

Malaga to Ellenbrook Rail Line

Targeted Black-stripe Minnow Survey

Biologic Environmental Survey

Report to METRONET

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EXECUTIVE SUMMARY

The Public Transport Authority of Western Australia (PTA) is proposing to develop the Malaga to Ellenbrook (MEL) Rail Works (the Project) as part of the Western Australian Government's METRONET vision. The Project's 501 ha Development Envelope extends east from the Tonkin Highway, north of Marshall Road to Bennett Springs where the railway alignment turns to the north to run adjacent to Drumpellier Drive (formerly Lord Street), passing under Gnangara Road and turning to the northeast to terminate south of The Parkway in Ellenbrook.

An Environmental Review Document (ERD) highlighted the presence of potential habitat for the conservation significant black-stripe minnow, *Galaxiella nigrostriata*, within the Development Envelope. The black-stripe minnow is currently listed as Endangered under the *Environmental Protection and Biodiversity Conservation (EPBC) Act 1999*, *Biodiversity Conservation Act 2016* (schedule 2) and IUCN Redlist of Threatened Species. As no previous targeted surveys have been undertaken in the area, METRONET required a targeted black-stripe minnow survey, focusing on wetlands likely to be impacted by the Project which support potential habitat for the species.

Six wetlands were surveyed extensively for black-stripe minnow, utilising all appropriate and possible methods at each location, including electrofishing, fyke nets, box traps, seine netting and dip netting. Water quality was recorded and a habitat assessment undertaken at each site. Given the large area of UFI 15259, this wetland was broken into two separate survey sites; the upper wetland/floodplain area and Bennett Brook proper. This resulted in a total of seven sites being intensively targeted for black-stripe minnow.

All sites except UFI 8724 (Horse Swamp) were found to support suitable habitat for black-stripe minnow, such as acidic, tannin-stained water and abundant vegetation present within a seasonal wetland. The neutral/slightly basic pH at UFI 8724 was outside their known preference (pH between 3.0 and 6.5). Despite the apparent suitability of habitat and survey effort expended, no black-stripe minnows were recorded.

The targeted survey was undertaken in August, coinciding with the most appropriate sampling time for black-stripe minnow; a time when wetlands are inundated following winter rains and black-stripe minnow movement is known to be highest. However, some wetlands had recently dried (UFI 8679) and others were notably shallow and showing signs of receding (i.e. UFI 15259 Wetland). While it may be argued that the lowering water levels may have prompted black-stripe minnows to begin aestivation early, digging amongst moist sediments at UFI 8679, searching through leaf litter, and dip netting throughout the entire surface water area remaining at UFI 15259 failed to locate any black-stripe minnows.

The sampling methods did manage to capture the cryptic nightfish, where it was present at UFI 15259 Bennett Brook Channel, as well as other native freshwater fish, crayfish and turtles from numerous sites. This suggests the methods used would likely have captured black-stripe minnows, if present. While the MEL wetlands are located within the historic range of the black-stripe minnow, with the closest known record lying approximately 14 km north of the

Development Envelope (EPP 173 Melaleuca Park), their distribution is known to have become fractured through habitat loss, with few populations remaining near Perth. It is likely a combination of factors that has resulted in their absence from the MEL wetlands. Climate change has led to drying of wetlands throughout the south-west, and while black-stripe minnows specialise in surviving drought, it may be that in this area soil moisture is not retained for a sufficient period over the dry season to allow their survival. Disturbance and fragmentation caused by surrounding urbanisation is another likely factor precluding black-stripe minnows from the area. With opportunities for population refreshment removed, once any local populations disappeared, there would be no return recruitment pathways for black-stripe minnow.

While no black-stripe minnows were recorded, the record of several other native fish species (western minnow, western pygmy perch, and nightfish) as well as southwestern snake-necked turtles and native crayfish (koonacs and gilgies) indicate that these wetlands are healthy and do contain notable environmental values. The low number of invasive mosquitofish was also encouraging.

1. INTRODUCTION

1.1 Background and objectives

The Public Transport Authority of Western Australia (PTA) is proposing to develop the Malaga to Ellenbrook (MEL) Rail Works (the Project) as part of the Western Australian Government's METRONET vision. The works include the installation of 13 km of new dual railway track which spurs off the proposed Bayswater to Malaga Rail Works line, and includes the construction and operation of three new stations at Malaga, Whiteman Park and Ellenbrook with intermodal rail, bus, carpark, and active mode (cycling and walking) facilities at each station and potential rail stabling. A potential future station is also proposed at Bennett Springs.

The Proposal's 501 ha Development Envelope extends east from the Tonkin Highway, north of Marshall Road to Bennett Springs where the railway alignment turns to the north to run adjacent to Drumpellier Drive (formerly Lord Street), passing under Gnangara Road and turning to the northeast to terminate south of The Parkway in Ellenbrook (Figure 1.1).

Several ecological surveys have been undertaken within the Development Envelope, as well as a desktop wetland assessment which synthesised all known information and values in one document. An Environmental Review Document (ERD) was also prepared for the Project, which highlighted the presence of potential habitat for the conservation significant black-stripe minnow, *Galaxiella nigrostriata*, within the Development Envelope. The black-stripe minnow is currently listed as Endangered under the *Environmental Protection and Biodiversity Conservation (EPBC) Act 1999*, *Biodiversity Conservation Act 2016* (schedule 2) and IUCN Redlist of Threatened Species (see Appendix A for a description of conservation listings). As no previous targeted surveys have been undertaken in the area, METRONET required a targeted black-stripe minnow survey, focusing on the wetlands likely to be impacted by the Project (either directly or indirectly) which support potential habitat for the species.

1.2 Scope of works

The scope of works included:

- Undertaking a targeted black-stripe minnow survey within the Development Envelope;
- Documentation of species assemblages, where present (abundance, length-frequency analysis);
- Preparation of maps showing species occurrences and distribution; and
- Preparation of a concise memo-style report of findings (this report).

Figure 1.1: Project Development Envelope

1.3 Black-stripe minnow

The black-stripe minnow, *Galaxiella nigrostriata,* is a small freshwater fish endemic to south-west Western Australia. It is found in seasonal wetlands within 100 km of the coast between Albany and Augusta, with several remnant populations occurring on the Swan Coastal Plan (Galeotti *et al.*, 2010). Isolated populations are also known from wetlands near Gelorup (Bunbury) (WRM, 2019), the Kemerton Nature Reserve (Bunbury) (Galeotti *et al.*, 2008), Lake Chandala (Gingin) (McLure & Horwitz, 2009) and EPP 173 Melaleuca Park (Ellen Brook) (Knott *et al.*, 2002).

