

Appendix G - SLR (2024) Fauna Technical Report – Black Striped Minnow and Western Swamp Tortoise



Supplementary Fauna Study and Literature Review For Proposed Northern Terminal – Neerabup Terminal 330 kV Line

Likelihood of Black-Stripe Minnow and Western Swamp Tortoise Habitat

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Basis of Report

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

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Executive Summary

Western Power is proposing the construction of a new 330 kV dual circuit transmission line, running approximately 29 km between the Northern Terminal in Malaga and Neerabup Terminal in Pinjar. An Environmental Impact Assessment (EIA) undertaken, identified a moderate likelihood of two conservation significant species occurring within the development envelope; Western Swamp Tortoise (*Pseudemydura umbrina*) and Black-Stripe Minnow (*Galaxiella nigrostriata*) (Western Power, 2024). As the EIA did not provide sufficient information to determine the impact of the development envelope on Black-Stripe Minnow and Western Swamp Tortoise, an additional desktop and literature review was undertaken to determine the suitability of habitat within the area and determine if a targeted survey would be required.

The fauna survey and subsequent desktop assessment completed by Western Power (2024) identified one wetland intersected by the development envelope that has potential habitat for Black-Stripe Minnow: wetland UFI 13,956. The reviewed literature revealed similarities between UFI 13,956 and Black-Stripe Minnow habitat (Melaleuca Park), such as vegetation structure and underlying geomorphology. Although these sites are within 6.5 km of each other, it was concluded that Black-Stripe Minnow presence is unlikely in UFI 13,956, given the lack of wetland connectivity, habitat disturbance and potential physio-chemical variability within this system.

The desktop assessment undertaken by Western Power (2024) identified two wetlands intersected by the Project that have potential habitat for Western Swamp Tortoise: wetland UFI 13,956 and 8,238. The reviewed literature revealed similarities between UFI 13,956 and 8,238 and Western Swamp Tortoise habitats (Ellen Brook Nature Reserve and Twin Swamps Nature Reserve), such as soil water holding capacity, potentially similar hydroperiods and water temperature ranges. However, it was concluded that Western Swamp Tortoise presence is highly unlikely in UFI 13,956 and UFI 8,238, given the distance and fragmentation between these wetlands and known populations, habitat disturbance, size of habitat and increased predation risk within these systems.

For both Black-Stripe Minnow and Western Swamp Tortoise although unlikely to occur within the Development Envelope, as there are no targeted studies published for these wetland systems, it is not possible to determine complete species absence.



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Acronyms and Abbreviations

PDWSA	Public Drinking Water Source Area
ASS	Acid Sulphate Soil
EIA	Environmental Impact Assessment
BSM	Black-Stripe Minnow
WST	Western Swamp Tortoise
SCP	Swan Coastal Plain
EBC	Ellen Brook Catchment
TSNR	Twin Swamps Nature Reserve
EBNR	Ellen Brook Nature Reserve
CPBE	Clay Pan Based Ecosystem
GWDE	Ground Water Dependent Ecosystem
DPIRD	Department of Primary Industries and Regional Development
DWER	Department of Water and Environmental Regulation



1.0 Introduction

1.1 Background

Western Power is proposing the construction of a new 330 kV dual circuit transmission line, running approximately 29 km between the Northern Terminal in Malaga and Neerabup Terminal in Pinjar. The purpose of this proposal is to remove constraints on existing connected generation and to allow future renewable energy generation connections for future demand in the North region. Located approximately 11 km to 29 km north-east of the Perth CBD, the development area falls within both the City of Swan and City of Wanneroo boundaries. Construction will be required across a mixture of land uses, ranging from urban, recreation, transport, infrastructure, and state forest, most of which has already been subject to some form of disturbance.

An Environmental Impact Assessment (EIA) identified a moderate likelihood of two conservation significant species occurring within the Project Area; Western Swamp Tortoise (*Pseudemydura umbrina*) and Black-Stripe Minnow (*Galaxiella nigrostriata*) (Western Power, 2024). As the EIA did not provide sufficient information to determine the impact of the Project Area on the Black-Stripe Minnow and Western Swamp Tortoise, an additional desktop and literature review will be undertaken to determine the suitability of habitat within the area and determine if a targeted survey would be required.

