRM (2017)	Marillana Creek Aquatic Fauna Survey 2017.	One site on upper Fortescue, rest on other sub-catchments of the Fortescue marsh	Water quality, habitat characterisation, aquatic invertebrates, fish	Dry season and wet season	56 macro taxa identified and two native fish species.	No conservation significant species recorded although a stygal water mite recorded may be a potential SRE.
Indo-Pacific Environmental (2018)	Memorandum: Survey of the aquatic fauna in the Fortescue River and Ophthalmia Dam.	Five sites within the upper Fortescue River below Ophthalmia Dam and 24 sites within the Dam	Fish and aquatic fauna	Dry season conditions	Four fish, one turtle and one freshwater crayfish species were recorded. No conservation Significant species recorded. One introduced fish species (*Poecilia latipinna*) and one introduced freshwater crayfish	No conservation significant or restricted fauna was recorded during the survey.

Reference	Survey name	Sites	Sampling Components	Seasonal Conditions	Key Biological findings	Significant / Restricted Fauna
					(*Cherax quadricarinatus*) recorded.	
Thorburn *et al.* (2018)	Introduction of an alien fish species in the Pilbara region of Western Australia.	Nine sites on the Fortescue River and Warrawanda Creek	Fish and aquatic fauna	Dry season and wet season	One introduced fish species (*Poecilia latipinna*) was recorded.	No conservation significant species recorded.
Indo-Pacific Environmental (2019)	Sailfin Molly eDNA survey of the Fortescue River and its tributaries, 2019.	Samples were collected from seven known Permanent or semi-permanent pools on the Fortescue River and its tributaries between Ophthalmia Dam and the headwaters of the Fortescue Marsh	Fish and aquatic fauna	Dry season	Native species recorded included three fish, one amphibian and one turtle species. One introduced fish and one freshwater crayfish species was recorded. In addition, five genera of macroinvertebrates were recorded.	No conservation significant species recorded.
Indo-Pacific Environmental (2021)	Fortescue River Aquatic Fauna Survey 2020-2021.	Twenty two sites surveyed in the upper Fortescue River catchment in both the wet and dry season	Fish and aquatic fauna	Dry season and wet season	Native species recorded included three fish, one amphibian and one turtle species. One introduced fish and one freshwater crayfish species was recorded. IN addition, 102 microinvertebrate, 107 hyporheic and 167 macroinvertebrate taxa were identified.	No conservation significant species recorded. Two cladoceran taxa may be new to science and three macroinvertebrate species were Pilbara endemic species.

3.2 Water Quality

3.2.1 Surface Water

Aquatic habitat in Homestead Creek and the upper Fortescue River was found to be highly ephemeral with a majority of the catchment rapidly drying after the cessation of rain and with relatively few semi-permanent pools remaining. In relation to Homestead Creek specifically, five sites within the study area were found to contain surface water during the wet season survey with these sites being small remnant pools and with the majority of the Homestead Creek being dry. Only one site (HC2) was found to contain surface water during the dry season survey. As Homestead Creek was dry at this time, it was considered possible that HC2 was maintained by groundwater. Although the upper Fortescue River channel would typically be dry in October and November, flow was present within the study area during the dry season survey as a result of the controlled release of water from Ophthalmia Dam. As a result, three sites were surveyed in both seasons in the main channel Fortescue River.

3.2.2 Electrical Conductivity

Electrical conductivity (EC) values were found to be higher at the majority of sites during the dry season in comparison to wet season results. This result is typical of rivers of northern Australia, with higher EC concentrations being the result of evapoconcentration as pools contract. During the wet season, sites within each reach remain broadly consistent, with the exception of HC2 which was found to have a higher EC than the remaining sites within the Homestead Creek reach. The EC at all Fortescue River sites downstream of Ophthalmia Dam and HC2 were found to exceed the ANZG (2018) DGV for lowland rivers in both seasons. The DGV for conductivity for lakes, reservoirs and wetlands was also exceeded at WS1 in both seasons (Figure 3 and Appendix 2). The highest EC was recorded at WS1 in both the wet and dry season being 1188 and 1175 µS/cm, respectively. Site WS1 is the collection and storage point for mine discharge waters. The elevated EC at WS1 is likely a factor of evapoconcentration as flushing and dilution from rainwater would be limited. Despite the elevated EC at WS1, an EC below 3800 µS/cm is classified as freshwater (Pusey *et al*. 2004), and it is generally accepted that freshwater ecosystems experience little ecological stress when the EC is below 1500 µS/cm (Hart *et al.* 1991; Horrigan *et al.* 2005; Butler 2008).

3.2.3 Dissolved Oxygen

Dissolved oxygen percentage saturation (DO%) varied between sites and season. Wet season results ranged from between 70.6% (FM1) to 102% (HC5), and dry season results ranged from 38.6% (OP2) to 98.4% (PH1). Variation in DO% is driven by a number of factors including the time of day water is sampled, the waterbody surface area, the density of aquatic vegetation, fauna presence, organic matter load, flow and depth which leads to stratification. Results measured during the current study were consistent with previous results from the Fortescue River and no measured result suggested the need for further investigation. While the DO% was below the DGVs at most of the sites during both seasons (Figure 3), it should be remembered that the ANZG DGVs are single values for use on aquatic systems throughout

northern Australia which incorporates a range of climatic conditions, flow regimes and freshwater habitats (i.e. they are not specific to the Pilbara region). As such, these results were not considered atypical of waters bodies in the Pilbara region. Despite some sites having lower DO%, detrimental effects to aquatic biota does not occur until DO% is less than 50% for an extended period (Butler *et al.* 1970; Connolly *et al.* 2004; EIFAC 1973; Flint *et al.* 2015). While the DO% at OP2 in the dry season was found to be 38.6%, this site was located in Ophthalmia Dam which is an expansive water body and numerous fish were captured at this location indicating the sites suitability for fauna (Figure 3, Appendix 2).

3.2.4 pH

The pH at the majority of sites within Ophthalmia Dam and Homestead Creek were relatively consistent during the wet season, ranging from 7.16 to 8.30. Similar results for the dry season were recorded from Ophthalmia Dam and Homestead Creek, however, sites downstream of Ophthalmia Dam were seen to have slightly higher values (i.e. PB1, PH1 and FM2). pH at a number of sites was seen to be above the DGV, however, this is likely a result of the hard alkaline red soils present in the area (Eliot *et al*. 2013). Overall results are comparable to studies that occur within the region which range from 7.0 to 10.2 (Pinder *et al.* 2010) and did not appear to have detrimental effects towards aquatic organisms.

3.2.5 Turbidity

The results for turbidity from all sites during both seasons were below detection limits (<15 NTU) with the exception of OP2 in the wet season, which recorded 90 NTU (Figure 3, Appendix 2). Turbidity is likely to be higher during wet season months which is attributed to the influx of rainwater runoff and flow which would have suspended fine particulate matter. This is supported by the fact that all dry season results were below reporting limits for turbidity due to lack of water flow and mixing which would cause fine particulate matter to settle out.

3.2.6 Nutrients

Results for nitrate as nitrogen (N_NOx), total nitrogen (TN) and total phosphorous (TP) concentrations varied between sites (Figure 4, Appendix 2) with several sites exceeding the DGVs during both the wet season and dry season. Elevated nutrient concentrations have been previously observed in the region, particularly when livestock are present. Additionally, permanent water sources can attract high densities of birds which can generate additional nutrient input. While a greater number of exceedances of the DGVs were observed in the dry season, this is likely the result of evapoconcentration of nutrients as water bodies retract.

Of note during the current study were the vastly higher concentrations of N_NOx and TN recorded at WS1 from both seasons in comparison to all other survey sites. Discharge water coming into WS1 was not assessed as part of the current study, nor is its specific origin known. While elevated nitrogen concentrations such as those observed are often associated with run-off containing fertilisers, the fact that TP values are low indicates that this is not the case in this instance. As such, the source of nitrogen in water being discharged to WS1 is unclear.

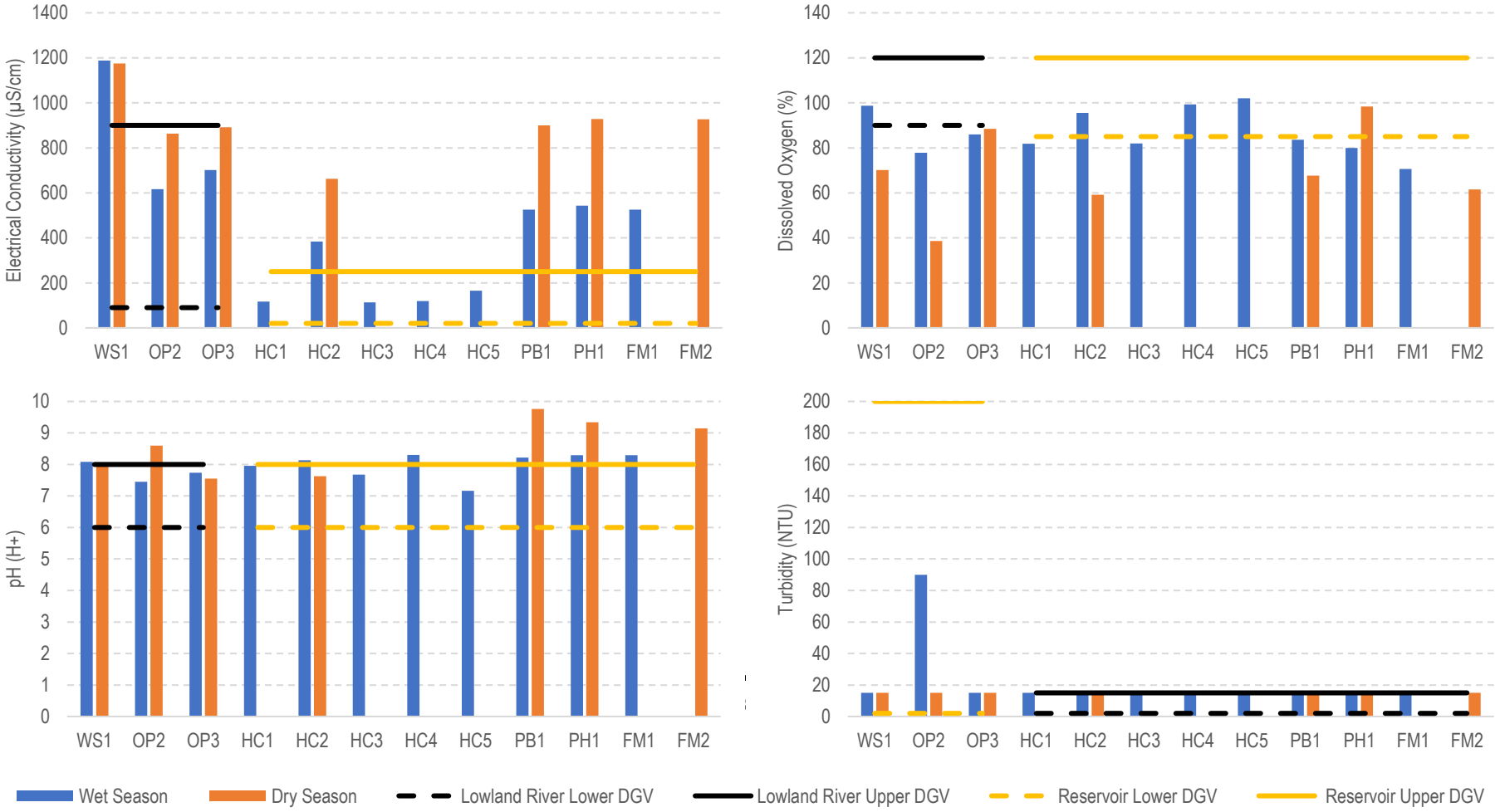


Figure 3. Electrical conductivity (µS/cm), dissolved oxygen (%), pH (H+) and turbidity (NTU) values recorded from sites surveyed within the study area during the wet and dry seasons. Corresponding tropical Australia Default Guideline Values (DGV) from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) are also displayed. N.B. In instances where a value is missing, the site was either dry or inaccessible at the time of the survey.

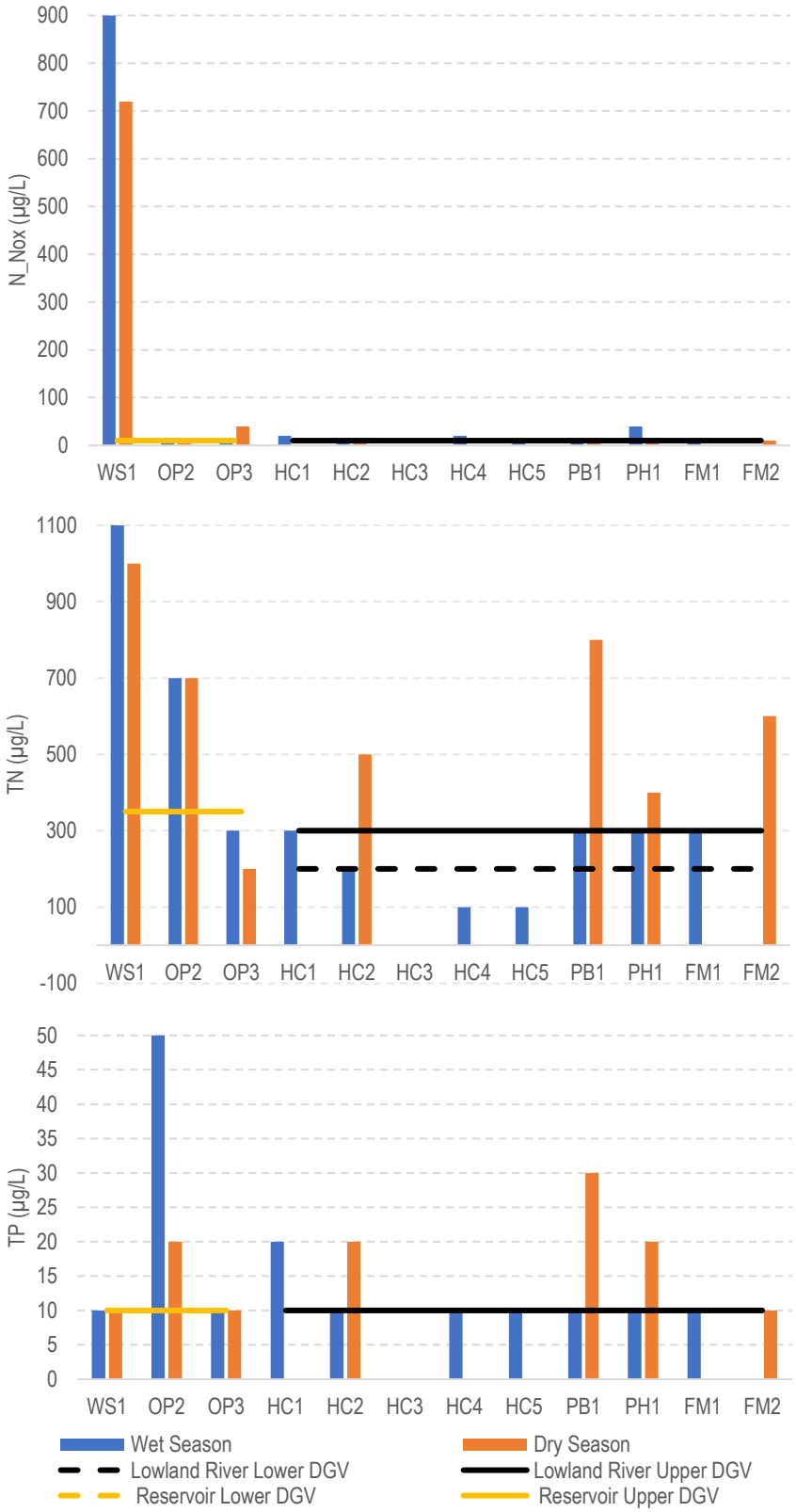


Figure 4. Nutrient concentrations (µg/L) recorded from sites surveyed within the study area during the wet and dry seasons. Corresponding tropical Australia Default Guideline Values (DGV) from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) are also displayed.

3.3 In-stream Habitat Characterisation

Most sites surveyed along Homestead Creek in 2021 largely consisted of gravel channels overlaying bedrock and clay, with sites sampled within Ophthalmia Dam (OP2 and OP3) dominated by silt and clay substrates, and subsequent sites sampled along Fortescue River downstream of Ophthalmia dam characterised by sandy gravel runs (Appendix 3). In-stream structure cover such as submerged and emergent macrophyte, algal cover and root mat cover were all higher at sites during the 2021 wet season, likely due to the recent water releases from Ophthalmia Dam prior to sampling in October 2021 (dry season). These releases inundated likely dry Fortescue River sites (i.e. PH1, PB1 and FM2) and contributing to the higher cover of displaced mineral substrates and detritus at these sites during the dry season (Figure 5). Land use was generally considered to be pastoral due to the presence of cattle or the effects of cattle being observed at most sites.

Based on the method outlined by the Water and Rivers Commission (2000), the majority of sites along Homestead Creek were considered to have a poor rating due to the lack of available in-stream habitat and variability in flow, generally with narrow riparian zones consisting of *Eucalyptus* spp. and invading grasses (Table 7). These sites were also dominantly artificial, lacking instream structure and flat, or heavily impacted by cattle resulting in absence of river bank structure and instream vegetation. Most reference sites along the Fortescue River were considered moderate to good due to the diversity of available habitat and native vegetation, despite the observation of pastoral use.

None of the habitats identified were considered unique in comparison to those that commonly occur throughout the wider region. However, those that retained water throughout the year could be considered key aquatic fauna habitats for species that require permanent water, providing refuge during the dry season and allowing them to persist within the region.