Black-stripe minnows typically inhabit shallow (< 30 cm depth), acidic (pH between 3.0 and 6.5), tannin-stained wetlands with intact riparian vegetation (Galeotti *et al.*, 2010). Little is known about their specific physio-chemical tolerances; however, they are considered unable to tolerate high water temperatures (< 26 ºC; Smith *et al.*, 2002a). They have been recorded from waters with salinity up to 5,000 µS/cm, i.e. Melaleuca Park (Knott *et al.,* 2002). Ogston *et al.* (2016) further indicated that the presence of black-stripe minnow wetlands is influenced by lower temperatures, lower pH, and an increase in connectivity between pools.

Black-stripe minnows are not found in permanent water sources (Gill & Morgan, 1996; Morgan *et al.*, 1998), and survive the summer months, when the waters of their seasonal pools recede below the substrate, by submerging into moist sediments (Gill & Morgan, 1996; Morgan *et al.*, 1998). There is a lack of knowledge regarding aestivation duration, depth, timing, and physiological tolerances for this species, however, survival of aestivating individuals in summer would depend upon soil moisture. Unlike some aestivating frog species, black-stripe minnows do not build a cocoon to aestivate, but rather survive within moist sediments. Anecdotal evidence suggests black-stripe minnows can use crayfish burrows to gain access to moist, humid substrates when wetlands dry (Morgan *et al.*, 1998), however, no research exists to support this (Galeotti *et al.*, 2010). They have also been recorded under leaf litter and just below the surface in sandy soils during dry conditions (Berra & Allen, 1989).

Populations near Perth are thought to be remnants of a much wider distribution fractured by loss of habitat (Gill & Morgan, 1996). The nearest confirmed population to the Development Envelope is at Melaleuca Park, approximately 14 km to the north (Knott *et al.*, 2002; Smith *et al.*, 2002a; Smith *et al.*, 2002b); however the recent discovery of an existing population at Lake Chandala, near Muchea, and another in Gelorup, near Bunbury, indicates that additional remnant populations may be found in areas of suitable habitat (McLure & Horwitz, 2009). Threats to the black-stripe minnow include habitat loss, habitat alteration, and the introduction of alien fish species (Gill & Morgan, 1996). Ogston *et al*. (2016) further indicated that severe population losses have occurred as a direct result of climate change in southwestern Australia.

2 METHODS

2.1 Field survey

2.1.1 Survey team

The targeted survey was conducted by Biologic's Principal Aquatic Ecologist and Manager of Aquatic Ecology Jess Delaney, and Senior Aquatic Ecologist Alex Riemer. Jess and Alex have 17- and nine-years' experience, respectively, undertaking aquatic ecosystem surveys throughout Western Australia, including targeted fauna surveys in the Perth Metropolitan Area and south-west region.

Fauna sampling was conducted under a DBCA Authorisation to Take or Disturb Threatened Species (TFA 2020-0099), issued to Kim Nguyen, and DPIRD Instrument of Exemption (3386), issued to Jessica Delaney.

2.1.2 Survey timing and weather

The field survey was undertaken between the 26th and 28th of August 2020. Maximum daily temperature ranged from 21.1 °C to 25.4 °C, and was 4.2 °C warmer than the long-term average for August (BoM, 2020). There was no rainfall over the survey period, though 108.8 mm was recorded from the Whiteman Park gauging station (#9263; BoM, 2020) for the month prior to the survey.

2.1.3 Project location and survey sites

Based on previous ecological surveys, the desktop wetland assessment and Biologic's site visit in April 2020, six wetlands within, and adjacent to, the Development Envelope were identified as supporting suitable habitat for black-stripe minnows (Figure 2.1). These were:

- UFI 8678 – Un-named REW
- UFI 8679 – Un-named REW
- UFI 15259 – Bennett Brook CCW
- UFI 8724 – Horse Swamp CCW
- UFI 8418 – Orchid Park CCW
- UFI 8429 – Un-named CCW.

These six wetlands were therefore the focus of the targeted survey. Given the large area of UFI 15259, this wetland was broken into two separate survey sites; the upper wetland/floodplain area and Bennett Brook proper (near Cranleigh Road) (see Figure 2.1 and Appendix B).

Figure 2.1: Targeted Black-stripe Minnow Sampling Sites

2.1.4 Water quality

In situ water quality was measured at each site to provide information on the suitability of habitat for black-stripe minnows. *In situ* water quality was measured using a portable YSI Pro Plus multimeter. Parameters recorded were pH, redox potential (redox; mV), electrical conductivity (EC; µS/cm), dissolved oxygen (DO; mg/L and % saturation), and water temperature (ºC). The collection of water samples for laboratory analysis of dissolved metal and nutrient concentrations was outside the scope of the current study.

2.1.5 Habitat assessment

At each site, habitat characteristics were recorded to provide information on the types of habitat present and to assist in explaining distribution patterns and the presence/absence of black-stripe minnow. Details of in-stream habitat and sediment characteristics were recorded by the same team member at all sites to reduce the potential for habitat differences related to subjective recordings by different personnel. Habitat characteristics recorded included percent cover by inorganic sediment, submerged macrophyte, floating macrophyte, emergent macrophyte, algae, large woody debris, detritus, roots, and trailing vegetation. Details of substrate composition included percent cover by bedrock, boulders, cobbles, pebbles, gravel, sand, silt, and clay.

Other information relating to habitat were also recorded, including:

- hydrology (permanent inundation, seasonal inundation, seasonal waterlogging)
- maximum depth of water (m)
- surrounding land use
- identification of any potential ecological linkages (i.e. whether the wetland was also part of a river system or wetland chain).

2.1.6 Black-stripe minnow sampling

Black-stripe minnows were targeted using several methods to effectively capture as many individuals as possible, if present. Sampling methods included seine (10 m net, with a 2 m drop and 6 mm mesh), box traps (2 mm mesh with 2 inch entrance), fyke nets, dip nets (3 mm mesh) and the use of a backpack electrofisher (Smith-Root LR24 model).

Backpack electrofishing, box trapping and fyke nets are recommended for sampling galaxiids in the survey guidelines for Australia's threatened fish (SEWPaC, 2011) as they are considered to be the most effective techniques for detecting fish, with low mortality rates. Backpack electrofishing is particularly effective in systems with clear, low salinity, slow flow water and, when used correctly, draws fauna towards the anode pole (from within macrophytes, under large woody debris and undercuts in banks) and results in minimal impact to fish. All habitats were shocked, but shocking was not continuous to reduce potential impact to fauna and to prevent fish from being driven in front of the electrical field. Instead, areas of optimum habitat were targeted and shocked. Then the operator moved to a new habitat before shocking again.

Once shocked, fish were removed from the water immediately and placed in a bucket filled with site water.

Six baited box traps were set overnight at each site. Box traps were half submerged to ensure air space for freshwater turtles and water rats. SEWPaC (2011) suggest collapsible box traps are well suited to sampling small, bottom dwelling, cryptic fish, such as galaxiids.