1.2 Scope of Work

To conduct a desktop literature review, to determine the likelihood of Black-Stripe Minnow and Western Swamp Tortoise habitat, including areas outlined in Western Power (2024) report, as well as any additional areas that might occur within the development envelope.

1.3 Study Area

The study area for the desktop review was inclusive of the inland surface waters up to 20 km from the development envelope, running approximately 29 km between the Northern Terminal in Malaga and Neerabup Terminal in Pinjar. The resultant study area considered multiple wetland systems along the Swan Coastal Plain (SCP) with focus on those within the Ellen Brook Catchment (EBC), particularly those intersecting the proposed development envelope: UFI 13,956 and UFI 8,238 (Figure 1).

2.0 Methods

2.1 Literature and Database Searches

Publicly available, relevant aquatic biology survey reports with research specific to the Black-Stripe Minnow and Western Swamp Tortoise were sourced and reviewed including but not limited to, relevant scientific reports and grey literature. The main aquatic biology reports reviewed are summarised in Table 1.



Table 2 lists the databases searched to ascertain distributions and habitat preferences relevant to this desktop assessment.

The literature review did not reveal any specific surveys of UFI 13,956 and UFI 8,238 so data was taken from the surrounding wetland systems between the proposed development envelope and the Ellen Brook Catchment (up to 20km).

Table 1. Main aquatic biology reports relevant to the study area and distribution of Black-Stripe Minnow and Western Swamp Tortoise, arranged by year of publication (for full citation, see References section).

YEAR OF PUBLICATION	AUTHOR	REPORT TITLE	REPORT TYPE
2002	Knott, Jasinka and Smith	Limnology and aquatic fauna of EPP 173, Melaleuca Park, refuge for an outlier population of the Black-stripe minnow <i>Galaxiella nigrostriata</i> (Galaxiidae), in southwestern Australia.	Scientific Journal Publication
2004	Burbidge and Kuchling	Western swamp tortoise (<i>Pseudemydura umbrina</i>) recovery plan.	Recovery Plan
2010	Galeotti, McCullough and Lund	Black-stripe minnow <i>Galaxiella nigrostriata</i> (Shipway 1953) (Pisces: Galaxiidae), a review and discussion.	Scientific Journal Publication
2014	Dade, Pauli, and Mitchell,	Mapping a new future: using spatial multiple criteria analysis to identify novel habitats for assisted colonization of endangered species.	Scientific Journal Publication
2016	Tareque	An integrated eco-hydrological approach for assessing critical wetland habitats and conservation reserves in a changing climate.	Thesis
2019	WRM	Bunbury Outer Ring Road Northern and Central Investigation Area: Targeted Conservation Significant Aquatic Fauna Survey.	Report
2024	Western Power	Environmental Impact Assessment - Northern Terminal (NT) to Neerabup Terminal (NBT).	EIA



Table 2. Database searches

DATABASE	DESCRIPTION	AUTHORITY	AREA OF SEARCH / KEYWORDS
Freshwater Fish Distribution in Western Australia	Search conducted by SLR on 14 th October 2024	DPIRD	Search for all records of <i>BSM</i>
Healthy Rivers South-West	Search conducted by SLR on 14 th October 2024	DWER	Search for all records of <i>BSM</i> and <i>WST</i>
Atlas of Living Australia (ALA)	Search conducted by SLR on 15 th October 2024.	Collaborative project between academic, private and community groups.	Search for all records of <i>BSM</i> and <i>WST</i>
SLR WA Enviro Map	Search Conducted by SLR on 15 th October 2024	SLR/SLIP/Landgate	Vegetation Complex, Soil Subsystems, Hydrography SCP, Geomorphic Wetlands SCP
DBCA Library	Search Conducted by SLR on 17 th October 2024	DBCA	Swan Coastal Plain