Table 7. The stream habitat rating of each site during the 2021 wet and dry season surveys derived using the Waters and Rivers Commissions habitat of rivers and creeks assessment (Water and Rivers Commission 2000, Appendix A). Definitions of ratings are provided below. N.B. sites that were dry or inaccessible during the season are highlighted grey.

Site Code	2021 Wet Season						2021 Dry Season					
	Emergent Veg.	Mid and Upper Bank Veg.	In-stream habitat	Flow Conditions	STREAM HABITAT RATING		Emergent Veg.	Mid and Upper Bank Veg.	In - stream habitat	Flow Conditions	STREAM HABITAT RATING	
HC1	1	3	2	2	8	Poor						
HC2	1	2	2	2	7	Poor	1	2	2	2	7	Poor
HC3	1	2	2	2	7	Poor						
HC4	2	1	2	2	7	Poor						
HC5	2	1	2	1	6	Very Poor						
WS1	1	1	3	2	7	Poor	1	1	3	2	7	Poor
OP2	3	3	4	2	12	Moderate	3	4	4	2	13	Moderate
OP3	2	3	2	2	9	Poor	3	3	3	2	11	Moderate
PB1	3	4	2	4	13	Moderate	4	4	4	4	16	Good
PH1	3	4	3	4	14	Good	4	4	3	3	14	Good
FM1	2	4	3	3	12	Moderate						
FM2							3	4	2	3	12	Moderate

Definitions

Score	*Rating*	*Condition*
17 - 20	*Excellent*	*Site in virtually natural condition with excellent habitat value*
14 - 16	*Good*	*Site is in natural condition with some weed invasion, localised disturbance or habitat infilling/sedimentation*
10 - 13	*Moderate*	*Some alteration from the natural state, moderate habitat value*
7 - 9	*Poor*	*Significant alterations from the natural state, reduced habitat value*
4 - 6	*Very Poor*	*Very degraded. Little available habitat*

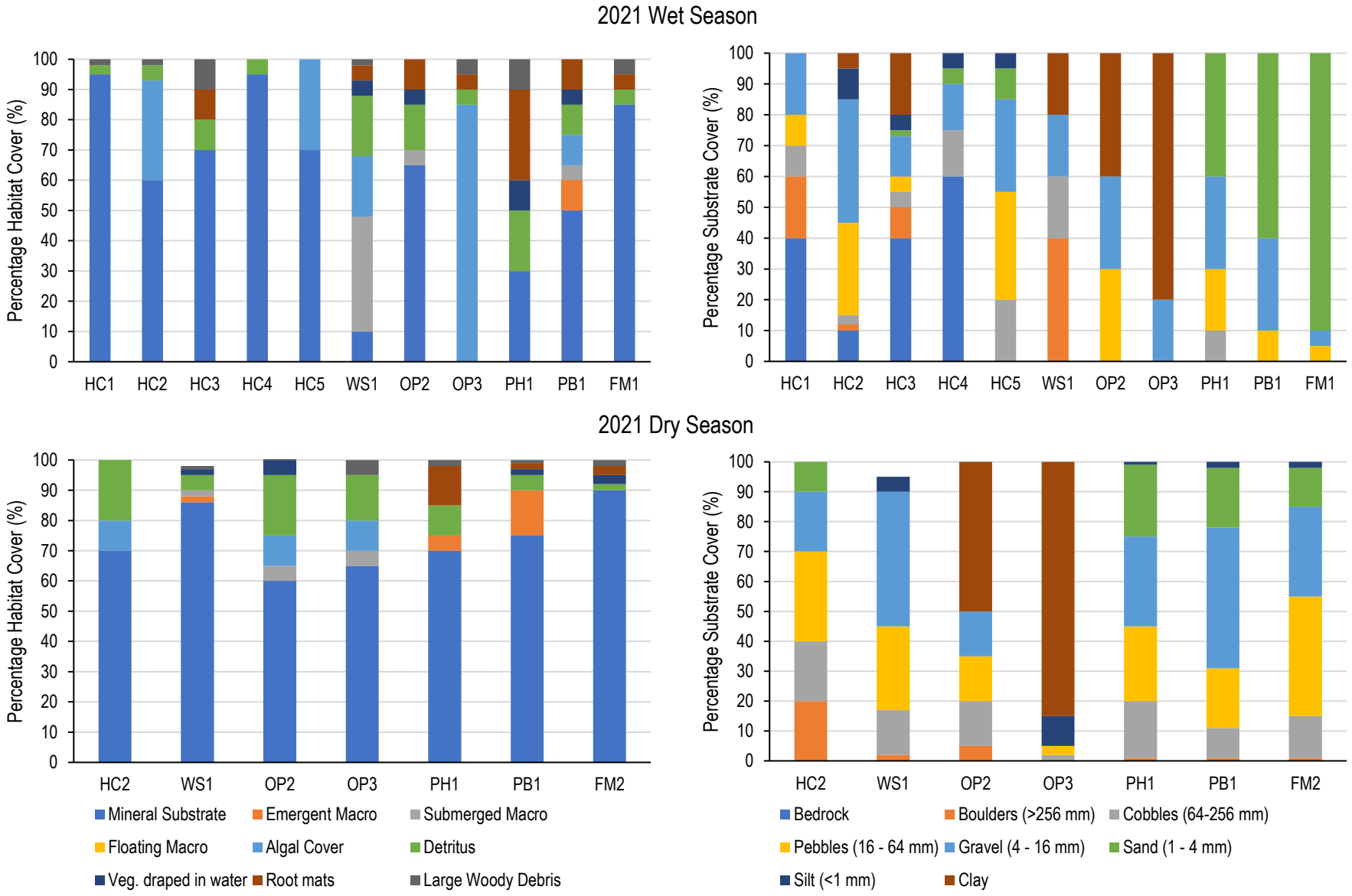


Figure 5. Plots of habitat compositions (left column) and substrate compositions (right column) showing percentage cover (%) at each site.

3.4 Microinvertebrate Fauna

3.4.1 Taxonomic Composition

Microinvertebrate fauna were collected from all 11 sites in the wet season and seven in the dry season sites (where surface water was present). A total of 72 and 44 microinvertebrate taxa were recorded during the wet and dry seasons, respectively (Table 8). The difference in diversity between seasons is highly likely to be attributable to the lower number of sites sampled in the dry season. Appendix 4 indicates that on occasion, some individuals could not be identified to species level due to unresolved taxonomy or being at varying stages of maturity. These have been treated as separate taxa as they could be representative of additional species. However, as this occurred on relatively few occasions, the diversity reported is considered close to actual.

Table 8. Major microinvertebrate groups recorded from the study area during the wet and dry seasons.

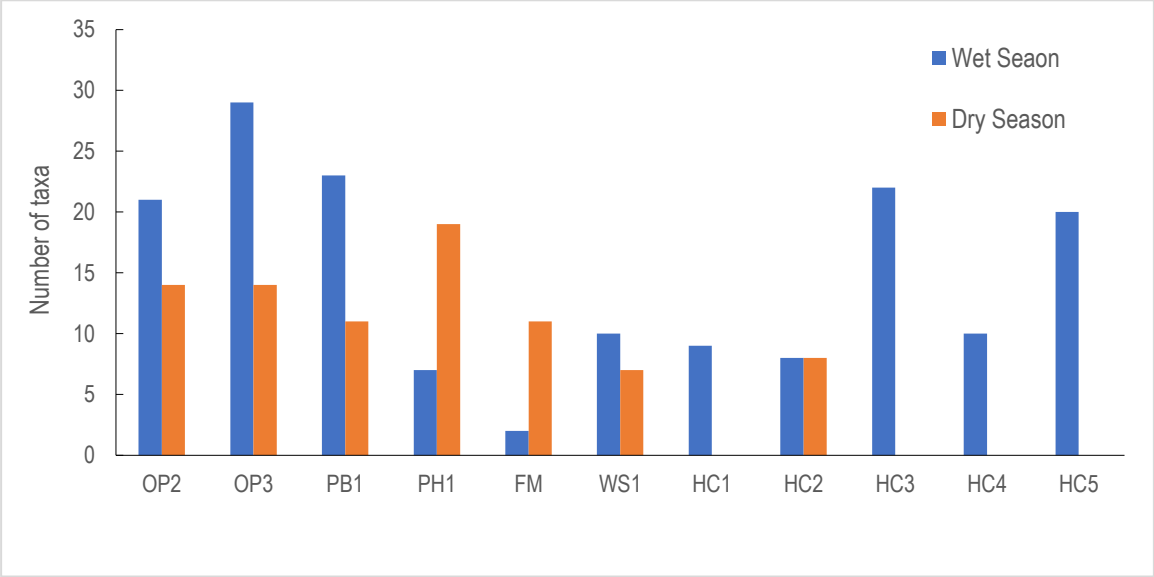
Major Group	Wet	Dry
Protista	14	6
Rotifera	30	16
Cladocera	14	10
Copepods	8	7
Ostracods	6	5
Total number of taxa	72	44

Microinvertebrate taxa richness was highest from site OP3 located in Ophthalmia Dam in the wet season, whilst the highest number of taxa were recorded from PH1 in the main channel of the Fortescue River in the dry season (Figure 6). In relation to Homestead Creek, the range in the number of taxa present in the wet season was comparable to the range in the number of taxa from other sites sampled. Taxa diversity at HC3 and HC5 were amongst the highest number of taxa recorded during the study indicating that ephemeral habitats provide equally important habitat for microinvertebrate taxa diversity as sites which hold permanent water such as those within Ophthalmia Dam. Of interest was the fact PH1 and FM2 recorded higher numbers of microinvertebrate taxa during the dry season sampling. As aforementioned, the release of water from Ophthalmia Dam had begun in the weeks prior to the survey being undertaken. As such, this may reflect the boom-and-bust strategy employed by microinvertebrate taxa occurring in the region and response to the presence of water after a period of dry channel. In addition, flow originally upstream from Ophthalmia Dam prior the sampling period may have resulted in microcrustacean fauna being carried from sites immediately downstream of the dam (where permanent water is known to occur), which has been a well-documented occurrence in the available literature (Richardson 1992; Lair 2006, Godfrey et al. 2020).

The microinvertebrate fauna collected during the current study was made up of all major groups collected during other recent studies of the Fortescue River (Indo-Pacific Environmental 2021) including Protista (Tubulinea and Spirotrichea), Rotifera (Bdelloidea and Monogononta), Cladocera (Branchiopoda), Copepoda (Maxillopoda) and Ostracoda (Table 8, Appendix 4). The suite encountered was considered

typical of tropical systems across the world, with members of Lecanidae and Brachionidae dominating the Rotifera, and members of the Chydoridae and Daphniidae prominent within Cladocera (e.g. Koste and Shiel 1983, Tait *et al.* 1984, Smirnov and De Meester 1996, Segers *et al*. 2004). Copedods were also amongst the most abundant taxa present.

Figure 6. The total number of microinvertebrate taxa recorded (taxa richness) from each site sampled during the wet and dry season surveys. Sites containing no taxa in the dry season were not sampled due to a lack of surface water.



3.4.2 Scientific significance of microinvertebrate fauna

In general, the microinvertebrate taxa recorded during the current study were common species with most taxa having distributions which extend throughout Australasia. While no species of significance were recorded during the current study, several noteworthy taxa were identified. For example, *Anthalona harti* was recorded from PB1 and WS1 during the wet season. This genus has not been formally recorded from Australia, with the species described from specimens collected in South Africa. The rotifer *Lecane* 'bulloid' was also recorded from a number of sites during the current season and in both seasons (Appendix 4). This is an undescribed species that has previously been recorded from the wider area and from the nearby Marillana and Weeli Wolli Creek systems. It is one of a species of complex of lecanids of similar morphology to *Lecane noobijupi*, but is of considerable size, being larger than *L. bulla* (Dr Hendrik Segers, Royal Belgian Institute of Natural Sciences, pers. comm.). Genetics is required to elucidate species within this complex. Currently, the 'bulloid' morphotype is known only from Western Australia.

3.5 Hyporheic Fauna

3.5.1 Taxonomic Composition

Fifty-nine and 47 hyporheic taxa were collected from the nine and four sites sampled during the wet and dry season, respectively (Table 4, Appendix 5). The presence of clay and rock substrates, in addition to the absence of any hyporheic zone at a number of sites during the dry season, resulted in some sites remaining unsampled. Of interest during the current study was the fact that overall diversity within the samples collected was higher during the dry season survey than the wet season survey (i.e. 20 to 27 species per site in the dry season cf. two to 18 species per site in the wet season) (Figure 7). This was also the case when considering the functional hyporheic categories of Boulton (2001) whereby each site sampled in the dry season had eight to thirteen species of hyporheos fauna whereas sites during the wet season were seen to have between two and eight species. Approximately 64% of the hyporheic taxa recorded during both seasons were stygoxene taxa (i.e. which reside for only part of their life in subterranean habitats) which lacking specialised adaptations for groundwater habitats. In relation to Homestead Creek, diversity was seen to be lowest at HC3, and to some extent HC4, during the wet season in comparison to other sites in Homestead Creek and elsewhere. HC2 was found to be the only site holding surface water in Homestead Creek during the dry season. Diversity at this site was comparable to the other sites sampled at that time. As discussed above, it is speculated that HC2 is supplemented by ground water. Considering hyporheic fauna only (as per Bouton 2001), a comparable number of species was found at HC2 as was found at sites surveyed in the main channel of the Fortescue River at that time. This provides some support to the presence of groundwater at HC2.

3.5.1 Scientific significance of hyporheic fauna

No range-restricted or significant species were recorded from hyporheic samples collected from Homestead Creek during the current assessment. However, some specimens collected from the broader survey area may be representative of species that are relatively new to science or endemic to the region. For the stygobitic species recorded, only *Parastenocaris jane* is considered to be a Pilbara endemic, however, it is widespread throughout the region (Bennelongia 2013, WRM 2018). Furthermore, *Candonopsis cf. tenuis* and *Vestalenula marmonieri* have been recorded across Australia and the Oceania region respectively (Halse *et al.* 2002). The occasional hyporheos stygophiles *Microcyclops varicans* and *Mesocyclops brooksi* have an Australian wide distribution (Halse *et al.* 2002), whilst *Karualona karua* has a pantropical distribution (Doan Dang *et al*. 2015). A single syncarid from the family Parabathynellidae was recorded from the Fortescue River (PB1) during the dry season survey. Syncarids are stygobitic/stygal crustaceans which are typical of groundwater habitats and are known to have cryptic distributions in the Pilbara region. Noting PB1 would trypically be dry in October/November, water released from Opthalmia Dam at the time of the survey, resulted in surface water flow being present. As a result, the presence of this specimen in the hyporheic zone at this time of year may be the result of recent surface water flows resulting in some connection with groundwater at the site.

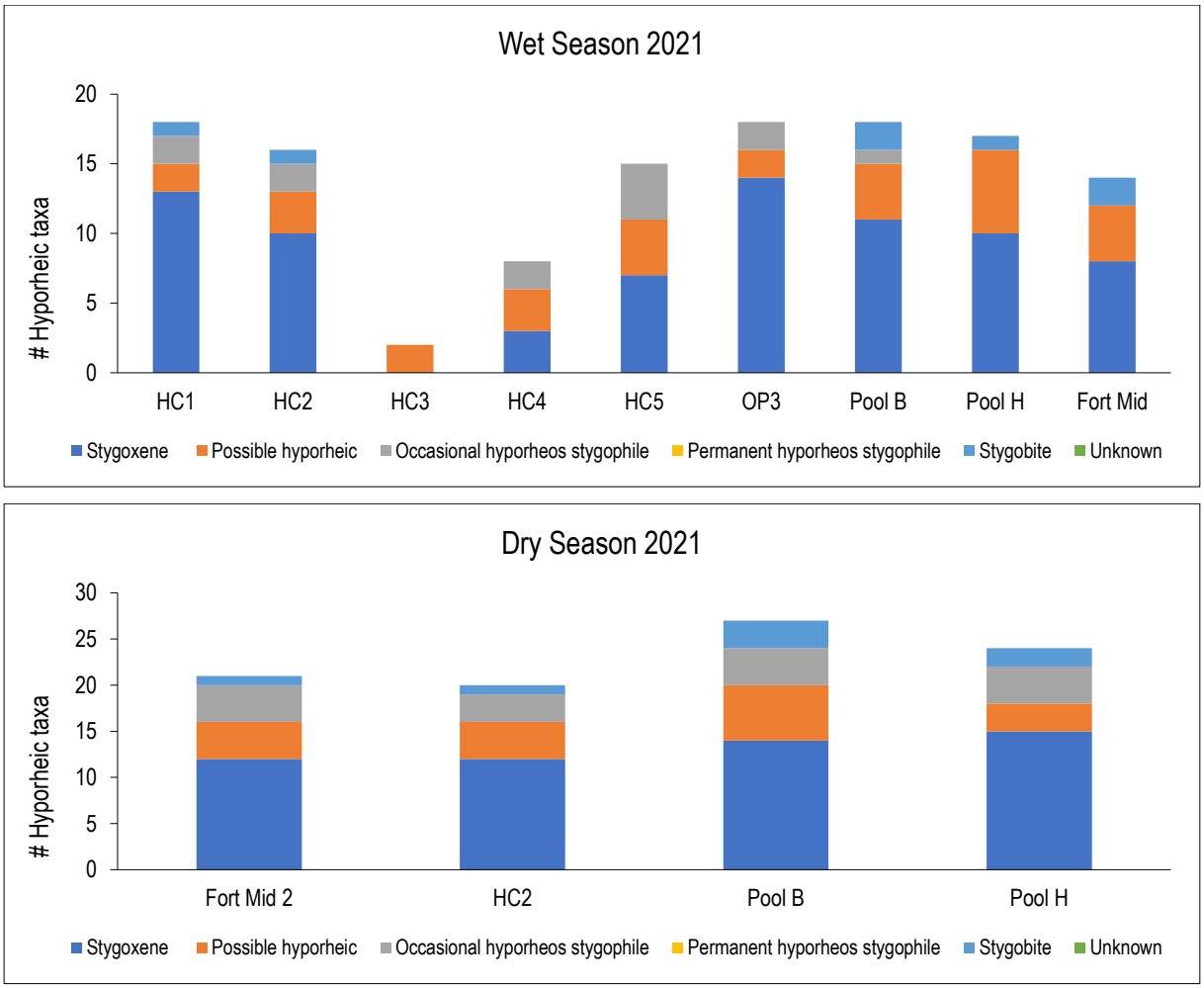


Figure 7. Taxonomic composition of hyporheic fauna recorded from each site during the wet and dry season surveys as categorised using Boulton's (2001) hyporheic categories.