Two fine soft mesh fyke nets were set overnight at each site, where there was sufficient space to do so. SEWPaC (2011) recommend their use because they are efficient for collecting galaxiids, while having minimal impact. Fyke nets comprised a double 10 m leader/wing (4 - 6 mm mesh, 1.5 m drop) and a 5 m hoop. In accordance with the guidelines (SEWPaC, 2011), a float was placed in the cod end of each net to ensure breathing space for turtles and water rats.

Shallow, open habitats with limited snags and woody debris were sampled using seine nets. Where seine netting was effectively undertaken, two hauls were conducted. Dip nets were used through macrophyte beds and along banks. Digging was conducted at sites were surface water had receded, but moist substrate remained where black-stripe minnows might be aestivating.

Fish, turtles, and crayfish were identified in the field, with appropriate measurements taken, and then released alive to the site of collection. As a condition of DPIRD exemptions, any introduced species were not returned to the site but were humanely euthanised in the field.

Plate 2.1: Electrofishing at UFI 8678.

Plate 2.2: Box trapping at UFI 8678.

Plate 2.3: Fyke net set across Horse Swamp.

2.2 Data analysis

2.2.1 Water quality

In situ water quality data were compared against the ANZECC & ARMCANZ (2000) default guideline values (DGVs) for the protection of aquatic ecosystems in the south-west of Western Australia (see Appendix C for default values). The primary objective of the guidelines is to "provide authoritative guidance on the management of water quality in Australia and New Zealand …. and includes setting water quality and sediment quality objectives designed to sustain current, or likely future, community values for natural and semi-natural water resources" (ANZG, 2018). DGVs are provided for a range of parameters designed to protect aquatic systems at a low level of risk but are not designed as pass or fail compliance criteria. Rather, exceedances of DGVs are triggers to inform managers and regulators that changes in water quality are occurring and may need to be investigated.

The guidelines have recently been updated to reflect a better understanding of physical and chemical stressors, the availability of additional monitoring data, the addition of recent toxicity data in DGVs for a number of toxicants, a weight of evidence approach, and the fact that water quality varies greatly across ecosystem types and regions (ANZG, 2018). The guidelines are now presented via an interactive online platform to improve usability and facilitate updates as new information becomes available. While information relating to management frameworks, background to derivation of DGVs, and approaches for sampling design and monitoring programs are available online, DGVs are not currently presented for all ecoregions. The Project falls within the Southwest Coast region and triggers for this area have not yet been updated. As such, water quality data from the current study were compared to the existing south-west W.A. DGVs for (a) 'lowland river systems' for Bennett Brook Channel or (b) 'wetlands' for all other sites sampled (ANZECC & ARMCANZ, 2000).

2.2.2 Fish

Where fish were recorded, length-frequency analysis was undertaken, whereby each species was classified into four age classes based on body size (standard length; SL[1]) mm. Age classes were determined from Pen *et al.* (1993) and other grey literature, and were based on the size of maturity for each species (Table 2.1).

Table 2.1 Standard lengths (mm) used for each age class for each species recorded.

Age class	Black-stripe minnow	Mud minnow	Western minnow
New recruit	≤ 20	≤ 25	≤ 30
Juvenile	21 - 24	26 - 30	31-50
Sub-adult	25 - 34	31 - 42	51-70
Adult	≥ 35	≥ 43	> 70

2.3 Assumptions and limitations

The survey was undertaken by qualified personnel with considerable experience in targeted aquatic fauna surveys. Potential limitations and constraints are summarised in Table 2.2.

Table 2.2: Summary of assumptions and limitations in relation to the current survey.

Potential limitation or constraint	Constraint (Yes / No)	Applicability to this survey
Experience of personnel	No	The principal and senior zoologists who undertook the survey have combined experience of 26 years undertaking targeted aquatic fauna surveys, with direct and relevant experience leading surveys in the southwest region. The team leader has 17 years' experience in aquatic ecosystem surveys, including targeted surveys for several conservation significant aquatic fauna species.
Scope (faunal groups sampled and whether any constraints affect this)	No	The scope was to conduct a field survey identifying any suitable habitat and determine the presence of black-stripe minnows, within six wetlands located within the Project Development Envelope. The survey was undertaken over a short period, limiting the survey effort to a single search event and single trapping night for each site. However, coverage of available habitat was not considered a limiting factor.
Proportion of aquatic fauna identified	No	All observed aquatic fauna was identified at the point of collection.
Sources of information (recent or historic) and availability of contextual information	No	Previous ecological surveys have been undertaken within the Development Envelope, though none specifically targeting black-stripe minnows. These reports provided context for the survey and locations to target sampling. Given that targeted sampling was undertaken at all sites, the historic records were not considered to pose any constraints.

[1] Standard length (SL) - measured from the tip of the snout to the posterior end of the last vertebra or to the posterior end of the midlateral portion of the hypural plate (i.e. this measurement excludes the length of the caudal fin).

Potential limitation or constraint	Constraint (Yes / No)	Applicability to this survey
Proportion of the task achieved	No	A targeted aquatic fauna survey at each of the six wetlands was completed and related to the broader contextual knowledge of the area.
Disturbances (e.g. fire or flood)	No	There were no recent fires or floods which posed a constraint to sampling effort. The vicinity of each site to public access meant there was potential for theft of field gear overnight. Though this was unlikely to impact the presence of black-stripe minnows, field personnel were careful to obscure nets and traps where possible, as well as place signs on equipment to minimise impact of theft on survey results.
Intensity of survey	No	The use of both active (electrofishing, seine, and dip nets) and passive (fyke nets and box traps) methods allowed for sufficient search effort for black-stripe minnows. While additional survey or replicated sampling effort may possibly identify black-stripe records, the intensity of the survey was considered adequate due to the use of several sampling methods.
Completeness of survey	No	The survey was adequately completed to meet the requirements of a targeted aquatic fauna survey.
Resources (e.g. degree of expertise available)	No	All resources required to complete the survey were available.
Remoteness or access issues	No	The majority of the Survey Area was accessible by foot (wading), thus the sampling techniques used during this survey were not constrained by accessibility.

3 RESULTS

3.1 Survey

3.1.1 Survey effort

All seven sites were surveyed for black-stripe minnow as intensively as site conditions allowed.

UFI 8678, Un-named REW

Electrofishing, two fyke nets, six box traps, and dip netting were used to survey UFI 8678 (Figure 3.1). Electrofishing shock time was 984 seconds. Seine netting was not possible due to site topography, with no banks with which to draw the seine net onto. Water quality was recorded, and a habitat assessment undertaken.

UFI 8679, Un-named REW

As this site was dry at the time of survey, usual fishing methods were not possible. The main pool area had only recently dried; however, and the substrate was still moist. As such, the team checked for aestivating minnows by digging shallow lines across the moist substrate and searching through leaf litter.