3.0 Results

3.1 Environment

3.1.1 IBRA Region

The Swan Coastal Plain (SCP) spans from Wedge island to Dunsborough, extending more than 100 km along the coast. In the Perth Region, the SCP eastern boundary is the Darling Scarp, approximately 25 kms from the coast. Its climate is classified as warm Mediterranean and rainfall ranges between 1000 and 600 mm annually (Semeniuk, 1988). It includes urban developments associated with the city of Perth and is dominated by woodlands of *Banksia spp.* and *Eucalyptus gomphocephala* on sandy soils, *Allocasuarina* on outwash plains, and *Melaleuca* in swampy areas (DBCA, n.d). The colluvial and aeolian sand areas represent three phases of Quaternary marine sand dune development, and include a complex series of seasonal freshwater wetlands, alluvial river flats, coastal limestones and several offshore islands. (DBCA, n.d). These wetlands include permanently, seasonally and episodically flooded water bodies, variously described as lakes, wetlands, swamps, marshes and damplands (Chessman, Trayler and Davis, 2002). The Moore/Gingin, Hill, Swan, Serpentine, Murray, Harvey, Collie, Preston, Capel and Wellesley rivers flow through the SCP. Most have their catchment areas in bioregions to the east (DBCA, n.d).

3.1.2 Project Area

The Project falls within the Ellen Brook Catchment which is located about 20 km north-east of Perth City and 25 km east from the coastline of Western Australia. The surface water catchment area of Ellen Brook, approximately 50 km long north-to-south and 20 km wide east-to-west, is 715 km². The Ellen Brook flows south and joins the Swan River near Belhus (Smith and Shams, 2002). The Impact Area consists of a mixture of low lying areas and sand dunes of the Bassendean Formation (Semeniuk and Glassford, 1989). The habitat is specifically classed as Bassendean Seasonal Swamp Phase and consists of grey sand over pale yellow sands generally underlain by humic, iron and peat podzols, containing *Banksia spp.* low open woodlands with a dense shrub layer (SLIP/Landgate, 2024). The flat plains of the catchment are prone to inundation in winter through either rising water table or water logging on surfaces with low permeability, therefore, majority of wetland systems surrounding the Impact Area are ephemeral and have the potential to hold free water over winter (Smith and Shams, 2002).

3.1.2.1 Geomorphic Wetlands

A review of the online database identified that a total of 14 geomorphic wetlands are intersected by the development envelope. These wetlands comprise all three types of geomorphic wetland (Resource Enhancement, Multiple Use Wetland and Conservation Category Wetland). These wetlands represent mixed ephemeral *Melaleuca preissiana* wetlands, with *Kunzea glabrescens* dominated shrub and mixed heath patches. Wetland birds such as the Australian Little Bittern (*Ixobrychus dubius*) and the Glossy Ibis (*Plegadis falcinellus*) are likely to utilise this habitat. The majority of the wetlands are located at the southern section of the Impact Area, from Bennet Brook (Western Power, 2024).



Wetland UFI 13,956

Wetland UFI 13,956 represents an unnamed Conservation Dampland basin in the north of the Project that supports intact riparian vegetation in ‘excellent’ condition. The total mapped extent of this wetland is approximately 49 ha. Clearing within the mapped extent of UFI 13,956 comprises 2.5 ha of permanent clearing and 1 ha for temporary construction activities. In total, up to 3.5 ha of wetland riparian vegetation will be affected (Western Power, 2024). UFI 13,956 is considered part of the EBC and is an ephemeral wetland that fills following winter rainfall and dries over summer (Western Power, 2024; SLIP/Landgate, 2024). The landscape is flat or gently undulating and the soil subsystem is a combination of Bassendean sand, peat, iron-humus podzols and diatomite deposits resulting in poorly drained depressions. The surrounding low open forest, low woodland and sedgeland are composed of *Banksia ilicifolia* and *Eucalyptus rudis* on sandy soils, *Allocasuarina* on outwash plains, and *Melaleuca preissiana* in swampy areas, with a dense fringing shrub layer and combination sedge and reed layer (SLIP/Landgate, 2024).