3.6 Macroinvertebrate Fauna

3.6.1 Taxonomic Composition

One hundred and twenty three macroinvetebrate taxa were recorded during the wet season, whilst 101 taxa were recorded during the dry season (Appendix 6). The highest macroinvertebrate taxa richness was recorded from PH1 during the 2021 wet season, where 58 taxa were recorded (Figure 8). In contrast, the lowest taxa richness of 25 was recorded from WS1 during the 2021 dry season.

Taxonomic composition during 2021 (wet season and dry season) was generally comparable, despite the absence of surface water at most sites along Homestead Creek during the dry season (Figure 8). During both seasons, macroinvertebrate taxa were dominated by the class Insecta, which represented 83.5% and 84.8% of taxa recorded during the wet and dry season respectively (Figure 9). The most diverse group within the class Insecta was Coleoptera (aquatic beetles) (34% of Insecta during the wet season and 33.7% during the dry season) followed by Hemiptera (true bugs) during the wet season (21.7% of Insecta during the wet season) and both Hemiptera and Diptera during the dry season (19.1% respectively during the dry season) (Figure 9). As such, taxa recorded comprised of Mollusca (aquatic snails),

Oligochaeta (aquatic worms), Acarina (aquatic mites), Cnidaria (hydra), Platyhelminthes (aquatic flatworms), Nematoda (aquatic roundworms), Entognatha (springtails), Crustacea (syncarida and crayfish), Odonata (dragonfly and damselfly larvae), Ephemeroptera (mayfly larvae), Hemiptera (true bugs), Coleoptera (aquatic beetles), Diptera (true fly larvae), Lepidoptera (moth larvae), Thysanoptera (thrip) and Trichoptera (caddisfly larvae) (Figure 10).

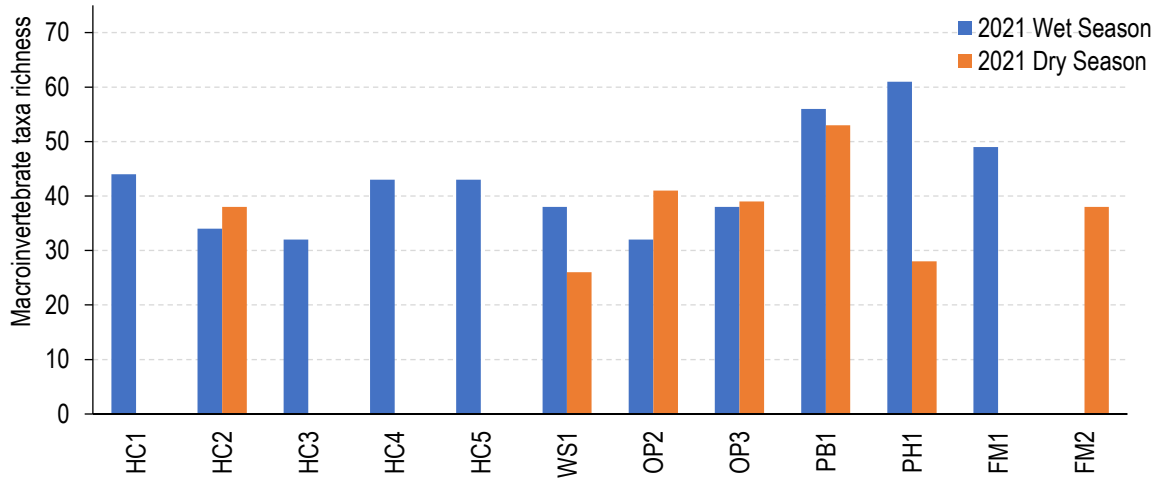


Figure 8. The total number of macroinvertebrate taxa recorded (taxa richness) from each site sampled during the 2021 wet season and dry season surveys. N.B. instances where no taxa were recorded were not surveyed during that season.

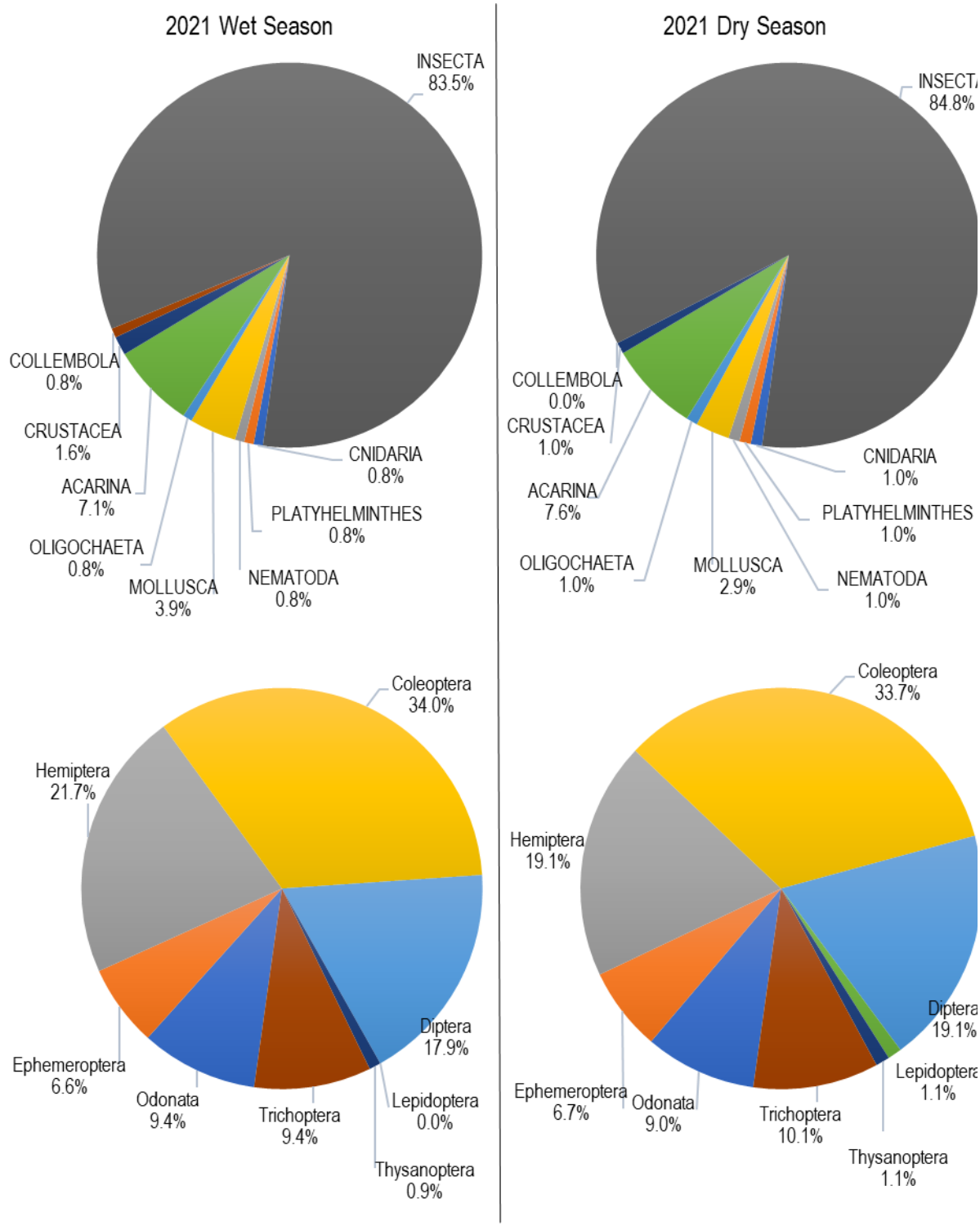


Figure 9. Pie graphs showing the classes of macroinvertebrate recorded during the 2021 wet (top left) and dry season (top right) surveys, in addition to the macroinvertebrate groups within the class Insecta recorded during the 2021 wet (bottom left) and dry season (bottom right) surveys.

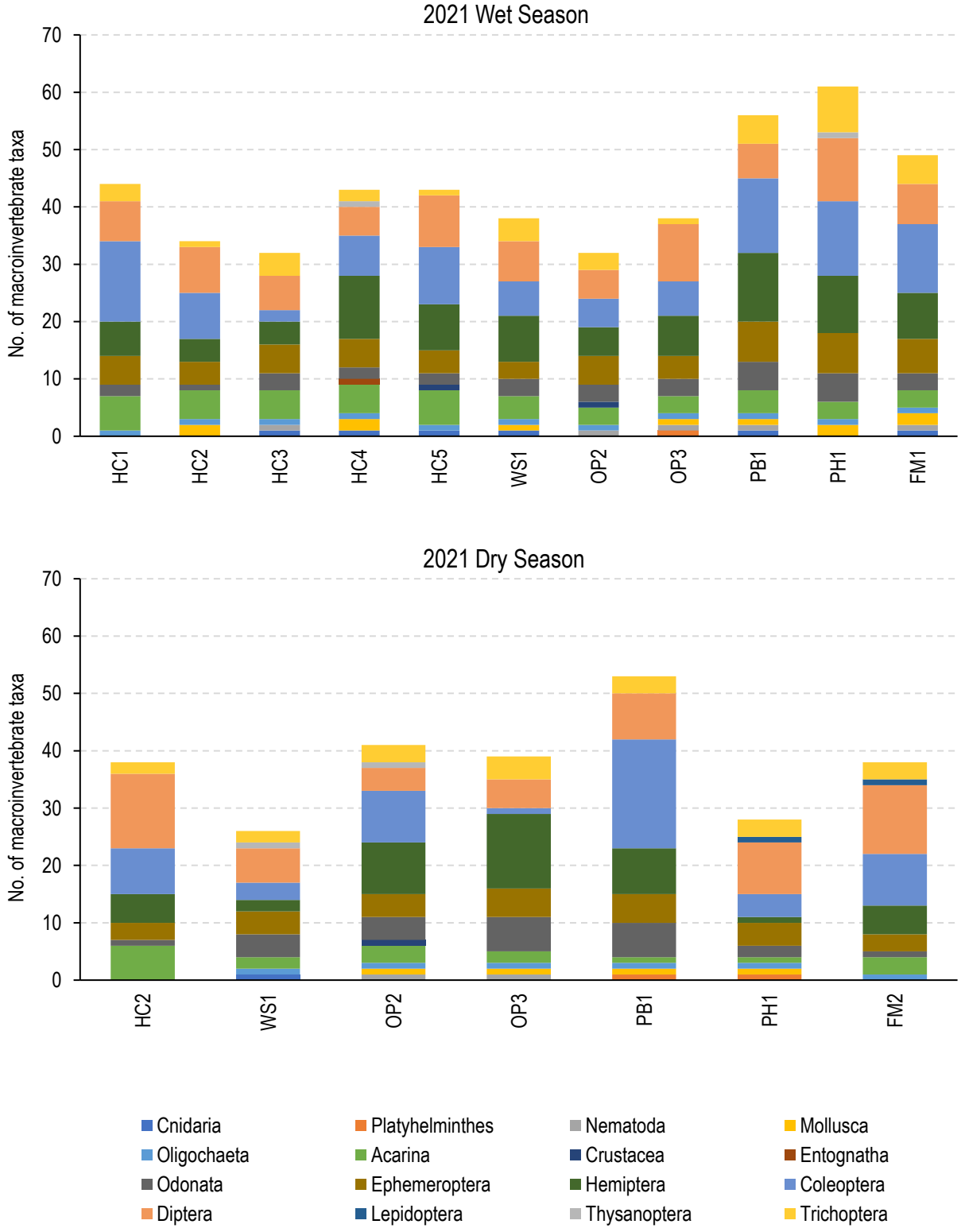


Figure 10. Macroinvertebrate taxonomic composition recorded from each site during the 2021 wet and dry season surveys.

3.6.2 Scientific significance of macroinvertebrate fauna

The majority of macrtoinvertebrate taxa recorded during the current study are considered common with widespread distributions across Northern Australia and Australasia. However, four species, *Eurysticta coolawanyah* (Pilbara pin damselfly), *Ictinogomphus dobsoni* (Pilbara tiger dragonfly), *Tiporus lachlani* and *Tiporus tambreyi* (aquatic dytiscid beetles) recorded within the study area are classified as Pilbara endemic species (Table 9). One to 10 individuals of these three species were recorded during the 2021 wet season survey, with no Pilbara endemic species being recorded during the 2021 dry season survey.

Table 9. Pilbara endemic (PE) species recorded during the 2021 wet**.**

Species	HC1	HC2	HC5	PB1	PH1	FM1
Ictinogomphus dobsoni (PE)	0	0	0	1	2	2
Eurysticta coolawanyah (PE)	0	0	0	0	1	0
Tiporus lachlani (PE)	1	0	0	0	0	0
Tiporus tambreyi (PE)	1	1	0	0	0	0

In addition to these Pilbara endemic species, an individual juvenile syncarid (*Atopobathynella* `sp. Biologic-PBAT041`) belonging to the family Parabathynellidae was recorded from HC5 during the wet season survey. Syncarids are stygobitic/stygal crustaceans which are typical of groundwater habitats. These crustaceans also notably have a cryptic distribution across the Pilbara region, not often being collected from surface water samples. In light of this, additional taxonomic investigation of the specimen may be considered beneficial to assist in determining the species historical distribution in the region and if the species is consistent with the specimen collected from PB1 in the Fortescue River during the dry season.

In terms of significant macroinvertebrate species, whilst *T. tambreyi* and *T. lachlani* is a Pilbara endemic species, it has a wide distribution throughout the region and should not be considered a significant species. Regarding the species *E. coolawanyah* and *I. Dobsoni*, both are listed on the IUCN Red List as Vulnerable (Dow 2019) and Near Threatened (Dow 2017), respectively. However, the IUCN Red List has no legislative power in Australia and neither species is afforded protection under the EPBC Act or BC Act. Furthermore, *I. dobsoni* is relatively common and widely distributed throughout the Pilbara, being recorded previously from the Fortescue River, Robe River, Ashburton River, Yule River and DeGrey River (DEC 2009, CSIRO 2015, Pinder *et al.* 2010). While *E. coolawanyah* was initially listed due to its restricted distribution throughout the Pilbara (of less than 500 km^2), it has since been recorded from various catchments and over 40 locations across the Pilbara region (Pinder *et al.* 2010).

3.7 Sediment Rehydration

3.7.1 Taxonomic Composition

A list of emergent taxa from rehydrated sediment samples is presented in Appendix 7. Fauna emerged from only four samples collected in the wet season and eight samples collected in the dry season. A total of 24 taxa were recorded, including two protists, seven rotifers, nine cladoceran and six ostracod taxa. This included several taxa which were unable to be identified to family level or beyond. Only three species were identified from samples collected during the wet season, all of which were from sites within Homestead Creek. No individuals were found to emerge from sediment collected from the Fortescue River at this time. This was attributable to the fact that flow was present at the time of sampling and sediments of the bed and bank were either inundated or damp. In contrast, 14 species were identified from samples collected in Homestead Creek during the dry season. The difference in diversity between seasons is not unexpected, and suggests that the collection of sediments for rehydration may be beneficial during the dry season only.

3.7.2 Scientific significance of emergent taxa

Most taxa identified from the rehydrated sediment samples were common, ubiquitous species that have previously been found across the Pilbara region from either rehydrated sediment samples or microcrustacean samples collected from surface water.

3.8 Other Fauna

A total of five vertebrate species, comprising three native fish, one introduced fish species and one reptile species were recorded during both seasons (Plate 1). The introduced crustacean *Cherax quadricarinatus* was also recorded within the study area. All native fish and reptile species recorded are known from the Pilbara region, with most also occurring more broadly throughout Australian inland waters (Cogger 2014, Doughty *et al.* 2011, Morgan *et al.* 2014, Morgan and Gill 2004). Furthermore, none were considered conservation significant species afforded protection under Western Australian State or Federal legislation.