UFI 15259, Bennett Brook Wetland CCW

Only a small channel of shallow surface water was located at the time of survey. Water quality was recorded, habitat assessment conducted, and dip netting undertaken.

UFI 15259, Bennett Brook Channel CCW

Electrofishing, two fyke nets, six box traps, and dip netting were used to survey this site (Figure 3.2). Electrofishing shock time was 946 seconds. Water quality was recorded, and a habitat assessment undertaken.

UFI 8724, Horse Swamp CCW

Electrofishing, two fyke nets, six box traps, dip netting and seine netting were used to survey this site (Figure 3.3). Electrofishing shock time was 744 seconds. Water quality was recorded, and a habitat assessment undertaken.

UFI 8418, Orchid Park CCW

Electrofishing, six box traps, and dip netting were used to survey this site (Figure 3.4). Electrofishing shock time (380 seconds) was lower than some other sites due to difficulties electrofishing through the heavily vegetated wetland, as well as the smaller area of surface water present. Seine and fyke netting were not possible due to the dense, heavily vegetated nature of this wetland. Water quality was recorded, and a habitat assessment undertaken.

UFI 8429, Un-named CCW

All fishing methods were used to survey UFI 8429 (Figure 3.5). Electrofishing on time (300 seconds) was shorter than some other wetlands due to the smaller size of this wetland. Water quality was recorded, and a habitat assessment undertaken.

Figure 3.1: Survey effort at UFI 8678, Un-named REW

Figure 3.2: Survey effort at UFI 15259, Bennett Brook Channel CCW

Figure 3.3: Survey effort at UFI 8724, Horse Swamp CCW

Figure 3.4: Survey effort at UFI 8418, Orchid Park CCW

Figure 3.5: Survey effort at UFI 8429, Un-named CCW

3.1.2 Water quality

Water quality varied between sites, with some parameters being outside ANZECC & ARMCANZ (2000) DGVs. These included;

- pH – was below the lower DGV (i.e. more acidic) at four sites (UFI 8678, UFI 15259 wetland, Orchid Park and UFI 8429)
- EC – was in excess of the wetlands DGV at UFI 15259 and the lowland river DGV at UFI 15259 Bennett Brook Channel
- DO – was below the lower DGV at all sites except Horse Swamp (Table 3.1).

DO saturation was generally low across all sites, likely due to the shallow water depths and abundance of submerged macrophyte and algae. DO varies throughout the day, with lower saturation recorded in the early morning, when respiration by aquatic fauna, plants and algae would be high and there is no photosynthesis to replenish DO. Over the day, DO increases due to photosynthetic activity by aquatic plants. The decay of algae and submerged macrophytes also reduces DO, as bacteria consume oxygen in the water during this process. The DO needs of aquatic biota also differ between species and life history stage.

Water temperature, pH and salinity were within range suitable for black-stripe minnow at all sites except UFI 8724 Horse Swamp, where the slightly basic pH of 7.51 may preclude their presence.

Table 3.1: Summary of *in situ* water quality results.

Exceedances of the ANZECC & ARMCANZ (2000) DGVs are highlighted in grey.

	Water quality parameter and units						
Site	Water temp. °C	pH	EC µS/cm	Salinity ppt	DO mg/L	DO %	Redox mV
UFI 8678, Un-named REW	13.2	6.41	733	0.47	6.28	61.5	163.2
UFI 8679, Un-named REW	-	-	-	-	-	-	-
UFI 15259, Bennett Brook Wetland CCW	18.2	4.53	1644	0.97	2.34	25.0	162.4
UFI 15259, Bennett Brook Channel CCW	15.8	6.74	597	0.36	6.32	64.6	187.4
UFI 8724, Horse Swamp CCW	18.4	7.51	423	0.23	9.48	100.9	197.1
UFI 8418, Orchid Park CCW	14.6	5.20	797	0.48	1.98	20.0	180.2
UFI 8429, Un-named CCW	12.4	5.58	186	0.12	1.90	14.3	61.9

3.1.3 Habitat assessment

In-stream substrate was dominated by sand at all six sites where water was present, with varying levels of silt and clay (Figure 3.7; Appendix D). Such substrate would be considered appropriate for black-stripe minnow, being sufficiently soft to allow them to submerge, but with clay present to allow the retention of soil moisture.

In-stream habitat varied between sites, with two wetlands being dominated by inorganic sediment, one by detritus, one by emergent macrophyte, and one my submerged macrophyte (Figure 3.6; Appendix D). Habitat diversity was generally high, with UFI 15259, UFI 8678, and

UFI 8724 having the greatest diversity of in-stream habitat available. Table 3.2 provides a summary of the habitat present at all six sites.

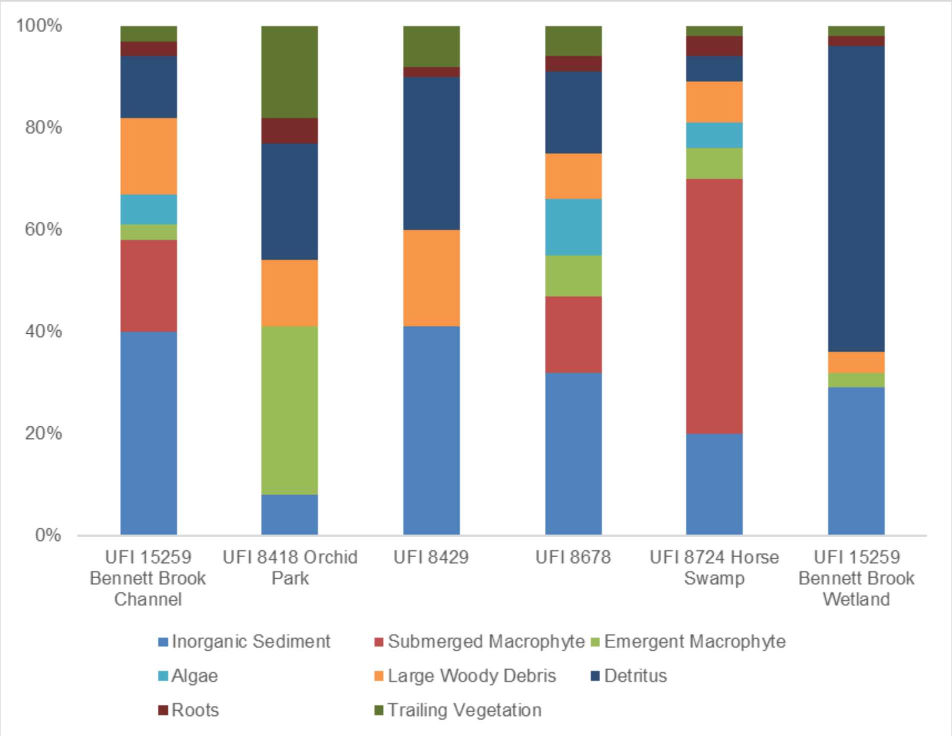


Figure 3.6: Percentage cover by habitat type at each site.