Wetland UFI 8,238

Wetland UFI 8,238 is situated within the Ellenbrook Catchment and represents an unnamed Multiple Use Dampland basin located in a pine plantation. It covers a mapped area of 90.44 hectares and clearing within the mapped extent of UFI 8,238 totals 2.6 ha. UFI 8,238 is also ephemeral, filling in winter and drying in summer (Western Power, 2024). The soil subsystem is a combination of Bassendean sand, peat and humus podzols resulting in poorly drained depressions. Although the wetland is surrounded by pine plantation, SLIP/Landgate (2024) describe the immediate vegetation as low open forest, low woodland and sedgeland composed of *Banksia ilicifolia* and *Eucalyptus rudis* on sandy soils, *Allocasuarina* on outwash plains, and *Melaleuca preissiana* in swampy areas, with a dense fringing shrub layer and combination sedge and reed layer. The reviewed literature did not reveal any ground truthed habitat and vegetation reports for the area, and therefore the quality of this vegetation is only known from Western Power (2024) as heavily disturbed and degraded because of the pine plantation.



3.2 Black-Stripe Minnow

3.2.1 Background

The Black-Stripe Minnow (*Galaxiella nigrostriata*) is currently listed as Endangered nationally (EPBC Act 1999) and at a state level in Western Australia (Schedule 2 of the Wildlife Conservation Specially Protected Fauna Notice 2018), as well as Endangered at an international level (IUCN, 2024). The Western Power (2024) review reported that the Black-Stripe Minnow are known to inhabit wetlands within the EBC, concluding that they are limited to seasonally or permanently inundated wetlands that may occur throughout the Project Area. The potential impact on this species was determined as low as the likelihood of presence was 'moderate'.

The Black-Stripe Minnow is endemic to south-western Australia and rare throughout its distribution. Its main distribution lies within the Warren sub-region, where numerous populations are found between Albany and Augusta. However, there are isolated populations on the Swan Coastal Plain, including Lake Chandala (near Gingin), Melaleuca Park (north of Perth), and wetlands within the Kemerton Nature Reserve (north of Bunbury) (Morgan, Gill and Potter, 1998; Allen, Midgley and Allen, 2002). In addition to the above occurrences on the Swan Coastal Plain, a survey by SLR in October 2018 recorded a population of Black-Stripe Minnows in Gelorup (WRM, 2019). It is thought that the populations on the Swan Coastal Plain are remnants of a once wider distribution (Morgan, Gill and Potter, 1998), suggesting that the loss of habitat caused by urban and rural development has had a significant impact on the extent of this species.

The Black-Stripe Minnow is capable of aestivating into soils to survive drying habitat and therefore can inhabit wetlands that dry over summer, appearing in pools following first rains (Morgan et al., 2011). They do not have any specific anatomical or physiological adaptations to aid aestivation and is assumed to survive either within moist soils or within crayfish burrows that contain water through dry periods. It appears that most individuals only live for one year, dying shortly after spawning (Morgan et al., 2011).

3.2.2 Historical Habitat Preferences

Black-Stripe Minnow are present in two confirmed populations on the Swan Coastal Plain within 6.5 km from the development envelope: Chandala Lake and EPP 173 within Melaleuca Park. Chandala Lake is located between Muchea and Gingin where it overlies three different sediment types: Cretaceous sand, Guildford clay and Bassendean sand. The wetland is a permanent freshwater system that supports relatively rich invertebrate communities (McLure and Horwitz, 2009). The wetlands historical average pH, temperature and salinity fall within the tolerances of Black-Stripe Minnow (6.8, 1013 to 2893 $\mu\text{S}/\text{cm}$ and 15 °C respectfully) (**Table 3**) and supports one of the SCP populations (McLure and Horwitz, 2009).