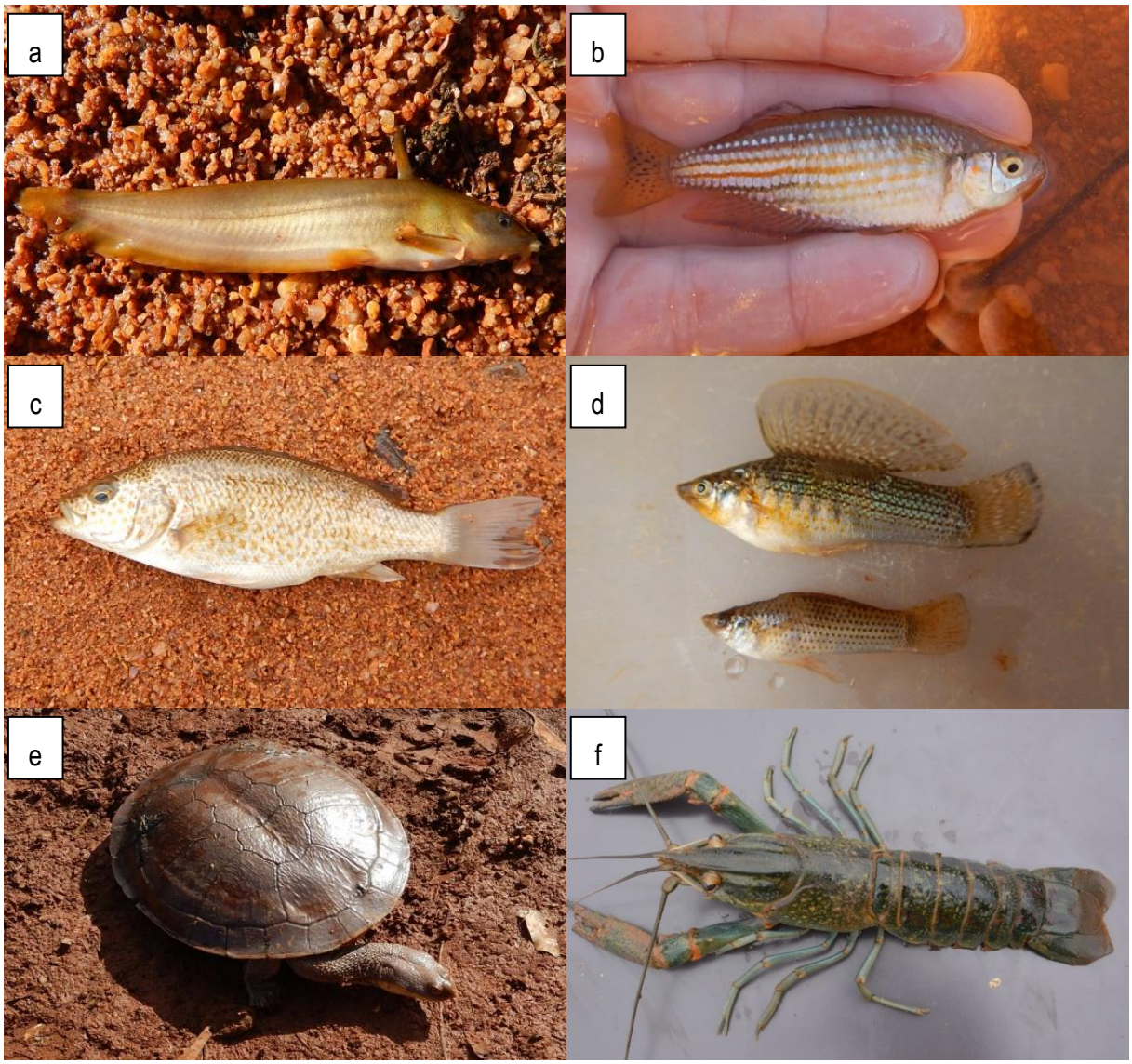


Plate 1. Aquatic fauna recorded within the study area; a) *Neosilurus hyrtlii*, b) *Melanotaenia australis*, c) *Leiopotherapon unicolor* d) *Poecilia latipinna,* e) *Chelodina steindachneri* and f) *Cherax quadricarinatus.*

3.8.1 Fish

The three native fish species, *Leiopotherapon unicolor* (Spangled Perch), *Melanotaenia australis* (Western Rainbowfish) and *Neosilurus hyrtlii* (Hyrtl's Tandan), recorded during the survey are not species of significance and are common throughout north-western Australia including the Pilbara region (Allen *et al.* 2002, Morgan *et al.* 2014). The low number of fish species recorded during this survey is typical of the upper reaches of the Fortescue River catchment and agrees with the findings of Morgan and Gill (2004) and Morgan *et al.* (2009) who found diversity to be low in the upper Fortescue compared to the lower Fortescue River and other drainage divisions in Australia. This low diversity has been attributed to the arid climate and sporadic periods of flow within the region (Allen *et al.* 2002). The introduced species *Poecilia latipinna* (Sailfin Molly) was also recorded during the wet season survey from site FM1 after being first recorded within the region in 2017 (Indo-Pacific Environmental 2017a).

Of the 5211 individual fish recorded during the 2021 wet and dry sampling surveys, *L. unicolor* and *N. hyrtlii* were the most abundant in both seasons, accounting for 74% (n = 3858) and 18% (n = 921) of the total individuals collected respectively (Table 10). Furthermore, these species were also the most widespread, with *L. unicolor* being recorded from all sites surveyed for such biota, and *N. hyrtlii* being recorded from eight sites in the wet season, and from three sites during the dry season. Although *M. australis* was widespread across the study area, lower numbers were recorded in 2021, with the species accounting for 11% (n=430) of individuals recorded (Table 10). The introduced fish *P. latipinna*, were less common and considered restricted, with only two individuals recorded from FM1 during the wet season survey.

With respect to the 2021 wet season survey, 3832 individual fish were recorded which represents approximately 75% of the total fish recorded during both seasons. This may be attributed to the fact flow was present in the Fortescue River and pools remained largely connected during the wet season. Furthermore, surface water was present at all survey sites in Homestead Creek during the wet season survey as opposed to the dry season where three of the five sites were dry. The remnant pools existing in the wet season provide more optimal spawning habitat (i.e. shallow and warm water temperature) for native fish species, which undoubtedly resulted in higher numbers of all species being recorded during the wet season (Beumer 1979; Lintermans 2007). Although some flow was present in the Fortescue River during the dry season survey as a result of water being released from Ophthalmia Dam, the release of water had only occurred for a brief period prior to undertaking the survey. As a result, any fauna within remnants pool that may have existed in the Fortescue River may have been flushed further downstream and limited dispersal of fauna into newly inundated sections of the Fortescue River had yet to occur.

No *P. latipinna* were recorded from Homestead Creek. This was likely attributed to the highly ephemeral nature of the environment present and lack of permanent water. Only two *P. latipinna* were recorded from the Fortescue River sites during the current study, with both being captured during the wet season. This is far fewer individuals than have been captured during previous surveys in the area, however this is not considered to be representative of the actual population present in this reach of the Fortescue River. Rather, the low number of individuals captured was considered to be the result of the survey sites assessed as part of the current study. For example, highest densities of *P. latipinna* have been found to be present in surface water immediately downstream of Ophthalmia Dam which are maintained by toe seepage. These sites were not surveyed as part of the current study. In addition, despite water being present in the Fortescue River during season survey, water had only recently been released from Ophthalmia Dam and thus the downstream dispersal of individuals may yet to have occurred.

Combined length-frequency histograms for fish species recorded during the wet and dry season surveys, respectively, are shown in Figure 11. Age-class structure for native species is visually presented in Figure 12 with maturity estimated from available literature including Beesley 2006, Bishop *et al*. 2001, and Lake 1971. While Figure 11 suggests that native fish species measured during the current study fell within relatively few size classes, this is a reflection of these species being comparatively short lived and adapted to the boom and bust conditions present in the Fortescue River when water is present. More important is

that size class data indicates that a broad range of sizes were measured including the presence of both new recruits and adults, indicating that populations are self-maintaining (Figure 12). A higher portion of the *M. australis* and *L. unicolor* measured consisted of smaller individuals/new recruits during the 2021 dry season, suggesting spawning had recently occurred. For *N. hyrtlii*, captured individuals comprised mainly of adults during the 2021 dry season survey and possibly reflects that this species relies on a more consistent flow throughout the catchment associated with the wet season to spawn, as opposed to the brief controlled release of water from Ophthalmia Dam prior to the survey. These results align with previous findings that environmental cues such as water temperature, and to a lesser extent flow, are known to trigger spawning events in fish occurring in Australian riverine environments (Llewellyn 1973).

Table 10. The total number of aquatic fauna recorded at each site sampled during the 2021 wet and dry season surveys using all survey methods. N.B. Introduced species have been highlighted red, whilst sites not surveyed during a season are highlighted grey.

	2021 Wet Season						2021 Dry Season					
Site Code	*Chelodina steindachneri*	*Leiopotherapon unicolor*	*Melanotaenia australis*	*Neosilurus hyrtlii*	*Poecilia latipinna*	*Cherax quadricarinatus*	*Chelodina steindachneri*	*Leiopotherapon unicolor*	*Melanotaenia australis*	*Neosilurus hyrtlii*	*Poecilia latipinna*	*Cherax quadricarinatus*
HC1	0	363	1	76	0	0						
HC2	0	32	77	2	0	0	0	9	93	0	0	0
HC3	0	40	21	3	0	0						
HC4	0	2	3	0	0	0						
HC5												
WS1	0	113	0	0	0	46	0	35	0	0	0	23
OP2	1	25	0	24	0	3	0	143	0	341	0	61
OP3	1	218	153	8	0	15	0	86	17	139	0	35
PB1	2	132	0	19	0	237	0	29	5	1	0	7
PH1	0	600	54	303	0	88	0	135	2	0	0	0
FM1	1	1554	2	5	2	27						
FM2							0	342	2	0	0	0
Total Number	5	3079	311	440	2	416	0	779	119	481	0	126
Sites Recorded	**4**	**10**	**7**	**8**	**1**	**6**	**0**	**7**	**5**	**3**	**0**	**4**

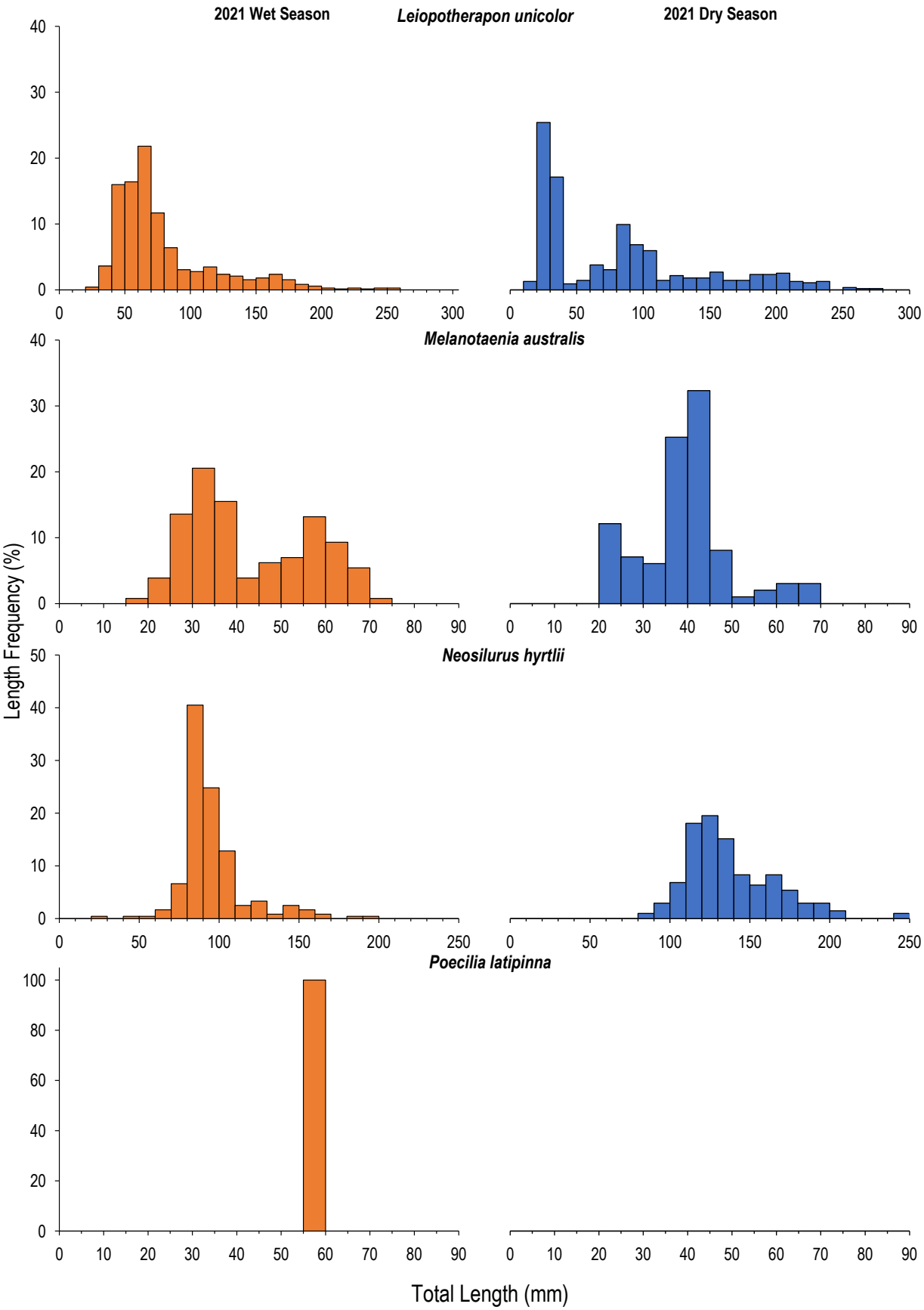


Figure 11. Combined length frequency plots of each fish species recorded from all sites within the study area during the 2021 wet and dry season surveys.

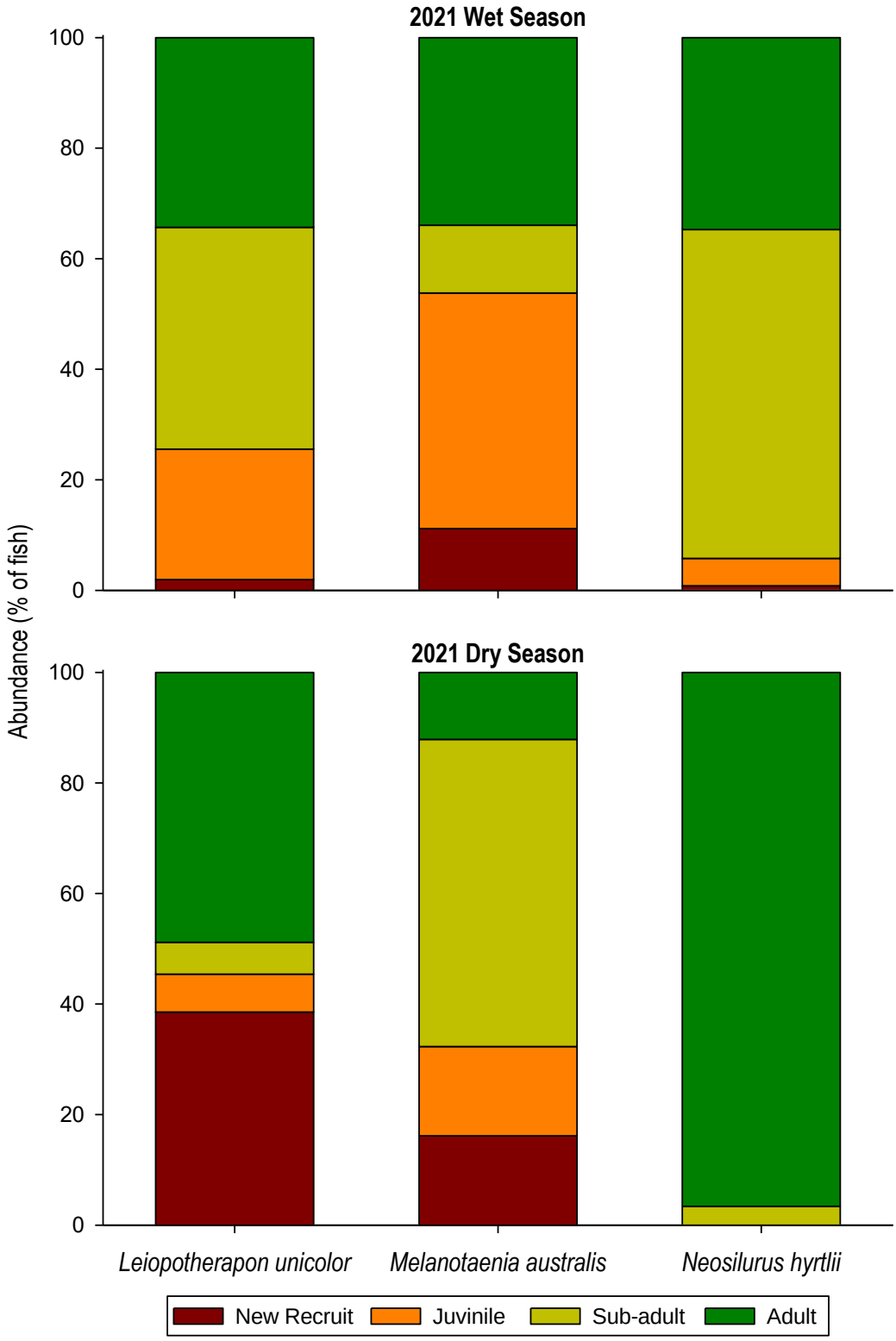


Figure 12. Combined age-class structures of native fish species recorded from all sites within the study area during the 2021 wet (top) and dry (bottom) season surveys

3.8.2 Reptiles

Five *Chelodina steindachneri* (Steindachner's Turtle) were captured by fyke net during the wet season survey with individuals ranging from 140 to 180 mm SCL (Table 10). All *C. steindachneri* were captured at sites within Ophthalmia Dam or the Fortescue River, with none captured from Homestead Creek. *Chelodina steindachneri* is the only freshwater turtle known to occur within the Pilbara region (Cogger 2014) and has been commonly captured throughout the main channel of the Fortescue River during previous surveys of aquatic fauna (see for example Indo-Pacific Environmental 2017a and 2017b). This species is known to aestivate through dry periods, with the onset of breeding triggered by rainfall and flash flooding, and peak breeding activity generally occurring between October and February (i.e. during the wet season) (Kuchling 1988, Legler and Georges 1993). In light of this breeding cycle, the fact that no individuals were captured in Homestead Creek suggests the general habitat present is not suitable for the species. Indeed, the highly ephemeral nature of Homestead Creek (i.e. lack of permanent or semi-permanent water) and lack of observed sandy substrates within which individuals may burrow to aestivate are unfavourable habitat characteristics for this species.