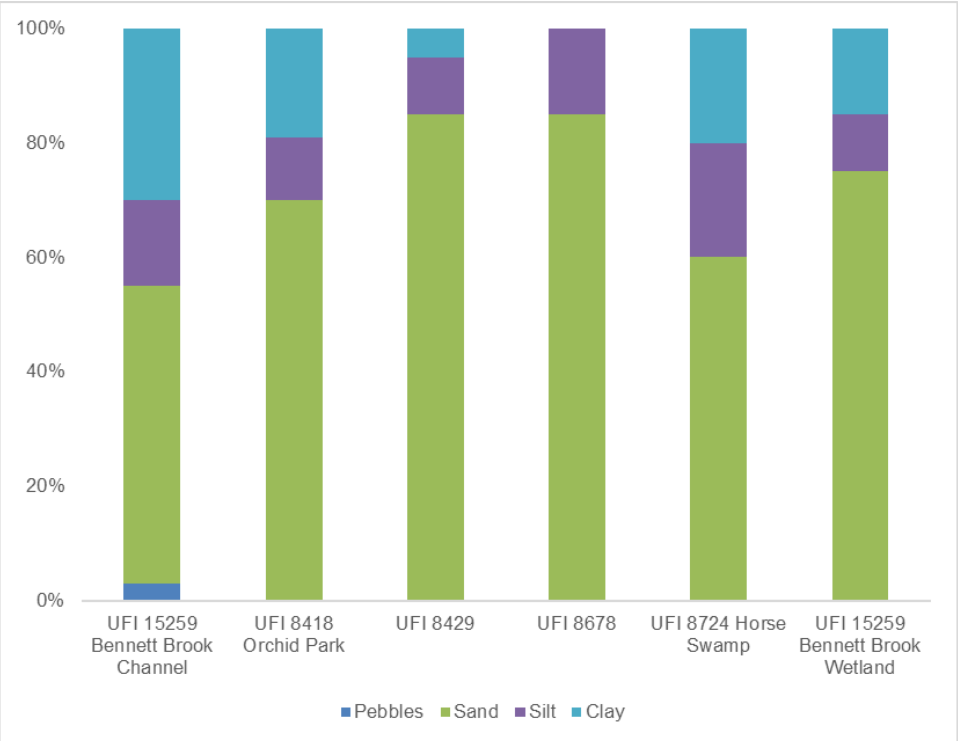
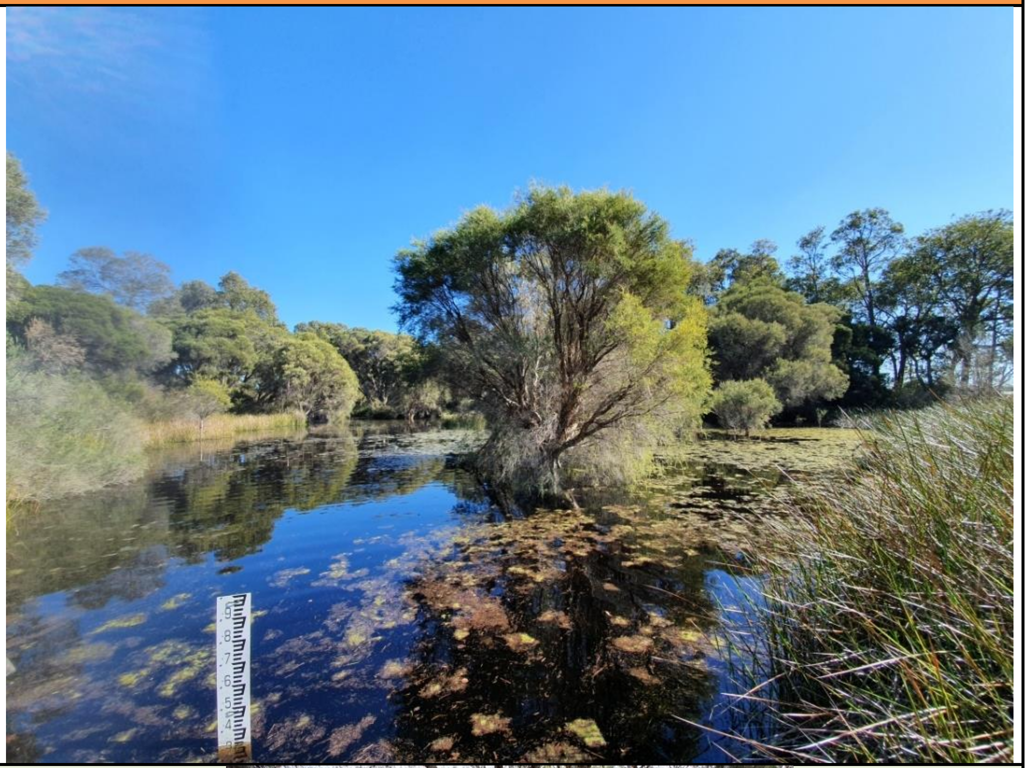
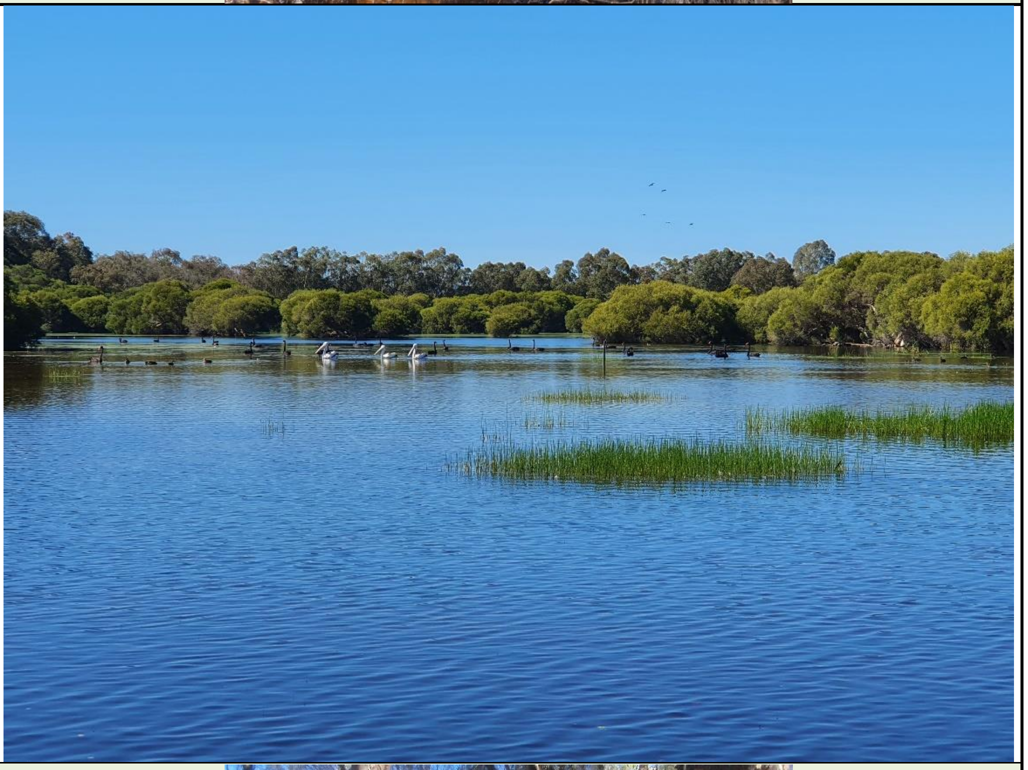