The Melaleuca Park wetland system is a complex of four swamps located on the eastern side of the park. The underlying sediment is Bassendean sand and peat which supports a variety of intact riparian vegetation and sedges such as *Baumea articulata* (Jointed Rush) within a combination of low open woodland and dense scrub (SLIP/Landgate, 2024). Of the four wetlands, EPP 173 alone receives permanent groundwater discharge which maintains several



square metres of standing water (<11cm) throughout warmer months when the other wetlands dry. EPP 173 has a historical pH of 3.3 to 5.5, temperature of 12.8°C to 17°C and salinity of 3060-5000 µS/cm, which is the highest salinity range recorded in Black-Stripe Minnow habitat (Knott, Jasinka and Smith, 2002). Other than these general observations, and anecdotal information, little is known about the preferred physio-chemical water properties of their habitats, with no correlations found between physio-chemical variables measured in wetlands across the south-west (Galeotti, 2013). However, individual populations appear to be sensitive to sudden, localised changes in water quality variables (Knott, Jasinka and Smith, 2002).

Table 3. Black-Stripe Minnow habitat components with description of parameters and preferences.

HABITAT COMPONENT	DESCRIPTION OF PARAMETERS AND PREFERENCES
Habitat and Vegetation	Populations studied within the Swan Coastal Plain have been most frequently observed in water bodies located in peat flats (Morgan and Gill, 2000). They are known to inhabit tannin stained, vegetated, ephemeral wetlands of approximately 300 mm deep (Morgan and Gill, 2000). The species tend to inhabit a wide variety of instream habitats, including large woody debris, emergent macrophytes, trailing vegetation, submerged macrophytes, and detritus (WRM, 2019). WRM (2019) reported undisturbed riparian cover ranging from 10% to 85%.
Soil Type	A combination of sand and clay substrate would be considered appropriate for Black-Stripe Minnow, being sufficiently soft to allow them to submerge, with clay present to allow the retention of soil moisture (Morgan and Gill, 2000).
Temperature	Ranges from 11–30°C (Morgan and Gill, 2000; Galeotti, McCulloch and Lund, 2008).
Salinity	While there is limited information on the salinity tolerance of the Black-Stripe Minnow, previous studies have recorded its presence in wetlands with salinity levels exceeding 3330 µS/cm (Morgan and Gill, 2000; Galeotti, McCulloch and Lund, 2008).
pH	Ranges from 3 – 8 (Morgan and Gill, 2000; Galeotti, McCulloch and Lund, 2008).

It has been hypothesised that small remnant populations may be found outside of these two Swan Coastal Plain populations, within their known range boundaries (Galeotti, McCulloch and Lund, 2010). Surveys conducted within the Kemerton region have shown that Black-Stripe Minnow populations will disperse in years of high rainfall; they were declared extinct in one of the pools, only to be recorded in subsequent surveys (MBS Environmental, 2009). It is thought that Black-Stripe Minnow populations have the ability to go through range extension from source habitats and contraction from sink habitats, forming metapopulations, although the trigger of this movement remains inconclusive (Galeotti, 2013). Migration between water bodies is limited to direct connections such as annual and perennial inundation, or during



temporary sheet flow caused by heavy rainfall, as they have been observed in water 2mm deep (Galeotti, 2013).