3.8.3 Freshwater Crayfish

Cherax quadricarinatus (Redclaw) was first recorded in the Fortescue River catchment by Indo-Pacific Environmental in 2018. Since that time the species has spread throughout the upper Fortescue River catchment with a dramatic increase in abundance being observed (Indo-Pacific Environmental 2020). During the current study, a total of 416 individuals were recorded from six sites during the wet season, whilst 126 individuals were recorded from four sites during the dry season survey (Table 10, Figure 13). No individuals were captured at sites within Homestead Creek and no evidence of the species presence was observed, for example, shell remnants or burrows. This is likely due to the highly ephemeral nature of Homestead Creek which rapidly dries after the cessation of rain. However, noting the option to discharge water into Homestead Creek, some potential exists for water to remain in the creek for a greater duration than would naturally occur, and semi-permanent or permanent pools may result. In this event, it is possible that *C. quadricarinatus* could colonise Homestead Creek. *Cherax quadricarinatus* is known to influence faunal and floral assemblages of river pools in the Pilbara (Pinder *et al.* 2019). In the event water is discharged to Homestead Creek and pools persist, ongoing monitoring would identify whether and at what rate the species establishes. *Cherax quadricarinatus* was recorded in relatively high abundance in the water storage dam surveyed. Noting the distance of this site from the Fortescue River and that connection to the dam is via a discharge pipeline it is likely that these individuals were translocated to the site. The water storage dam is in very close proximity to the Marble Bar Road and has only recently had fencing installed around its perimeter. Anecdotal evidence indicated the water storage dams were a popular site for local residents to fish for *C. quadricarinatus.* This was also evidenced by the fact remnants of small fires, cooking grills and *C. quadricarinatus* shell which had been cooked was found at several locations around the dams.

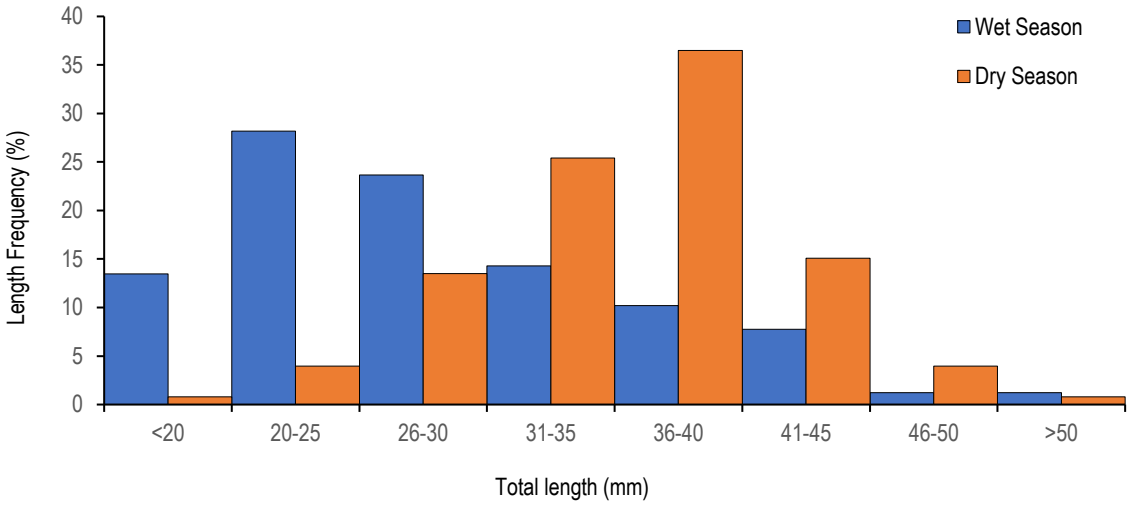


Figure 13. Length frequency of *Cherax quadricarinatus* recorded from all sites during the wet and dry season surveys.

4 CONCLUSIONS

This report provides a comprehensive assessment of the aquatic fauna and habitat within Homestead Creek, as well as a limited number of survey sites in the Fortescue River main channel (located downstream of the confluence), within Ophthalmia Dam and one site within the Eastern Ridge recharge ponds (referred to as the Water Storage Dam). Homestead Creek and the upper Fortescue River main channel were found to be highly ephemeral whilst discharge to the water storage dam and Ophthalmia Dam meant permanent water persisted throughout the dry season. The Homestead Creek channel was found to be predominantly rock whilst Fortescue River main channel sites downstream of the confluence contained a far greater proportion of sand. The majority of sites along Homestead Creek were considered to be marginal aquatic habitat due to the lack of permanent water, available in-stream habitat and generally narrow riparian zones with high density of introduced grasses. Furthermore, a number of sites within Homestead Creek were the result of being located immediately downstream of an elevated road crossing and/or culvert to facilitate the carriage of water when flow is present.

Three native species of fish were found to be present at survey sites within Homestead Creek, including *L. unicolor*, *M. australis* and *N. hyrtlii.* These species have commonly been recorded throughout Australian inland waters including the Fortescue River (Morgan *et al.* 2014; Morgan and Gill 2004). During the wet season, sites surveyed in Homestead Creek were small contracted pools. Noting that a number of these sites were completely dry during the dry season survey, and that any aquatic fauna would have perished, it is considered unlikely that aquatic habitat within Homestead Creek represents any critical breeding habitat for fish. While the native turtle *Chelodina steindachneri* was recorded from Ophthalmia Dam and the Fortescue River, it was not recorded from Homestead Creek. This was considered largely due to the predominantly rocky substrates present in Homestead Creek which would prohibit the species burrowing to aestivate during dry periods. This provided an additional indication that Homestead Creek represents marginal habitat for larger aquatic fauna. The introduced *P. latipinna* was recorded from one site in the Fortescue River during the wet season, whilst *C. quadricarinatus* were recorded from the majority of Fortescue River surveys sites in both seasons. Neither of these species were recorded from Homestead Creek.

In general, macroinvertebrate, microinvertebrate, hyporheic and sediment rehydration taxa were considered common species having widespread distributions across northern Australia. While several species endemic to the Pilbara were identified, no species afforded protection under the EPBC Act or BC Act was identified. However, of note during the current study was that a juvenile syncarid (*Atopobathynella* `sp. Biologic-PBAT041`) belonging to the family Parabathynellidae was recorded from surface water at HC5 during the wet season survey. An additional syncarid was also collected from the Fortescue River (PB1) from the hyporheic zone in the dry season. Syncarids are stygobitic/stygal crustaceans which are typical of groundwater habitats. These crustaceans also notably have a cryptic distribution across the Pilbara region, not often being collected from surface water samples. In light of this, additional taxonomic investigation of the specimens may be considered beneficial to assist in determining the species historical distribution in the region.

5 REFERENCES

Allen, G. R., Midgley, S. H. and Allen, M. (2002). *Field guide to the freshwater fishes of Australia*. Western Australian Museum, Perth.

ANZECC (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

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

Barker, D., Allan, G. L., Rowland, S. J., Kennedy, J. D. and Pickles, J. M. (2009). *A Guide to Acceptable Procedures and Practices for Aquaculture and Fisheries Research*. Report to the Primary Industries (Fisheries) Animal Care and Ethics Committee, New South Wales.

Beesley, L. (2006). Environmental stability: its role in structuring fish communities and life history strategies in the Fortescue River, Western Australia.

Bennelongia. (2013). *Bungaroo South: Subterranean Fauna Assessment Final Report*. Unpublished report to Iron Ore Holdings Ltd.

Beumer, J.P. (1979). Reproductive cycles of two Australian freshwater fishes: the spangled perch, *Therapon unicolo*r Gunther, 1859 and the East Queensland rainbowfish, *Nematocentris splendida* Peters, 1866. *J. Fish Biol*. 15: 111-134.

BHPBIO, BHP Billiton Iron Ore. (2020) Aquatic Fauna Assessment Methods (0098594). Unpublished manuscript prepared by BHP Billiton Iron Ore. Perth, Western Australia.

BHPBIO, BHP Billiton Iron Ore. (2020) Biodiversity Survey Spatial Data Requirements (SPR-IEN-EMS-015). Unpublished manuscript prepared by BHP Billiton Iron Ore. Perth, Western Australia.

Bishop, K. A., Allen, S. A., Pollard, D. A. and Cook, M. G. (2001). *Ecological Studies on the Freshwater Fishes of the Alligator Rivers Region, Northern Territory*: Autecology. Supervising Scientists Report 145, Supervising Scientist, Darwin.

Boulton, A. J. (2001). Twixt two worlds: taxonomic and functional biodiversity at the surface water/groundwater interface. *Records of the Western Australian Museum, Supplement*, 64(1): 1.

Butler, B., Doudoroff, P. and Shumway, D. L. (1970) Dissolved oxygen requirements of freshwater fishes. FAO Fisheries Technical Paper No. 86, 291 pp.

Butler, B. (2008). Report 5: Water quality. In G.P. Lukacs and C.M. Finlayson (eds) 2008. *A Compendium of Ecological Information on Australia's Northern Tropical Rivers*. Sub-project 1 of Australia's

Tropical Rivers – an integrated data assessment and analysis (DET18). Report to Land & Water Australia. National Centre for Tropical Wetland Research, Townsville, Queensland.

Cogger, H. G. (2014). *Reptiles and Amphibians of Australia*. CSIRO Publishing, Collingwood.

Connolly, N. M., Crossland, M. R. and Pearson, R. G. (2004). Effect of low dissolved oxygen on survivial, emergence, and drift of tropical stream macroinvertebrates. *Journal of the North American Benthological Society* 23: 251-270.

CSIRO (2015a). *Australian National Insect Collection Taxon Database*. Available at: http://anic.ento.csiro.au/database [Accessed on 17th August 2021].

CSIRO (2015b). Pilbara Water Resource Assessment: Upper Fortescue region. An overview report to the Government of Western Australia and industry partners from the CSIRO Pilbara Water Resource Assessment. CSIRO Land and Water, Australia.

Delamare Deboutteville C (1960). Biologie des eaux souterraines littorales et continentales. *Actualities Scientifiques et Industrielles* No. 1280. Hermann, Paris, pp. 740.

DEC (2009). *Resource Condition Report for Significant Western Australian Wetland: Fortescue Marshes*. Department of Environment and Conservation. Perth, Australia.

Department of Biodiversity Conservation and Attractions. (2020). *Recovery plans and interim recovery plans*. Available at: https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/wa-s-threatened-ecological-communities.

Doan Dang, P., Van Khoi, N., Nguyet Nga, L. T., Thanh, D. N. and Ho Thanh, H. (2015). *Identification Handbook of Freshwater Zooplankton of the Mekong River and its Tributaries*. Mekong River Commission, Vientiane.

Doughty, P., Rolfe, J., Burbidge, A., Pearson, D. and Kendrick, P. (2011). Herpetological assemblages of the Pilbara biogeographic region, Western Australia: Ecological associations, biogeographic patterns and conservation. *Records of the Western Australian Museum*, Supplement, 78. https://doi.org/10.18195/issn.0313-122x.78(2).2011.315-341

Dow, R. A. (2017). *Ictinogomphus dobsoni*. The IUCN Red List of Threatened Species 2017: e.T14278410A59256758. Available at: https://dx.doi.org/10.2305/IUCN.UK.2017-1.RLTS.T14278410A59256758.en.

Dow, R. A. (2019). *Eurysticta coolawanyah*. The IUCN Red List of Threatened Species 2019: e.T163568A14675082. Available at: https://dx.doi.org/10.2305/IUCN.UK.2019-2.RLTS.T163568A14675082.en.

EIFAC (1973). *Water Quality Criteria for European freshwater Fish: Report on Zinc and Freshwater Fish*. European Inland Fisheries Advisory Commission (EIFAC) Working Party on Water Quality Criteria and European Freshwater Fish. EIFAC Technical Paper No. 21, 322 pp.

Environmental Protection Authority (EPA). (2002) Position Statement Number 3: Terrestrial biological surveys as an element of biodiversity protection. Environmental Protection Authority.

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

Environmental Protection Authority (EPA). (2009) EPA Guidance Statement Number 20: Sampling of short-range endemic invertebrate fauna for environmental impact assessment in Western Australia. Environmental Protection Authority, May 2009.

Flint, N., Crossland, M. R. and Pearson, R. G. (2015). Sublethal effects of fluctuating hypoxia on juvenile tropical Australian freshwater fish. *Marine and Freshwater Research* 66: 293–304.

Godfrey, P. C., Pearson, R. G., Pusey B. J. and Arthington, A. H. (2020) Drivers of zooplankton dynamics in a small tropical lowland river. *Marine and Freshwater Research* 72**:** 173-185.

Halse, S. A., Scanlon, M. D. and Cocking, J. S. (2002). Do springs provide a window to the groundwater fauna of the Australian arid zone. In *Balancing the Groundwater Budget: Proceedings Of an International Groundwater Conference, Darwin* pp. 1-12.

Hart, B. T., Bailey, P., Edwards, R., Hortle, K., James, K., McMahon, A., Meredith, C. and Swadling, K. (1991). A review of salt sensitivity of Australian freshwater biota. *Hydrobiologia* 210: 105-144.

Horrigan, N., Choy, S., Marshall, J. and Recknagel, F. (2005) Response of stream macroinvertebrates to changes in salinity and the development of a salinity index. *Marine and Freshwater Research* 56: 825–833.

Indo-Pacific Environmental (2017a). *Fortescue River Aquatic Fauna Survey*. Unpublished report to BHP WAIO.

Indo-Pacific Environmental (2017b). *Innawally Pool Aquatic Survey* BHPBIO. Unpublished report to BHP WAIO.

Indo-Pacific Environmental (2018). *Memorandum: Survey of the aquatic fauna in the Fortescue River and Ophthalmia Dam.* Unpublished report to BHP WAIO.

Indo-Pacific Environmental (2019). *Sailfin Molly eDNA survey of the Fortescue River and its tributaries.* Unpublished report to BHP WAIO.

Indo-Pacific Environmental (2021). Fortescue River Aquatic Fauna Survey 2020-2021. Unpublished report to BHP WAIO.

Koste, W. and Shiel. R. J. (1983) Morphology, systematics and ecology of new monogonont Rotifera (Rotatoria) from the Alligator Rivers region, Northern Territory. *Transactions of the Royal Society of South Australia* 107: 109-121.

Kuchling, G. (1988). Gonadal cycles of the Western Australian long-necked turtles *Chelodina oblonga* and *Chelodina steindachneri* (Chelonia: Chelidae). *Records of the Western Australian Museum* 14: 189–198.

Lair, N. (2006) A review of regulation mechanisms of metazoan plankton in riverine ecosystems: aquatic habitat versus biota. *River Research and Applications* 22, 567-593.

Lake, J. S. (1971). *Freshwater Fishes and Rivers of Australia*. Thomas Nelson, Australia.

Legler, J. M. and Georges, A. (1993). Family Chelidae. In: C. G. Glasby, G. J. B. Ross, P. L. Beesley, eds, *Fauna of Australia. Volume 2A Amphibia and Reptilia*. Australian Government Publishing Service, Canberra.

Lintermans, M. (2007). *Fishes of the Murray-Darling Basin. An Introductory Guide*. Murray-Darling Basin Authority, Canberra.

Llewellyn, L. C. (1973). Spawning, development, and temperature tolerance of the spangled perch, *Madigania unicolor* (Gunther), from inland waters in Australia. *Marine and Freshwater Research* 24: 73-94.

Morgan, D. L. and Gill, H. S. (2004). Fish fauna in inland waters of the Pilbara (Indian Ocean) Drainage Division of Western Australia–evidence for three subprovinces. *Zootaxa* 636: 1-43.

Morgan, D. L., Allen, M. G., Beatty, S. J., Ebner, B. C. and Keleher, J. J. (2014). *A Field Guide to the Freshwater Fishes of Western Australia's Pilbara Province*. Freshwater Fish Group and Fish Health Unit, Murdoch University, Perth.

MWH Australia. (2016). *Ophthalmia Dam Aquatic Fauna Survey*. Unpublished report to BHP Billiton Iron Ore.

Orr, T. M. and Milward, N. E. (1984). Reproduction and development of *Neosilurus ater* (Perugia) and *Neosilurus hyrtlii* Steindachner (Teleostei: Plotosidae) in a tropical Queensland stream. *Marine and Freshwater Research* 35: 187-195.

Pinder, A., Halse, S., Shiel, R. and McRae, J. (2010). An arid zone awash with diversity: patterns in the distribution of aquatic invertebrates in the Pilbara region of Western Australia. *Records of the Western Australian Museum* 78: 205-246.

Pinder, A., Lyons, M., Collins, M., Lewis L., Quinlan, K., Shiel, R.J. and Coppen, R. (2017). *Wetland Biodiversity Patterning Along the Middle to Upper Fortescue Valley (Pilbara Region: Western Australia) to Inform Conservation Planning*. Department of Biodiversity, Conservation and Attractions, Perth.

Pinder, A., Harman, A., Bird, C., Quinlan, K., Angel, F., Cowan, M., Lewis, L., and Thillainath, E. (2019). Spread of the non-native redclaw crayfish *Cherax quadricarinatus* (von Martens , 1868) into

natural waters of the Pilbara region of Western Australia , with observations on potential adverse ecological effects. *BioInvasions Records* 8.

Pusey, B. J., Kennard, M. J. and Arthrington, A. H. (2004) *Fishes of North-eastern Australia*. CSIRO, Collingwood.

Richardson, W. B. (1992) Microcrustacea in flowing water: experimental analysis of washout times and a field test. *Freshwater Biology* 28, 217-230.

Segers, H., Kotethip, W. and Sanoamuang, L. (2004) Biodiversity of freshwater microfauna in the floodplain of the River Mun, Northeast Thailand: The Rotifera, Monogononta. *Hydrobiologia* 515: 1-9.