Figure 3.7: Percentage cover by sediment type at each site.

Table 3.2: Habitat summary for all sites sampled, including site photos.

Site	Description	Site photo
UFI 8678, Un-named REW	Open *Melaleuca* wetland surrounded by sedges. One large main pool. Some floating green algae present. Some submerged macrophyte present. Disturbances include vehicle tracks nearby and proximity of major roads (runoff). Maximum water depth 0.3 m. Tannin-stained.	
UFI 8679, Un-named REW	Dry at time of survey but with moist sediments present	
UFI 15259, Bennett Brook Wetland CCW	Small channel within the large floodplain wetland. *Melaleuca* woodland with some sedges. Maximum water depth 0.15 m. Tannin-stained.	

Site	Description	Site photo
UFI 15259, Bennett Brook Channel CCW	Turbid creek line through *Melaleuca* woodland. Several species of submerged macrophyte present. Disturbances include vehicle tracks, runoff from nearby roads and agricultural land, introduced vegetation, and human access. Maximum water depth 0.7 m.	
UFI 8724, Horse Swamp CCW	Open wetland. High cover of submerged macrophyte. Numerous species of water birds present at the time of survey. Disturbances include vehicle tracks surrounding the wetland, runoff from nearby roads and agricultural land, and human and livestock access. Maximum water depth 0.5 m.	
UFI 8418, Orchid Park CCW	Highly vegetated wetland. *Melaleuca* over sedges. Shallow water present across the main body of the wetland. Disturbances include introduced vegetation, runoff from nearby roads, and litter. Maximum water depth 0.2 m.	

Site	Description	Site photo
UFI 8429, Un-named CCW	Small *Melaleuca* wetland. No submerged macrophyte present. Disturbances include vehicle tracks, litter, and major roads nearby (runoff). Maximum water depth 0.55 m. Tannin-stained water.	

3.1.4 Black-stripe minnow

No black-stripe minnows were recorded at any of the seven sites surveyed, despite considerable sampling effort.

3.1.5 Other fish species

A total of 330 individual fish were recorded during the survey, representing four species of freshwater fish: western minnow (*Galaxias occidentalis*), western pygmy perch (*Nannoperca vittata*), nightfish (*Bostockia porosa*), and the introduced mosquitofish (*Gambusia holbrooki*) (Table 3.3).

Table 3.3: Freshwater fish abundance recorded from each site.

Species	Common name	UFI 8724 Horse Swamp CCW	UFI 15259 Bennett Brook Wetland CCW	Total
Galaxias occidentalis	**Western minnow**	175	65	**240**
Nannoperca vittata	**Western pygmy perch**		28	**28**
Bostockia porosa	**Nightfish**		58	
Gambusia holbrooki*	**Mosquitofish**		4	
	Total	**175**	**155**	**330**

*Introduced species

<u>Western minnow (*Galaxias occidentalis*)</u>

Western minnows are common in streams, lakes, and pools, in south-west Western Australia. They are found from Arrowsmith, 250 km north of Perth, to Albany (Morgan *et al.*, 1998). Their diet consists primarily of terrestrial insects and small aquatic crustaceans (Pen & Potter, 1991a). Western minnows attain a considerably larger maximum size (130 mm SL, but commonly 85 to 100 mm SL) than black-stripe minnows (50 mm SL, but commonly 35 mm SL). They are also readily distinguishable by the series of irregular darker bars along their sides (Plate 3.1).

A total of 240 western minnows were recorded from two sites during the survey: 175 at UFI 8724 and 65 at UFI 15259 Bennett Brook Channel. All size classes from new recruit to adult were recorded from UFI 8724. UFI 15259 Bennett Brook Channel supported juveniles, sub-adults, and adults.

Plate 3.1: Western minnow recorded from UFI 8724 Horse Swamp CCW.

Western pygmy perch (*Nannoperca vittata*)

Western pygmy perch (Plate 3.2) are common and widespread in south-western Australia, inhabiting fresh to brackish rivers, creeks, wetlands, and lakes (Bray & Thompson, 2019). They feed on aquatic invertebrates, primarily dipteran larvae, copepods, and ostracods (Pen & Potter, 1991b).

A total of 28 western pygmy perch were recorded from UFI 15259 Bennett Brook Channel, ranging in size from 25 mm to 49 mm. Male adult western pygmy perch were displaying breeding colours, indicating a viable breeding population was present. No other sites recorded western pygmy perch.

Plate 3.2: Western pygmy perch recorded from UFI 15259 Bennett Brook Channel.

Nightfish (*Bostockia porosa*)

Nightfish (Plate 3.3) are also widespread in south-western Australia. Their range extends from Jurien Bay in the north to Albany in the south (Morgan *et al.*, 1998). Nightfish inhabit clear or tannin-stained streams, rivers, lakes, and swamps where they hunt for benthic invertebrates at night and shelter in rock crevices and amongst vegetation during the day (Thompson & Bray, 2020). Given survey methods were adequate to capture this cryptic species, they should also be sufficient to catch black-stripe minnow, if present.

Nightfish were recorded from one site during the current survey: UFI 15259 Bennett Brook Channel. A total of 58 nightfish were recorded from this site, ranging in size from 42 mm to 105 mm. Nightfish were not recorded from any of the other sites sampled.

Plate 3.3: Nightfish recorded from UFI 15259 Bennett Brook Channel.

Mosquitofish (*Gambusia holbrooki*)

Mosquitofish were first introduced in Western Australia in 1934, ostensibly to control mosquitoes (Mees, 1977). They have since become a serious pest species in many wetlands and rivers throughout south-west Western Australia (Mees, 1977; White & Pyke, 2011). They are highly fecund, and able to tolerate a wide range of habitat conditions, which has allowed them to thrive where other fish species may be in decline (Pyke, 2005). While 'mosquitofish' are actually quite inept at mosquito control, they have many adverse effects on native freshwater fish and frogs, through competition, aggression and predation (Reynolds, 2009; White & Pyke, 2011).