Shiel, R. J. and Tan, L. W. (2013) Zooplankton response monitoring: Lower Lakes, Coorong and Murray Mouth October 2011 – April 2012. Final report to Dept of Envt, Water & Natural Resources, Adelaide: March, 49 pp. incl. appendices.

Smirnov, N. N. and De Meester, L. (1996) Contributions to the Cladocera fauna from Papua New Guinea. *Hydrobiologia* 317: 65–68.

Streamtec (2004) *Aquatic Ecosystems of the Upper Fortescue River Catchment*. Unpublished report to BHP Billiton Iron Ore Pty. Ltd.

Sudmeyer, R. (2016). *Climate in the Pilbara', Bulletin 4873*. Department of Agriculture and Food, Western Australia, Perth.

Tait, R. D., Shiel, R. J. and Koste, W. (1984) Structure and dynamics of zooplankton communities, Alligator Rivers region, NT, Australia. *Hydrobiologia* 113: 1-13.

Thorburn, D. C., Keleher, J. J. and Longbottom, S. G. (2018). Introduction of an alien fish species in the Pilbara region of Western Australia. *Records of the Western Australian Museum* 33:108-114.

van Looij, E. (2009). *Western Australia AUSRIVAS Sampling and Processing Manual. Water Science Technical Series Report No. 13*. Department of Water, Western Australia.

Water and Rivers Commission (WRC) (2000). *Advisory Notes for Land Managers on River and Wetland Restoration: Water Note 8 Habitat of Rivers and Creeks*. Natural Heritage Trust, Government of Western Australia.

Wetland Research and Management. (2009). Hope Downs 4 aquatic ecosystem surveys: dry season sampling 2008. Unpublished report for Rio Tinto Iron Ore, Perth, Western Australia.

Wetland Research and Management. (2011). Yandicoogina: Aquatic Management Report. Unpublished report by Wetland Research and Management Iron Ore. Unpublished report.

Wetland Research and Management. (2013). Baseline Aquatic Survey of the Fortescue Marsh Wet Season 2012 Unpublished report.

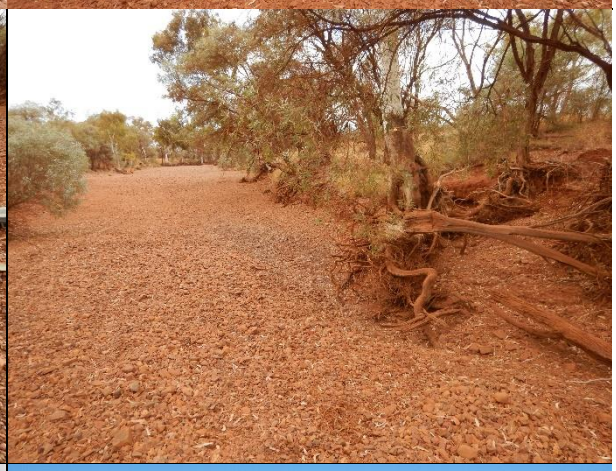
Wetland Research and Management. (2017). Marillana Creek Aquatic Fauna Survey 2017. Unpublished report.

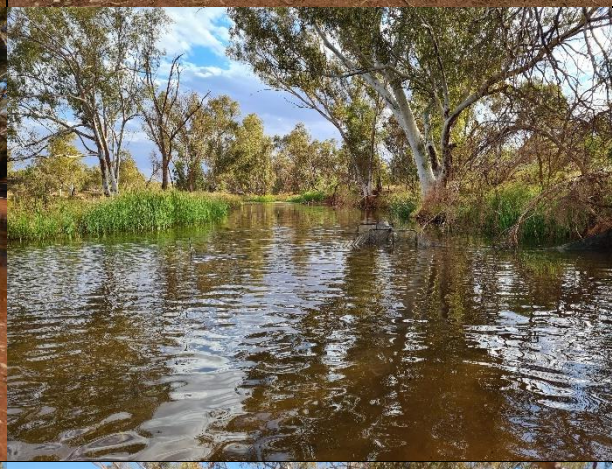
Wetland Research and Management (2018) Warramboo Project: Baseline Aquatic Ecosystem Survey Wet Season Sampling 2018. Unpublished final report to Rio Tinto Iron Ore Pty Ltd

APPENDICES

Appendix 1. Photographs taken at sites surveyed during the 2021 wet season (May) and dry season (October).

2021 Wet Season	2021 Dry Season
HC1 	
HC2 	
HC3 	

2021 Wet Season	2021 Dry Season
HC4 	
HC5 	
WS1 	
OP2 	

2021 Wet Season	2021 Dry Season
	
	
	
	

Appendix 2. Water quality values recorded during each survey period.

Table A2-1. *In situ* water quality results. Highlighted values indicate exceedances of the corresponding tropical Australia Default Guideline Values (DGV) from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018).

Survey Period	Reach	Site	Conductivity	Dissolved Oxygen		pH	Salinity	Temperature
			µS/cm	(ppm)	(%)	(+)	(PSU)	(°C)
2021 Wet Season	Lakes, reservoir and wetlands DGVs		90-900	-	90-120	6-8	-	-
	Ophthalmia Dam	OP2	616	6.94	77.80	7.45	0.30	21.40
		OP3	702	7.61	86.00	7.74	0.34	18.44
	Water Storage Dam	WS1	1188	8.41	98.70	8.08	0.59	20.85
	Lowland River DGVs		20-250	-	85-120	6-8	-	-
	Homestead Creek	HC1	117	7.87	81.80	7.96	0.06	14.3
		HC2	384	9.20	95.50	8.13	0.19	14.34
		HC3	113	7.40	82.00	7.68	0.05	17.47
		HC4	119	9.71	99.30	8.30	0.06	13.42
		HC5	165	7.96	102.00	7.16	0.08	25.26
	Fortescue River Downstream of Ophthalmia Dam	PB1	525	7.35	83.60	8.22	0.26	18.88
		PH1	543	7.93	79.90	8.29	0.26	22.04
		FM1	525	6.56	70.60	8.05	0.26	15.84
		FM2	Not Sampled					
2021 Dry Season	Lakes, reservoir and wetlands DGVs		90-900	-	90-120	6-8	-	-
	Ophthalmia Dam	OP2	863	6.56	38.60	8.60	0.42	27.29
		OP3	892	6.33	88.40	7.55	0.43	28.56
	Water Storage Dam	WS1	1175	5.49	70.20	7.99	0.59	25.10
	Lowland River DGVs		20-250	-	85-120	6-8	-	-
	Homestead Creek	HC1	Dry					
		HC2	663	4.71	59.20	7.63	0.32	22.39
		HC3	Dry					
		HC4	Dry					
		HC5	Dry					
	Fortescue River Downstream of Ophthalmia Dam	PB1	900	5.48	67.7	9.76	0.44	23.38
		PH1	928	7.32	98.4	9.34	0.45	27.80
		FM1	Not Sampled					
		FM2	927	4.99	61.5	9.15	0.46	22.99

Table A2-2. Laboratory results of nutrient and alkalinity concentrations. Highlighted values indicate exceedances of the corresponding tropical Australia Default Guideline Values (DGV) from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018).

Survey Period	Reach	Site	Turbidity	Ammonia as N	Nitrite + Nitrate as N (N_NOx)	Total Nitrogen	Total Phosphorus	Alkalinity (CaCO3)
			NTU	ug/L	ug/L	ug/L	ug/L	mg/L
		Reporting Limit	15	10	10	10	10	1
2021 Wet Season	Lakes, reservoir and wetlands DGVs		2–200	-	10	350	10	-
	Ophthalmia Dam	OP2	90	20	<10	700	50	170
		OP3	<15	10	<10	300	<10	202
	Water Storage Dam	WS1	<15	20	900	1100	<10	314
	Lowland River DGVs		2–15	-	10	200–300	10	-
	Homestead Creek	HC1	<15	20	20	300	20	52
		HC2	<15	<10	<10	200	10	126
		HC3	Not Sampled					
		HC4	<15	10	20	100	<10	49
		HC5	<15	10	<10	<100	<10	66
	Fortescue River Downstream of Ophthalmia Dam	PB1	<15	10	<10	300	<10	192
		PH1	<15	20	40	300	<10	134
		FM1	<15	20	<10	300	<10	130
		FM2	Not Sampled					
2021 Dry Season	Lakes, reservoir and wetlands DGVs		2–200	-	10	350	10	-
	Ophthalmia Dam	OP2	<15	10	<10	700	20	212
		OP3	<15	20	40	200	<10	207
	Water Storage Dam	WS1	<15	20	720	1000	<10	326
	Lowland River DGVs		2–15	-	10	200–300	10	-
	Homestead Creek	HC1	Dry					
		HC2	<15	<10	<10	500	20	184
		HC3	Dry					
		HC4	Dry					
		HC5	Dry					
	Fortescue River Downstream of Ophthalmia Dam	PB1	<15	20	<10	800	30	141
		PH1	<15	20	<10	400	20	142
		FM1	Not Sampled					
		FM2	<15	<10	<10	600	10	138

Table A2-3. Laboratory results of total suspended solids (TSS), hardness and ionic analyte concentrations (mg/L).

Season Year	Reach	Site	TSS	Hardness as CaCO3	Ions				
					Chloride	Calcium	Magnesium	Sodium	Potassium
		Limit of reporting	5	1	1	1	1	1	1
2021 Wet Season	Ophthalmia Dam	OP2	30	241	71	42	33	53	9
		OP3	<5	284	86	48	40	58	9
	Water Storage Dam	WS1	<5	531	167	74	84	85	7
	Ophthalmia Dam Downstream	HC1	<5	48	5	11	5	7	4
		HC2	<5	169	35	38	18	26	4
		HC3	Not Sampled						
		HC4	<5	53	6	13	5	6	4
		HC5	<5	64	7	14	7	13	3
	Fortescue River Downstream of Ophthalmia Dam	PB1	<5	197	108	36	26	93	9
		PH1	<5	184	74	34	24	55	8
		FM1	<5	168	72	31	22	53	8
		FM2	Not Sampled						
2021 Dry Season	Ophthalmia Dam	OP2	<5	278	133	29	50	70	9
		OP3	<5	318	116	40	53	68	8
	Water Storage Dam	WS1	<5	450	171	58	74	77	6
	Homestead Creek	HC1	Dry						
		HC2	<5	172	90	36	20	67	4
		HC3	Dry						
		HC4	Dry						
		HC5	Dry						
	Fortescue River Downstream of Ophthalmia Dam	PB1	<5	244	194	17	49	90	11
		PH1	<5	249	194	19	49	91	11
		FM1	Not Sampled						
		FM2	<5	248	201	20	48	90	11

Appendix 3. Habitat Factors collected for qualitative habitat assessment based on AUSRIVAS methods of sites surveyed for aquatic fauna in Homestead Creek and the Fortescue River in May 2021 and October 2021.

2021 Wet Season												
Habitat component	**Attribute**	**HC1**	**HC2**	**HC3**	**HC4**	**HC5**	**WS1**	**OP2**	**OP3**	**PB1**	**PH1**	**FM1**
Site Measures	Habitat Type	Isolated Pool	Isolated Pool	Isolated Pool	Isolated Pool	Isolated Pool	Storage Dam	Dam	Dam	Channel Pool	Channel Pool	Channel Pool
	Site Length (m)	25	15	40	20	7	100	40	40	100+	100+	100+
	Site Width (m)	10	10	10	6	2	250	50	50	20	8	50
	Depth (m)	0.8	1	2	0.9	0.2	3.5	1.1	1	2	0.7	0.6
	Velocity (cm/s):	0	0	0	0	0	0	0	0	0.5	0.5	0.5
Habitat Area (% Cover)	Mineral Substrate	95	60	70	95	70	10	65	0	50	30	85
	Emergent Macro	0	0	0	0	0	0	0	0	10	0	0
	Submerged Macro	0	0	0	0	0	38	5	0	5	0	0
	Floating Macro	0	0	0	0	0	0	0	0	0	0	0
	Algal Cover	0	33	0	0	30	20	0	85	10	0	0
	Detritus	3	5	10	5	0	20	15	5	10	20	5
	Veg. draped in water	0	0	0	0	0	5	5	0	5	10	0
	Root mats	0	0	10	0	0	5	10	5	10	30	5
	Large Woody Debris	2	2	10	0	0	2	0	5	0	10	5
Sediment Substrate (% Cover)	Bedrock	40	10	40	60	0	0	0	0	0	0	0
	Boulders (>256 mm)	20	2	10	0	0	40	0	0	0	0	0
	Cobbles (64-256 mm)	10	3	5	15	20	20	0	0	0	10	0
	Pebbles (16 - 64 mm)	10	30	5	0	35	0	30	0	10	20	5
	Gravel (4 - 16 mm)	20	40	13	15	30	20	30	20	30	30	5
	Sand (1 - 4 mm)	0	0	2	5	10	0	0	0	60	40	90
	Silt (<1 mm)	0	10	5	5	5	0	0	0	0	0	0
	Clay	0	5	20	0	0	20	40	80	0	0	0
Disturbances (0= None, 1= Some, 2= Moderate, 3= High)	Cattle Grazing	0	0	2	1	1	1	0	1	1	1	1
	Frequent Fire	0	0	0	0	0	0	0	1	0	0	1
	Mining Exploration	1	1	2	2	2	1	0	0	0	0	0
	Road/ Access Track	0	1	2	2	2	2	1	2	1	1	1
	Rubbish/ Litter	0	1	0	0	0	1	1	2	0	0	1
	Weed Invasion	0	0	0	0	0	1	0	1	0	0	0
	Other	0	0	0	0	0	0	2	0	0	0	0
	None Discernible	0	0	0	0	0	0	0	0	0	0	0
	Local Erosion	0	0	0	0	0	0	0	1	0	1	0

2021 Dry Season								
Habitat component	**Attribute**	**HC2**	**WS1**	**OP3**	**OP2**	**PH1**	**PB1**	**FM2**
Site Observations	Habitat Type	Isolated pool	Isolated pool	Dam	Dam	Channel Pool	Channel Pool	Channel Pool
	Site Length (m)	10	70	40	40	100+	100+	100+
	Site Width (m)	6	40	70	60	10	20	20
	Depth (m)	0.7	2+	2	1	0.4	1.5	1
	Velocity (cm/s):	0	0	0	0	0.5	0.5	0.5
Habitat Area	Mineral Substrate	70	86	65	60	70	75	90
	Emergent Macro	0	2	0	0	5	15	0
	Submerged Macro	0	2	5	5	0	0	0
	Floating Macro	0	0	0	0	0	0	0
	Algal Cover	10	0	10	10	0	0	0
	Detritus	20	5	15	20	10	5	2
	Veg. draped in water	0	2	0	5	0	2	3
	Root mats	0	0	0	0	13	2	3
	Large Woody Debris	0	1	5	10	2	1	2
Sediment Substrate	Bedrock	0	0	0	0	0	0	0
	Boulders (>256 mm)	20	2	0	5	1	1	1
	Cobbles (64-256 mm)	20	15	2	15	19	10	14
	Pebbles (16 - 64 mm)	30	28	3	15	25	20	40
	Gravel (4 - 16 mm)	20	45	0	15	30	47	30
	Sand (1 - 4 mm)	10	0	0	0	24	20	13
	Silt (<1 mm)	0	5	10	0	1	2	2
	Clay	0	0	85	50	0	0	0
Disturbances (0= None, 1= Some, 2= Moderate, 3= High)	Cattle Grazing	0	0	0	1	0	1	0
	Frequent Fire	0	0	1	0	0	0	0
	Mining Exploration	2	0	0	0	0	0	0
	Road/ Access Track	2	1	1	1	0	1	0
	Rubbish/ Litter	0	0	3	1	0	0	0
	Weed Invasion	0	1	0	0	0	1	0
	Other	0	0	0	0	0	0	0
	None Discernible	0	0	0	0	0	0	0
	Local Erosion	0	0	0	0	1	1	1

Appendix 4a. Microinvertebrate taxa list collected during the wet season (May) 2021. Values are total abundances. Asterix indicates species present in the sample though not quantified.

Kingdom	Phylum	Class	Order	Family	Lowest taxon	OP2	OP3	PB1	PH1	FM1	WS1	HC1	HC2	HC3	HC4	HC5
Protista	Ciliophora	Spirotrichea	Euplotida	Euplotidae	*Euplotes sp. indet.*			2								
					Stentor amethystinus										1987	2
	Amoebozoa	Tubulinea	Arcellinida	Arcellidae	*Arcella discoides*	*										
					Arcella hemisphaerica											7
				Centropyxidae	*Centropyxis aculeata*	*	23							*		
					Centropyxis platystoma		23									
				Difflugiidae	*Difflugia acuminata*	*										
					Difflugia australis			1								
					Difflugia cf. lismorensis	23	46									
					Difflugia sp. indet.											3
				Lesquereusiidae	*Lesquereusia modesta*		23							*		
					Lesquereusia spiralis											137
				Netzeliidae	*Netzelia gramen*		23									
					Netzelia tuberculata		23									*
Animalia	Rotifera	Bdelloida			Bdelloidea indet. sp. indet.			3	1					*		15
		Monogononta	Ploima	Asplanchnidae	*Asplanchna brightwelli*									*		
				Brachionidae	*Anuraeopsis coelata*			1								
					Brachionus angularis									3718		
					Brachionus dichotomus	1000	876	1						128		
					Brachionus falcatus	209	69							*		
					Brachionus sp. indet.			2				*				
					Keratella procurva	93	461						6315	*		
					Keratella tropica	47	92	3						*		
					Plationus patulus											3
				Euchlanidae	*Euchlanis dilatata*			3								
					Euchlanis incisa											16
				Lecanidae	*Lecane bulla*			5	1			164				28
					Lecane 'bulloid' n. sp. indet.		23	5					105	*	*	21
					Lecane nitida											3
					Lecane papuana	*	23									
					Lecane unguitata		23									
					Lecane (M.) sp. indet.			1								
				Lepadellidae	*Colurella sp. indet.*											13
					Lepadella patella			1								

Kingdom	Phylum	Class	Order	Family	Lowest taxon	OP2	OP3	PB1	PH1	FM1	WS1	HC1	HC2	HC3	HC4	HC5
				Mytilinidae	*Lophocharis salpina*											2
				Notommatidae	*Cephalodella sp. indet.*			1								
				Synchaetidae	*Polyarthra sp. indet.*			1					1473	128		
				Trichocercidae	*Trichocerca similis*									6795	449	2
			Floscullariaceae	Conochilidae	*Conochilus dossuarius*									641	1282	
					Conochilus natans									2179		
				Hexarthridae	*Hexarthra mira*	70	415	1						*		
				Trochosphaeridae	*Filinia longiseta*	186	256									
					Filinia pejleri		23									
					ROTIFERA indet. sp. indet.											3
	Arthropoda	Branchiopoda	Diplostraca	Chydoridae	*Alona rigidicaudis*			2			3					2
					Alonella excisa										*	
					Anthalona harti			2			5					
					Armatalona macrocopa			1	1		3					
					Chydorus cf. sphaericus	*										
					Ephemeroporus barroisi		233	2								
				Daphniidae	*Ceriodaphnia cornuta*	*	115									
					Ceriodaphnia cf. dubia	93	*									
					Daphnia sens. lat. carinata						*					
					Simocephalus heilongjiangensis		23									
				Macrotrichidae	*Macrothrix australiensis*		23									
					Macrothrix sp. indet.	*										2
				Moinidae	*Moina micrura*							*	*		64	
				Sididae	*Diaphanosoma excisum*	93	23					*		*		
		Maxillopoda	Cyclopoida	Cyclopidae	*Mesocyclops brooksi*							*	105	*		
					Mesocyclops notius		184				13					3
					Thermocyclops decipiens	326								*		
					Tropocyclops prasinus							3607	105	*	*	
					Cyclopidae indet. sp. indet.	1163	1590	3	1		452	28525	12947	14487	5769	31
			Calanoida	Diaptomidae	*Eodiaptomus lumholtzii*	488	*						*	*	641	
					Diaptomidae indet. sp. indet.	860	23					328		128	2628	
			Harpacticoida	Canthocamptidae	Canthocamptidae indet. sp. indet.				7	8						
		Ostracoda	Podocopida	Candonidae	*Candonopsis cf. tenuis*						3					
				Cyprididae	*Cypretta sp. indet.*		*				3					
					Stenocypris major			1								
					Ostracoda indet. sp. indet.	*	*		2		8					
				Darwinulidae	*Vestalenula marmonieri*			2	1							
				Limnocytheridae	*Limnocythere sp. indet.*		*	5			18	*				

Kingdom	Phylum	Class	Order	Family	Lowest taxon	OP2	OP3	PB1	PH1	FM1	WS1	HC1	HC2	HC3	HC4	HC5
					Total taxa	21	29	23	7	1	10	9	8	22	10	19

Appendix 4b. Microinvertebrate taxa list collected during the dry season (October/November) 2021. Values are total abundances. Asterix indicates species present in the sample though not quantified.

Kingdom	Phylum	Class	Order	Family	Lowest taxon	OP2	OP3	PB1	PH1	FM2	HC2	WS1
Protista	Ciliophora	Spirotrichea	Euplotida	Euplotidae	*Stentor amethystinus*	145				1		
	Amoebozoa	Tubulinea	Arcellinida	Arcellidae	*Arcella vulgaris*		23					
				Centropyxidae	*Centropyxis ecornis*				12			
					Centropyxis sp. indet.						1000	
				Difflugiidae	*Difflugia lacustris*				12			
				Lesquereusiidae	*Lesquereusia spiralis*			4				
Animalia	Rotifera	Bdelloida			Bdelloidea indet. sp. indet.				180	4		
		Monogononta	Ploima	Brachionidae	*Keratella procurva*	5507	256	100	1465	2	123000	1142
				Euchlanidae	*Euchlanis dilatata*					1		
				Lecanidae	*Lecane bulla*				48	1		
					Lecane 'bulloid' n. sp. indet.				60		*	
					Lecane hornemanni			4				
					Lecane luna				12	2		
					Lecane obtusa				24			
					Lecane unguitata				12	1		
				Lepadellidae	*Colurella sp. indet.*				12			
				Mytilinidae	*Mytilina ventralis*				24			
				Synchaetidae	*Polyarthra sp. indet.*	1159						
				Trichocercidae	*Trichocerca sp. indet.*							7428
			Floscullariaceae	Floscullariidae	*Sinantherina sp. indet. (solitary)*				48			
				Hexarthridae	*Hexarthra intermedia*	145						20000
				Testudinellidae	*Testudinella patina*				12			
	Arthropoda	Branchiopoda	Diplostraca	Chydoridae	*Armatalona macrocopa*			4				
					Chydorus cf. sphaericus						*	
					Dunhevedia crassa		*		24	2		
					Leberis diaphanus				72	12		
					Leydigia australis	*						
				Daphniidae	*Ceriodaphnia cornuta*		23	4		2		
					Ceriodaphnia cf. dubia	290	116					
					Daphnia sens. lat. carinata	*		4				
					Daphnia projecta				12			
				Macrotrichidae	*Macrothrix spinosa*	725						
		Maxillopoda	Cyclopoida	Cyclopidae	*Mesocyclops brooksi*	*					*	*
					Microcyclops varicans	725	*	4				
					Thermocyclops decipiens		70		12			
					Tropocyclops prasinus							*
					Cyclopidae indet. sp. indet.	19275	2767	28	12		76000	28857
			Calanoida	Diaptomidae	*Eodiaptomus lumholtzii*	725	558				*	

Kingdom	Phylum	Class	Order	Family	Lowest taxon	OP2	OP3	PB1	PH1	FM2	HC2	WS1
					Diaptomidae indet. sp. indet.	725	884				*	
		Ostracoda	Podocopida	Cyprididae	*Cypretta sp. indet.*		*	*				
					Stenocypris sp. indet.		23					
					Ostracoda indet. sp. indet.	*	47					
				Darwinulidae	*Vestalenula marmonieri*			8		1		*
				Limnocytheridae	*Limnocythere sp. indet.*		*	56				
					Total taxa	**14**	**14**	**11**	**18**	**11**	**8**	**7**

Appendix 5a. Hyporheic taxa list recorded during the wet season (May) 2021. Values are log_{10} abundance categories, where 1= 1 individual, 2 = 2-10 individuals, 3 = 11-100, 4 = 101-1000 etc.

Phylum/Class/Order	Family	Lowest taxon	Hypo Category	HC1	HC2	HC3	HC4	HC5	OP3	PB1	PH1	Fort Mid
CNIDARIA												
HYDROZOA												
Anthoathecata	**Hydridae**	*Hydra sp. indet.*	P					1		2	2	
NEMATODA		Nematoda indet. sp. indet.	P		1		1	1	1		2	
ANNELIDA												
OLIGOCHAETA		Oligochaeta indet. sp. indet.	P	3	2		3	4		4	4	3
ARTHROPODA												
CRUSTACEA												
BRANCHIPODA												
Diplostraca												
Cladocera	**Chydoridae**	*Alona rigidicaudis*	X							2		
		Chydorus sphaericus	X	1	1							
	Daphnidae	*Ceriodaphnia cornuta*	X						2			
		Simocephalus heilongjiangensis	X						2			
	Macrotrichidae	*Macrothrix spinosa*	X						1			
	Moinidae	*Latonopsis australis*	X						2			
OSTRACODA	**Candoninae**	*Candonopsis cf. tenuis*	S	1	2							
	Cyprididae	*Cypretta sp. indet.*	O						2			
		Cypridopsis sp. indet.	O					1				
		Stenocypris major	X						1	2	1	
	Darwinulidae	*Vestalenula marmonieri*	S							3	2	3
	Limnocytheridae	*Limnocythere sp. indet.*	X								2	
MAXILLOPODA												
COPEPODA												
Cyclopoida		Cyclopoida indet. sp. indet.	P	3	4	2	2	4	2		1	2
	Cyclopidae	*Mesocyclops brooksi*	O						2			
		Microcyclops varicans	O		3			2				
		Tropocyclops prasinus	O	4			1					
Calanoida	**Diaptomidae**	Diaptomidae indet. sp. indet.	P			2						
		Eodiaptomus lumholtzii	X	3			2		2			
Harpacticoida	**Canthocamptidae**	Canthocamptidae indet. sp. indet.	P							2	2	2

Phylum/Class/Order	Family	Lowest taxon	Hypo Category	HC1	HC2	HC3	HC4	HC5	OP3	PB1	PH1	Fort Mid
	Parastenocarididae	*Parastenocaris jane*	S							1		1
CHELICERATA												
ARACHNIDA		Arachnida indet. sp. indet.	X	1								
Sarcoptiformes		Sarcoptiformes indet. sp. indet.	X						1			1
Trombidiformes	**Halacaridae**	Halacaridae indet. sp. indet.	P									1
	Hygrobatidae	Hygrobatidae indet. sp. indet.	X		1						1	
	Unionicolidae	Unionicolidae indet. sp. indet.	X						1	1		
HEXAPODA												
COLLEMBOLA												
Entognatha												
Entomobryomorpha		Entomobryomorpha indet. sp. indet.	O					1				
Symphypleona		Symphypleona indet. sp. indet.	O				1					
INSECTA												
Odonata												
Anisoptera		Odonata indet. sp. indet.	X						1			
Ephemeroptera	**Baetidae**	Baetidae indet. sp. indet.	X		2							
		Cloeon sp. Red Stripe	X		1							
	Caenidae	Caenidae indet. sp. indet.	X	2	1			1		1	2	1
Coleoptera	**Dytiscidae**	Dytiscidae indet. sp. indet.	X					3				
	Hydraenidae	*Hydraena sp. indet.*	O	1				1				
		Limnebius sp. indet.	O							1		
	Hydrophilidae	*Enochrus sp. indet.*	X		1							
	Scirtidae	Scirtidae indet. sp. indet.	O		1							
	Staphylinidae	Staphylinidae indet. sp. indet.	X	1								
Diptera	**Ceratopogonidae**	Ceratopogonidae indet. sp. indet.	X	2	2		1	2	2	1		3
		Dasyheleinae indet. sp. indet.	X									2
	Chironomidae	Chironomidae indet. sp. indet.	X	2								
	Chironominae	Chironominae indet. sp. indet.	X	3	2		1	2	1	1		2
		Polypedilum sp. indet.	X						1			
	Orthocladinae	*Corynoneura sp. indet.*	X								2	
		Cricotopus albitarsis	X							1		
		Cricotopus sp. 2	X								2	
	Tanypodinae	Tanypodinae indet. sp. indet.	X	2	2						2	
		Ablabesmyia hilli	X							3		
		Ablabesmyia sp. indet.	X	2								

Phylum/Class/Order	Family	Lowest taxon	Hypo Category	HC1	HC2	HC3	HC4	HC5	OP3	PB1	PH1	Fort Mid
		Larsia albiceps	X	2				2	1	3	2	1
		Paramerina sp. indet.	X					2				
		Paramerina sp. 2	X									2
		Procladius sp. indet.	X	2	1					2		
	Simuliidae	Simuliidae indet. sp. indet.	X								1	
	Tipulidae	Tipulidae indet. sp. indet.	X						1			2
Trichoptera	**Ecnomidae**	*Ecnomus sp. indet.*	X	1						1		
	Hydropsychidae	*Hydropsychidae indet. sp. indet.*	X								2	
			Total Taxa	**18**	**16**	**2**	**8**	**15**	**18**	**18**	**17**	**14**

Appendix 5b. Hyporheic taxa list recorded during the dry season (October/November) 2021. Values are log_{10} abundance categories, where 1= 1 individual, 2 = 2-10 individuals, 3 = 11-100, 4 = 101-1000 etc.

Phylum/Class/Order	Family	Lowest taxon	Hypo Category	FM2	HC2	PB1	PH1
CNIDARIA							
HYDROZOA							
Anthoathecata	**Hydridae**	*Hydra sp. indet.*	P			2	
NEMATODA		*Nematoda indet. sp. indet.*	P	2	2	1	1
MOLLUSCA							
GASTROPODA							
Hygrophila	**Lymnaeidae**	*Bullastra vinosa*	X			1	
ANNELIDA							
OLIGOCHAETA		*Oligochaeta indet. sp. indet.*	P	3	2	3	3
ARTHROPODA							
CRUSTACEA							
BRANCHIPODA							
Diplostraca							
Cladocera	**Chydoridae**	*Dunhevedia crassa*	X			2	
		Ephemeroporus barroisi	X		3		2
		Karualona karua	X				2
	Daphnidae	*Ceriodaphnia cornuta*	X				1
		Daphnia sens. lat. carinata	X				2
OSTRACODA							
	Candoninae	*Candonopsis cf. tenuis*	S			2	
	Darwinulidae	*Vestalenula marmonieri*	S	2		3	3
	Limnocytheridae	*Limnocythere sp. indet.*	X			2	
MAXILLOPODA							
COPEPODA							
Cyclopoida		*Cyclopidae indet. sp. indet.*	P	3	3	3	1
	Cyclopidae	*Eucyclops sp. indet.*	P		1		
		Microcyclops varicans	O	2	2	1	1
	Diaptomidae	*Eodiaptomus lumholtzii*	X		2		
	Canthocamptidae	*Canthocamptidae indet. sp. A*	P	1		1	
		Canthocamptidae indet. sp. B	P			2	

Phylum/Class/Order	Family	Lowest taxon	Hypo Category	FM2	HC2	PB1	PH1
	Parastenocarididae	*Parastenocaris jane*	S		1		2
MALACOSTRACA							
SYNCARIDA							
Bathynellacea	**Parabathynellidae**	*Parabathynellidae indet. sp. indet.*	S			1	
CHELICERATA							
ARACHNIDA							
Sarcoptiformes		*Sarcoptiformes indet. sp. indet.*	X	3	4	1	3
Mesostigmata		*Mesostigmata indet. sp. indet.*	X			1	
HEXAPODA							
COLLEMBOLA							
Entognatha							
Entomobryomorpha		*Entomobryomorpha indet. sp. indet.*	O	3	2	1	2
Poduromorpha		*Poduromorpha indet. sp. indet.*	O	2			1
Symphypleona		*Symphypleona indet. sp. indet.*	O	2			
INSECTA							
Ephemeroptera	**Baetidae**	*Baetidae indet. sp. indet.*	X	1		1	2
Coleoptera	**Carabidae**	*Carabidae indet. sp. indet.*	X	1			
	Dytiscidae	*Dytiscidae indet. sp. indet.*	X		1	1	
	Hydraenidae	*Hydraena sp. indet.*	O		2	2	2
		Ochthebius sp. indet.	O			1	
	Hydrophilidae	*Enochrus sp. indet.*	X	2		2	2
		Helochares sp. indet.	X			1	
	Ptiliidae	*Ptiliidae indet. sp. indet.*	X		2		2
	Staphylinidae	*Staphylinidae indet. sp. indet.*	X		1		
Diptera	**Ceratopogonidae**	*Ceratopogonidae indet. sp. indet.*	X	2	3	3	2
		Dasyheleinae indet. sp. indet.	X	3	3	2	
	Chironomidae						
	Chironominae	*Chironominae indet. sp. indet.*	X		2	3	1
	Orthocladiinae	*Orthocladiinae indet. sp. indet.*	X	1			2
	Tanypodinae	*Tanypodinae indet. sp. indet.*	X	2		3	2
	Dolichopodidae	*Dolichopodidae indet. sp. indet.*	X			1	
	Muscidae	*Muscidae indet. sp. indet.*	X	2	2		1
	Syrphidae	*Syrphidae indet. sp. indet.*	X				1
	Tabanidae	*Tabanidae indet. sp. indet.*	X		2		
	Tipulidae	*Tipulidae indet. sp. indet.*	X	2			2

Phylum/Class/Order	Family	Lowest taxon	Hypo Category	FM2	HC2	PB1	PH1
Lepidoptera	**Crambidae**	*Crambidae indet. sp. indet.*	X		2		
Hemiptera	**Micronectidae**	*Micronecta annae*	X	1			
	Pleidae	*Paraplea sp. indet.*	X	2			
			Total Taxa	**21**	**20**	**27**	**24**

Appendix 6a. Macroinvertebrate taxa list collected during the wet season (May) 2021. Values are log_{10} abundance categories, where 1= 1 individual, 2 = 2-10 individuals, 3 = 11-100, 4 = 101-1000 etc.