Only four mosquitofish were recorded, also at UFI 15259 Channel. They ranged in size from 25 mm to 35 mm. No other sites recorded mosquitofish. The low abundance of mosquitofish recorded from only one site is a promising indication of the health of these wetlands.

3.1.6 Freshwater crayfish

Two species of native freshwater crayfish were recorded during the survey: the gilgie (*Cherax quinquecarinatus*) and koonac (*Cherax preisii*). Gilgies (Plate 3.4) have the widest distribution of all endemic freshwater crayfish in south-western Australia (Austin & Knott, 1996). They are able to thrive in a wide variety of wetland types, from ephemeral swamps to deep rivers (Beatty *et al.*, 2005). Koonacs tend to be found primarily in semi-permanent streams and swamps, where they dig burrows in the substrate (Austin & Knott, 1996). While both species are currently rated Least Concern by the IUCN Red List, endemic crayfish are threatened by habitat loss and competition from invasive crayfish species (Gouws *et al.*, 2006; Lynas *et al.*, 2007; Whiting *et al.*, 2000).

Three sites recorded freshwater crayfish during the survey:

- UFI 8678 - one adult male koonac and two juvenile gilgies;
- UFI 8418 - two male and two female gilgies; and,
- UFI 15259 Bennett Brook Channel - one female gilgie.

See Appendix F for carapace length (CL) measurements.

Plate 3.4: Juvenile gilgie from UFI 8678.

3.1.7 Turtles

The southwestern snake-necked turtle (*Chelodina oblonga*[2]) is endemic to south-western Australia where is inhabits swamps, lakes and slow-moving rivers, and feeds on a variety of small fish, tadpoles, molluscs, and crustaceans (Cogger, 2014). It is currently listed on the IUCN Redlist of Threatened Species as Near Threatened. Populations are under threat from habitat loss and fragmentation from increasing urbanisation, predation by invasive species such as foxes and cats, and vehicle impacts (Dawson *et al.*, 2016; Santoro *et al.*, 2020).

Six southwestern snake-necked turtles were recorded during the survey:

- UFI 8678 - three females and two males
- UFI 15259 Bennett Brook Channel – one male.

See Appendix E for carapace and plastron measurements.

Plate 3.5: Southwestern snake-necked turtle (*Chelodina oblonga*).

3.1.8 Frogs

Tadpoles were observed at all sites where water was present, and mating calls were heard at most sites. Adult squelching froglet (*Crinia insignifera*) and slender tree frog (*Litorea adelaidensis*) were observed at UFI 8724. Further survey of frogs was not undertaken as part of this survey, as targeted frog surveys are being undertaken by Mike Bamford separately.

[2] The identity of *Chelodina oblonga* has been unclear for some time, due to inclusion of populations throughout south-west WA, northern Australia, Cape York and southern New Guinea, as well as uncertainty over the identity of type specimens. A recent paper reviewing this issue, including genetic evidence, resolved some of the inconsistencies and returned the name *C. oblonga* to the south-western species (from the recent *C. colliei*) (Shea *et al.*, 2020).

4 DISCUSSION

Appropriate habitat for black-striped minnow was present at all sites surveyed except for Horse Swamp, where pH was too basic. All other sites comprised shallow, seasonal, tannin-stained, acidic, and well-vegetated wetlands. The wetlands were all surveyed as intensively as possible within the current scope and time frame, utilising all appropriate and available methods. These methods did manage to capture the cryptic nightfish, where it was present at UFI 15259 Bennett Brook Channel, as well as other native freshwater fish, crayfish and turtles from numerous sites. Despite the considerable survey effort and apparent suitability of habitat, no black-stripe minnows were recorded during the survey. While the MEL wetlands are located within the historic range of the black-stripe minnow, their distribution is known to have become fractured through habitat loss, with few populations remaining near Perth. It is likely that several factors have led to their absence from the MEL wetlands. The increased drying of climate within the region has reduced the length of time wetlands maintain soil moisture. This may mean that soil moisture is not retained for sufficient time to allow black-stripe minnow survival over the dry season. Disturbance and fragmentation caused by surrounding urbanisation may also preclude black-stripe minnows from the area. With opportunities for population refreshment removed, once any local populations disappeared, there would be no return recruitment pathways for black-stripe minnow.

The targeted survey was undertaken in August, coinciding with the most appropriate sampling time for black-stripe minnow; a time when wetlands are inundated following winter rains and black-stripe minnow movement is known to be highest. However, some wetlands had recently dried (UFI 8679) and others were notably shallow and showing signs of receding (i.e. UFI 15259 Wetland). While it may be argued that the lowering water levels may have prompted black-stripe minnows to begin aestivation early, digging amongst moist sediments at UFI 8679, searching through leaf litter, and dip netting throughout the entire surface water area remaining at UFI 15259 failed to locate any black-stripe minnows.

While no black-stripe minnows were recorded, the record of several other native fish species, as well as southwestern snake-necked turtles and native crayfish indicate that these wetlands are healthy and contain notable environmental values. The low number of invasive mosquitofish was also encouraging.

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APPENDICES

Appendix A: Conservation status codes

International Union for Conservation of Nature

Category	Definition
Extinct (EX)	A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
Extinct in the Wild (EW)	A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
Critically Endangered (CR)	A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (see Section V), and it is therefore considered to be facing an extremely high risk of extinction in the wild.
Endangered (EN)	A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Section V), and it is therefore considered to be facing a very high risk of extinction in the wild.
Vulnerable (VU)	A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see Section V), and it is therefore considered to be facing a high risk of extinction in the wild.
Near Threatened (NT)	A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future
Data Deficient (DD)	A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases, great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

Environment Protection and Biodiversity Conservation Act 1999

Category	Definition
Extinct (EX)	Taxa not definitely located in the wild during the past 50 years.
Extinct in the Wild (EW)	Taxa known to survive only in captivity.
Critically Endangered (CE)	Taxa facing an extremely high risk of extinction in the wild in the immediate future.
Endangered (EN)	Taxa facing a very high risk of extinction in the wild in the near future.
Vulnerable (VU)	Taxa facing a high risk of extinction in the wild in the medium-term future.
Migratory (MG)	Consists of species listed under the following International Conventions: Japan-Australia Migratory Bird Agreement (JAMBA) China-Australia Migratory Bird Agreement (CAMBA) Convention on the Conservation of Migratory Species of Wild animals (Bonn Convention)

Biodiversity Conservation Act 2016

Category	Definition
CR	Rare or likely to become extinct, as *critically endangered* fauna.
EN	Rare or likely to become extinct, as *endangered* fauna.
VU	Rare or likely to become extinct, as *vulnerable* fauna.
EX	Being fauna that is presumed to be extinct.
MI	Birds that are subject to international agreements relating to the protection of migratory birds.
CD	Special conservation need being species dependent on ongoing conservation intervention. (Conservation Dependant)
OS	In need of special protection, otherwise than for the reasons pertaining to Schedule 1 through to Schedule 6 Fauna. (Other specially protected species

Department of Biodiversity, Conservation and Attractions Priority codes

Category	Definition
Priority 1 (P1)	Taxa with few, poorly known populations on threatened lands.
Priority 2 (P2)	Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.
Priority 3 (P3)	Taxa with several, poorly known populations, some on conservation lands.
Priority 4 (P4)	Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection but could be if present circumstances change.

Appendix B: GPS location of sites sampled.

Site Sampled	Date	Latitude	Longitude
UFI 8678, Un-named REW	26/08/2020 – 28/08/2020	-31.8325062°	115.9631722°
UFI 8679, Un-named REW	26/08/2020 – 28/08/2020	-31.8353276°	115.9582918°
UFI 15259, Bennett Brook Wetland CCW	26/08/2020 – 28/08/2020	-31.8419194°	115.9412805°
UFI 15259, Bennett Brook Channel CCW	26/08/2020 – 28/08/2020	-31.8514903°	115.9540576°
UFI 8724, Horse Swamp CCW	26/08/2020 – 28/08/2020	-31.8459076°	115.9573124°
UFI 8418, Orchid Park CCW	26/08/2020 – 28/08/2020	-31.8573576°	115.923451°
UFI 8429, Un-named CCW	26/08/2020 – 28/08/2020	-31.8454148°	115.923938°

Appendix C: Default ANZECC & ARMCANZ (2000) water quality guidelines.

Default trigger values for some physical and chemical stressors for south-west Australia for slightly disturbed ecosystems (TP = total phosphorus; FRP = filterable reactive phosphorus; TN = total nitrogen; NOx = total nitrates/nitrites; NH4+ = ammonium). Data derived from trigger values supplied by Western Australia (ANZECC & ARMCANZ 2000).

Aquatic Ecosystem	Analyte						
	TP mg/L	FRP mg/L	TN mg/L	NOx mg/L	NH_4^+ mg/L	DO % saturation[i]	pH
Upland River[f]	0.02	0.010	0.45	0.20	0.06	90-na	6.5-8.0
Lowland River[f]	0.06	0.040	1.20	0.15	0.08	80-120	6.5-8.0
Lakes & Reservoirs	0.01	0.005	0.35	0.01	0.01	90-no data	6.5-8.0
Wetlands[d]	0.06	0.030	1.50	0.10	0.04	90-120	7.0[e]-8.5[e]

na = not applicable;

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

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

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

Default trigger values for salinity and turbidity for the protection of aquatic ecosystems, applicable to indicative of slightly disturbed ecosystems in south-west Australia (ANZECC & ARMCANZ 2000).

Salinity	(µs/cm)	Comments
Aquatic Ecosystem		
Upland & lowland rivers	120-300	Conductivity in upland streams will vary depending on catchment geology. Values at the lower end of the range are typically found in upland rivers, with higher values found in lowland rivers. Lower conductivity values are often observed following seasonal rainfall.
Lakes, reservoirs & wetlands	300-1,500	Values at the lower end of the range are observed during seasonal rainfall events. Values even higher than 1,500 µScm^{-1} are often found in saltwater lakes and marshes. Wetlands typically have conductivity values in the range of 500-1,500 µScm^{-1} over winter. Higher values (>3,000 µScm^{-1}) are often measured in wetlands in summer due to evaporative water loss.
Turbidity	**(NTU)**	
Aquatic Ecosystem		
Upland & lowland rivers	10-20	Turbidity and SPM are highly variable and dependent on seasonal rainfall runoff. These values representative of base river flow in lowland rivers.
Lakes, reservoirs & wetlands	10-100	Most deep lakes have low turbidity. However, shallow lakes have higher turbidity naturally due to wind-induced re-suspension of sediments. Wetlands vary greatly in turbidity depending on the general condition of the catchment, recent flow events and the water level in the wetland.

Appendix D: Habitat Assessment: Percentage cover by in-stream substrate type.

Site	Bedrock	Boulders	Cobbles	Pebbles	Gravel	Sand	Silt	Clay
UFI 8678, Un-named REW	0	0	0	0	0	85	15	0
UFI 15259, Bennett Brook Wetland CCW	0	0	0	0	0	75	10	15
UFI 15259, Bennett Brook Channel CCW	0	0	0	3	0	52	15	30
UFI 8724, Horse Swamp CCW	0	0	0	0	0	60	20	20
UFI 8418, Orchid Park CCW	0	0	0	0	0	70	11	19
UFI 8429, Un-named CCW	0	0	0	0	0	85	10	5

Habitat Assessment: Percentage cover by vegetation type.

Site	Inorganic Sediment	Submerged Macrophyte	Emergent Macrophyte	Floating Macrophyte	Algae	Large Woody Debris	Detritus	Roots	Trailing Vegetation
UFI 8678, Un-named REW	32	15	8	0	11	9	16	3	6
UFI 15259, Bennett Brook Wetland CCW	29	0	3	0	0	4	60	2	2
UFI 15259, Bennett Brook Channel CCW	40	18	3	0	6	15	12	3	3
UFI 8724, Horse Swamp CCW	20	50	6	0	5	8	5	4	2
UFI 8418, Orchid Park CCW	8	0	33	0	0	13	23	5	18
UFI 8429, Un-named CCW	41	0	0	0	0	19	30	2	8

Appendix E: Survey records of southwestern snake-necked turtle (*Chelodina oblonga*).

Site	Sex	Carapace length (mm)	Carapace width (mm)	Plastron midline length (mm)	Plastron max width (mm)	Shell height (mm)	Extended tail length (mm)
8678	Female	240	106	141	51	38	37
8678	Male	141	90	108	46	34	51
8678	Male	138	94	106	41	35	41
8678	Female	158	100	124	54	36	25
8678	Female	131	89	105	45	37	17
15259	Male	215	110	134	57	50	48

Appendix F: Survey records of freshwater crayfish.

Site	Species	Sex	Carapace length (mm)
8678	*Cherax preisii*	Male	58
8678	*Cherax quinquecarinatus*	Juvenile	<10
8678	*Cherax quinquecarinatus*	Juvenile	<10
15259	*Cherax quinquecarinatus*	Female	46
8418	*Cherax quinquecarinatus*	Male	16
8418	*Cherax quinquecarinatus*	Male	38
8418	*Cherax quinquecarinatus*	Female	27
8418	*Cherax quinquecarinatus*	Female	35