Phylum/Class/Order	Family	Lowest taxon	HC1	HC2	HC3	HC4	HC5	WS1	OP2	OP3	PB1	PH1	FM1
CNIDARIA													
HYDROZOA													
Anthoathecata	**Hydridae**	*Hydra sp. indet.*			1	2	2	2			2		1
PLATYHELMINTHES	Turbellaria indet. sp. indet.									1			
NEMATODA		Nematoda indet. sp. indet.			1				2	2	1		1
MOLLUSCA													
GASTROPODA													
Hygrophila	**Lymnaeidae**	*Bullastra vinosa*									1	1	2
	Planorbidae	*Bayardella sp. indet.*		1		2							
		Ferrissia petterdi								1		1	1
		Gyraulus sp. indet.		3				1					
		Leichhardtia sisurnius				2							
ANNELIDA													
OLIGOCHAETA		Oligochaeta indet. sp. indet.	2	4	3	4	4	2	2	4	4	4	4
ARTHROPODA													
CHELICERATA													
ARACHNIDA													
Trombidiformes	**Arrenuridae**	Arrenuridae indet. sp. indet.	3	2	3		3		1		2		
	Eylaidae	Eylais sp. indet.			3	2							
	Hydrachnidae	Hydrachnidae indet. sp. indet.						3					
	Hydryphantidae	Hydryphantidae indet. sp. indet.	3			2		2					
	Hygrobatidae	Hygrobatidae indet. sp. indet.	4	2	3	4	3	3	2	1	3	3	3
	Limnesiidae	Limnesiidae indet. sp. indet.	3	2	4	3	2	3		1	3	4	4
	Oxidae	Oxidae indet. sp. indet.	3				3						
	Pionidae	Pionidae indet. sp. indet.		3			2						
	Unionicolidae	Unionicolidae indet. sp. indet.	3	3	3	2	3		2	2	2	4	3
CRUSTACEA													
Malacostraca													
Bathynellacea	**Parabathynellidae**	Atopobathynella `sp. Biologic-PBAT041'.					1						
Decapoda	**Parastacidae**	*Cherax quadricarinatus*							2				
HEXAPODA													
COLLEMBOLA													
Entognatha													
Entomobryomorpha		Entomobryomorpha indet. sp. indet.				1							
INSECTA													

Phylum/Class/Order	Family	Lowest taxon	HC1	HC2	HC3	HC4	HC5	WS1	OP2	OP3	PB1	PH1	FM1
Odonata		Odonata indet. sp. indet.	2	2	2	1	1	3	2	3	2	3	3
	Corduliidae	*Hemicordulia tau*									1		
	Gomphidae	*Austrogomphus gordoni*			1						1		
	Libellulidae	*Diplacodes haematodes*	1		1	2	2						
		Orthetrum caledonicum						1	2	2			
	Lindeniidae	*Ictinogomphus dobsoni*									1	2	2
	Coenagrionidae	*Agriocnemis sp. indet.*										2	
		Pseudagrion aureofrons									1		
	Isostictidae	*Eurysticta coolawanyah*										1	
Ephemeroptera	**Baetidae**	Baetidae indet. sp. indet.	4	3	3	3	3	3	4	2	3	4	4
		Cloeon sp. Red Stripe	4	4	3	3	2	3	3	2	3	4	3
		Offadens sp. G1WA2									3	3	
		Pseudocloeon hypodelum									3	3	3
	Caenidae	Caenidae indet. sp. indet.	4	4	3	4	1	1	3	3	4	4	4
		Tasmanocoenis sp. M	4		2	2			3		4	4	3
		Tasmanocoenis sp. P/arcuata	3	3	2	3	1		3	2	3	3	3
Hemiptera	**Belostomatidae**	*Diplonychus sp. indet.*								1	2	2	
	Gerridae	Gerridae indet. sp. indet. (imm./dam.)				2	2				4	2	3
		Limnogonus fossarum subsp. gilguy					1	1			2		
		Rhagadotarsus anomalus				2					1	2	
	Hebridae	Hebridae indet. sp. indet.						2					
		Merragata hackeri						1					
	Mesoveliidae	Mesoveliidae indet. sp. indet.					1	2		2		2	1
		Mesovelia vittigera									1	2	
		Mesovelia sp. indet.						1				1	
	Micronectidae	Micronectidae indet. sp. indet.	4	2	1	3	3	2	4	3			
		Micronecta sp. indet.	2				2		4	3			2
		Austronecta sp. indet.	3	1	2	3							
		Austronecta bartzarum	2			2	2						
		Austronecta micra							3				
		Micronecta annae				2		1	3	2	1		2
		Micronecta paragoga								2			
	Nepidae	*Ranatra diminuta*				1					2	2	2
	Notonectidae	*Anisops hackeri*									1		
	Pleidae	*Paraplea sp. indet.*	3	1	4	3	2	3	3	2	2	2	2
	Veliidae	Veliidae indet. sp. indet.	2	2	1	3	2				2	3	2
		Nesidovelia sp. indet.				2							
		Nesidovelia peramoena				2					2	3	1
		Nesidovelia herberti									1		
Coleoptera	**Dytiscidae**	Dytiscidae indet. sp. indet.		2			2	1					
		Allodessus bistrigatus	2										
		Cybister tripunctatus									2	3	2
		Eretes australis										2	
		Hydroglyphus grammopterus	2						1	2	2		2
		Hydroglyphus leai	1			2		2	1	3	3	2	2
		Hydroglyphus orthogrammus				2	2	1			2	2	2
		Hyphydrus elegans			1		1						2
		Hyphydrus lyratus	2		2	2	2	2			2	2	3

Phylum/Class/Order	Family	Lowest taxon	HC1	HC2	HC3	HC4	HC5	WS1	OP2	OP3	PB1	PH1	FM1
		Laccophilus sharpi		1		2					2	2	2
		Limbodessus compactus	1	1			2						
		Necterosoma regulare							1				
		Necterosoma sp. indet.								1			2
		Neobidessodes denticulatus							1		2	3	2
		Platynectes decempunctatus var. decempunctatus										2	
		Rhantaticus congestus									2		
		Tiporus lachlani	1										
		Tiporus sp. indet.	1										
		Tiporus tambreyi	1	1									
	Elmidae	*Austrolimnius sp. indet.*	1										
	Gyrinidae	*Dineutus australis*									1		
	Hydraenidae	*Hydraena sp. indet.*	3	1		1	3				2	3	1
		Limnebius sp. indet.	2	1			2					1	
	Hydrochidae	*Hydrochus sp. indet.*	2				1		1		3	2	3
	Hydrophilidae	*Berosus dallasae*									1		
		Berosus pulchellus				1							
		Enochrus deserticola								1			
		Helochares sp. indet.					2	1		1			
		Helochares tatei	1										
		Hydrophilus brevispina										1	
		Paracymus sp. indet.		2									
		Paracymus spenceri	1				1			1			
		Regimbartia attenuata									2	3	2
	Noteridae	*Neohydrocoptus subfasciatus*				1							
	Scirtidae	Scirtidae indet. sp. indet.		1									
	Staphylinidae	Staphylinidae indet. sp. indet.						1					
Diptera	**Cecidomyiidae**	Cecidomyiidae indet. sp. indet.					2						
	Ceratopogonidae	Ceratopogonidae indet. sp. indet.					1						
		Dasyheleinae indet. sp. indet.		1			2	2		1		2	2
	Chaoboridae	Chaoboridae indet. sp. indet.	2							1			
	Chironomidae	Chironomidae indet. sp. indet.	3	2	3	2	1	2	2	2	3	3	4
		Chironominae indet. sp. indet.	4	3	4	4	3	4	4	3	4	4	4
		Orthocladiinae indet. sp. indet.	2		2				2		4	4	3
		Tanypodinae indet. sp. indet.	4	3	4	4	4	4	4	4	4	4	4
	Culicidae	Culicidae indet. sp. indet.		2									
		Aedes sp. indet.						1		1			
		Anopheles sp. indet.		3	2	2	1	1		1			2
		Culex sp. indet.		2						1		2	
	Dolichopodidae	Dolichopodidae indet. sp. indet.					2						
	Muscidae	Muscidae indet. sp. indet.	2							1			
	Simuliidae	Simuliidae indet. sp. indet.									4	3	
	Stratiomyidae	Stratiomyidae indet. sp. indet.										1	
	Tabanidae	Tabanidae indet. sp. indet.										1	
Thysanoptera		Thysanoptera indet. sp. indet.				3						1	
Trichoptera	**Ecnomidae**	*Ecnomus sp. indet.*	4	2	3	4	1	2			4	2	3
	Hydropsychidae	*Cheumatopsyche wellsae*									3	4	
	Hydroptilidae	*Hellyethira sp. indet.*			1							2	1

Phylum/Class/Order	Family	Lowest taxon	HC1	HC2	HC3	HC4	HC5	WS1	OP2	OP3	PB1	PH1	FM1
		Orthotrichia sp. indet.	2							1	1	2	
	Leptoceridae	Leptoceridae indet. sp. indet.						2	1			2	3
		Leptocerus atsou			1								
		Oecetis sp. indet.	2		2	1		1	3		2	2	3
		Triplectides ciuskus subsp. seductus						2	1		1		2
	Philopotamidae	Philopotamidae indet. sp. indet.										3	
		Chimarra sp. AV17										3	
		Total Taxa	**43**	**33**	**31**	**42**	**42**	**36**	**30**	**36**	**55**	**58**	**47**

Appendix 6a. Macroinvertebrate taxa list collected during the dry season (October/November) 2021. Values are $\log_{10}$ abundance categories, where 1= 1 individual, 2 = 2-10 individuals, 3 = 11-100, 4 = 101-1000 etc.

Phylum/Class/Order	Family	Lowest taxon	HC2	WS1	OP2	OP3	PB1	PH1	FM2
CNIDARIA									
HYDROZOA									
Anthoathecata	**Hydridae**	Hydra sp. indet.		2					
PLATYHELMINTHES									
RHABDITOPHORA	**Temnocephalidae**	Temnocephalidae indet. sp. indet.					2	1	
NEMATODA		Nematoda indet. sp. indet.			1	1			
MOLLUSCA									
GASTROPODA									
Hygrophila	**Lymnaeidae**	*Bullastra vinosa*					1		
	Planorbidae	*Ferrissia petterdi*			2	1			
		Gyraulus sp. indet.						1	
ANNELIDA									
OLIGOCHAETA		Oligochaeta indet. sp. indet.		1	2	1	2	4	4
ARTHROPODA									
CHELICERATA									
ARACHNIDA									
Mesostigmata		Mesostigmata indet. sp. indet.			1				1
Sarcoptiformes		Sarcoptiformes indet. sp. indet.		1					
Trombidiformes	**Arrenuridae**	Arrenuridae indet. sp. indet.	3						
	Hygrobatidae	Hygrobatidae indet. sp. indet.	3		1				2
	Limnesiidae	Limnesiidae indet. sp. indet.	4	2	2	1	1	2	
	Oxidae	Oxidae indet. sp. indet.	3						
	Pionidae	Pionidae indet. sp. indet.	3						2
	Unionicolidae	Unionicolidae indet. sp. indet.	3			1			
CRUSTACEA									
Malacostraca									
Decapoda	**Parastacidae**	*Cherax quadricarinatus*			1				
HEXAPODA									
INSECTA									
Odonata		Odonata indet. sp. indet.	1	4	2	2	2	3	1
	Libellulidae	*Diplacodes bipunctata*				2	1		
		Diplacodes haematodes				2	1		

Phylum/Class/Order	Family	Lowest taxon	HC2	WS1	OP2	OP3	PB1	PH1	FM2
		Orthetrum caledonicum			1	1	1		
	Coenagrionidae	*Agriocnemis sp. indet.*		3	1				
		Argiocnemis rubescens					1		
		Ischnura aurora		2		1			
Ephemeroptera	**Baetidae**	Baetidae indet. sp. indet.	3	4	3	4	3	4	3
		Cloeon sp. Red Stripe	3	4	3	4	4	4	4
		Offadens sp. G1WA2					4		
	Caenidae	Caenidae indet. sp. indet.		2	3	4	4	3	4
		Tasmanocoenis sp. M	1			3			
		Tasmanocoenis sp. P/arcuata		1	3	3	4	3	
Hemiptera	**Belostomatidae**	*Diplonychus sp. indet.*			2	2			
	Gerridae	Gerridae indet. sp. indet. (imm./dam.)				2	1		1
		Rhagadotarsus anomalus				2			
	Mesoveliidae	Mesoveliidae indet. sp. indet.		1					
	Micronectidae	Micronectidae indet. sp. indet.	2			4	3		
		Micronecta sp. indet.			4	4	3		2
		Austronecta bartzarum	2						
		Austronecta micra			4	3			
		Micronecta annae			4	4	3		2
	Nepidae	*Laccotrephes tristis*	1						
		Ranatra diminuta				2			
	Notonectidae	Notonectidae indet. sp. indet.			2		3		2
		Anisops sp. indet.			2	2	2	1	
		Anisops hackeri			1	2			
		Anisops nasutus				1			
	Pleidae	*Paraplea sp. indet.*	1	3	4	3	2		2
	Veliidae	Veliidae indet. sp. indet.	2		1	2	1		
Coleoptera	**Dytiscidae**	*Dytiscidae indet. sp. indet.*	2					2	1
		Allodessus bistrigatus	2				2		2
		Copelatus nigrolineatus					2		
		Cybister sp. indet.					1		
		Hydroglyphus grammopterus			2		2		
		Hydroglyphus leai			3		2		
		Hydroglyphus orthogrammus					3	2	1
		Hyphydrus elegans			2		2	1	2
		Hyphydrus lyratus			2	1	3		2
		Hyphydrus sp. indet.					2	2	1
		Laccophilus sp. indet.					2		
		Limbodessus compactus	1		2				
		Necterosoma sp. indet.					2		
		Neobidessodes denticulatus			3		3		
		Rhantus sp. indet.							1
		Rhantus suturalis							1
		Sternopriscus multimaculatus	1				2		
	Gyrinidae	*Dineutus australis*					2		
	Hydraenidae	*Hydraena sp. indet.*	2				1		
		Limnebius sp. indet.	2						
		Ochthebius sp. indet.			1				

Phylum/Class/Order	Family	Lowest taxon	HC2	WS1	OP2	OP3	PB1	PH1	FM2
	Hydrochidae	*Hydrochus sp. indet.*		2					
	Hydrophilidae	*Berosus sp. indet.*					1		
		Enochrus sp. indet.							1
		Helochares sp. indet.	1	3			2		
		Helochares tatei			1				
		Paracymus spenceri		2	1				
		Regimbartia attenuata	2				1		
	Spercheidae	Spercheus sp. indet.					1		
Diptera	**Ceratopogonidae**	Ceratopogonidae indet. sp. indet.	4	2	4	3	3	2	3
		Dasyheleinae indet. sp. indet.	2						1
	Chironomidae	Chironomidae indet. sp. indet.	2	2	2	2	3	4	3
		Chironominae indet. sp. indet.	3	4	3	4	4	4	4
		Orthocladiinae indet. sp. indet.		2		1	4	4	3
		Tanypodinae indet. sp. indet.	3	4	4	4	4	4	4
	Culicidae	Culicidae indet. sp. indet.	2	1					
		Anopheles sp. indet.	2				2	2	3
		Culex sp. indet.	1						2
	Dolichopodidae	Dolichopodidae indet. sp. indet.	1						
	Muscidae	Muscidae indet. sp. indet.	1						
	Simuliidae	Simuliidae indet. sp. indet.					4	3	2
	Tabanidae	Tabanidae indet. sp. indet.	2					2	1
	Thaumaleidae	Thaumaleidae indet. sp. indet.							2
	Tipulidae	Tipulidae indet. sp. indet.	2						
Lepidoptera	**Crambidae**	Crambidae indet. sp. indet.						1	1
Thysanoptera		Thysanoptera indet. sp. indet.		1	1				
Trichoptera	**Ecnomidae**	*Ecnomus sp. indet.*	2	1	2	2	3		
	Hydropsychidae	*Cheumatopsyche wellsae*					2		
	Hydroptilidae	*Hellyethira sp. indet.*	3						
	Leptoceridae	Leptoceridae indet. sp. indet.				1			2
		Leptocerus atsou				1			
		Oecetis sp. indet.		2	2			2	2
		Triaenodes sp. indet.				1			
		Triplectides ciuskus subsp. seductus			2		2	2	2
	Philopotamidae	*Chimarra sp. AV17*						1	
		Total Taxa	**37**	**25**	**40**	**38**	**51**	**26**	**37**

Appendix 7. Sediment rehydrate taxa list. Values are log_{10} abundance categories, where 1= 1 individual, 2 = 2-10 individuals, 3 = 11-100, 4 = 101-1000 etc.

						Wet Season				Dry Season							
Kingdom	**Phylum**	**Class**	**Order**	**Family**		**HC1**	**HC2**	**HC3**	**HC5**	**HC1**	**HC2**	**HC3**	**HC5**	**FM2**	**PB1**	**PH1**	**OP3**
Protista	Amoebozoa	Tubulinea	Arcellinida	Difflugiidae	*Difflugia sp. indet.*								1				
				Lesquereusiidae	*Lesquereusia spiralis*								3				
Animalia	Rotifera	Bdelloida			Bdelloidea indet. sp. indet.						2		1			1	
		Monogononta	Ploima	Euchlanidae	*Euchlanis incisa*								3				
				Lecanidae	*Lecane bulla*						2						
					Lecane 'bulloid' n. sp. indet.						2						
					Lecane nitida						3		2			2	
					Lecane (s.str.) sp. a						2						
				Notommatidae	*Notommata pachyura*			2	2		2						
	Arthropoda	Branchiopoda	Diplostraca	Chydoridae	*Alona rigidicaudis*										3	3	
					Armatalona macrocopa											3	2
					Chydorus cf. sphaericus					4	3	3	3				
					Ephemeroporus barroisi					3	2		3		2		
					Karualona karua										3	2	
					Chydoridae indet. sp. indet.											3	
				Daphniidae	*Ceriodaphnia cf. dubia*											2	
				Macrotrichidae	*Macrothrix sp. indet.*						1					4	
				Moinidae	*Moina micrura*	3										4	
		Ostracoda	Podocopida	Cyprididae	*Cypretta sp. indet.*						2		3	2	3	1	3
					Cyprinotus cingalensis												2
					Riocypris sp. indet.												3
					Stenocypris major												3
					Ostracoda indet. sp. indet.					1			1			2	4
				Limnocytheridae	*Limnocythere sp. indet.*		1							1			
					Total Taxa	**1**	**1**	**1**	**1**	**3**	**10**	**1**	**9**	**2**	**4**	**11**	**6**

End document.