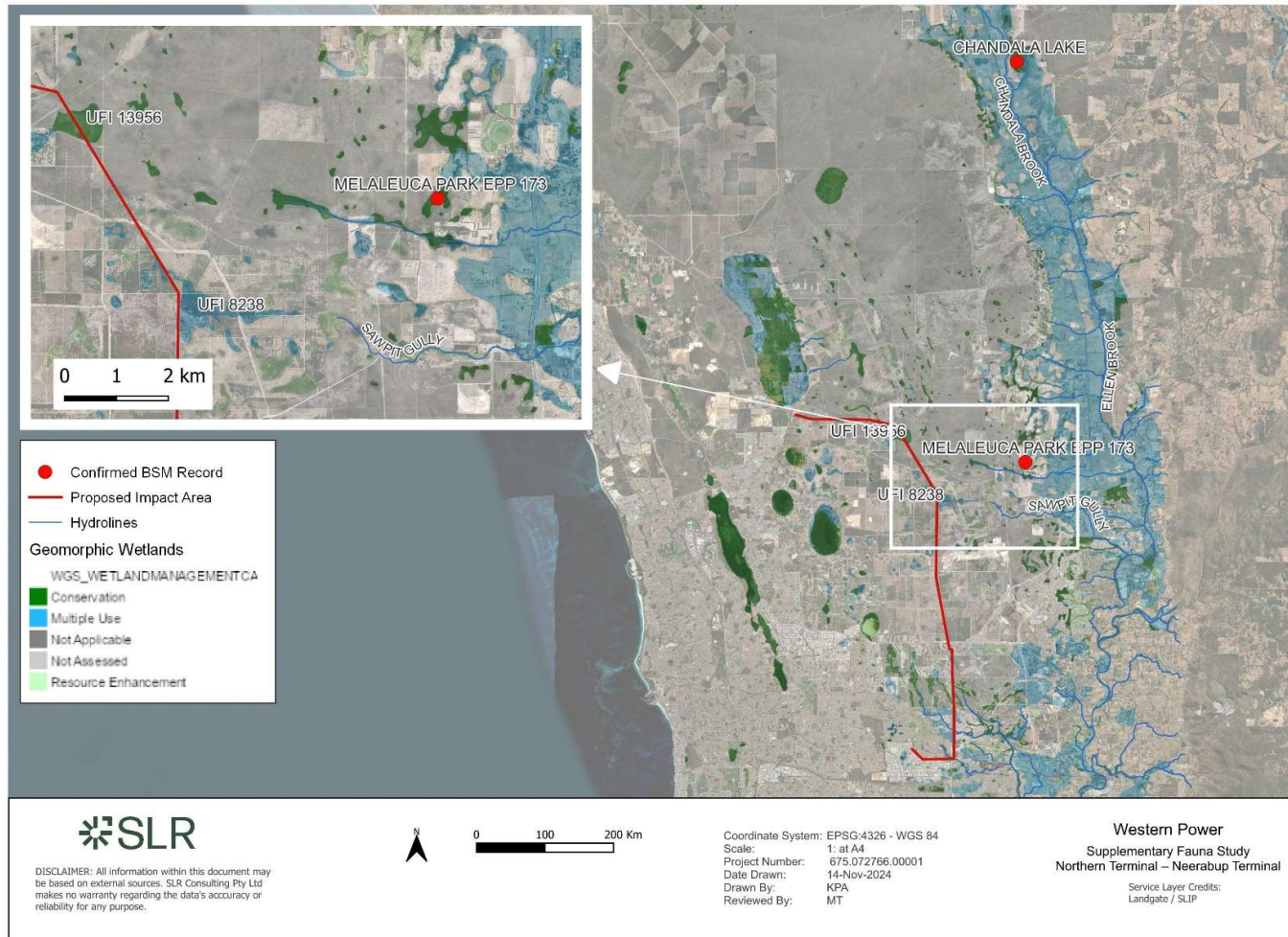


Figure 1. Black-Stripe Minnow populations of the SCP and Proposed Impact Area.



3.2.3 Potential Habitat within the Development Envelope

The fauna survey and subsequent desktop assessment completed by Western Power (2024) identified one wetland intersected by the development envelope that has potential habitat for Black-Stripe Minnow: wetland UFI 13,956, described above. The Project is approximately 6.5 km from the closest mapped habitat. Review of literature returned no recorded water quality parameters, habitat or vegetation reports for comparison to Melaleuca Park or Chandala Lake. Food availability is also unknown.

UFI 13,956 lies within 6.5km of the Melaleuca Park (**Figure 1**) and is composed of the same combination of Bassendean sand and peat soil system. Both sites also contain a variety of intact riparian vegetation and sedges within a combination of low open woodland and dense scrub, which is suitable Black-Stripe Minnow habitat.

The Melaleuca Park wetland system is fed from ground water and an unnamed creek off the Ellenbrook River, which holds water year-round. Although the underlying geomorphology and vegetation appears similar based on (SLIP/Landgate, 2024), as UFI 13,956 does not receive permanent ground water discharge and completely dries over summer, it is therefore likely to have greater physio-chemical variability (Boon, 2024) than Melaleuca Park and Chandala Lake. Connection between UFI 13,956 and Melaleuca Park is unlikely as UFI 13,956 falls outside of the inundation range of creek lines surrounding Melaleuca Park (Smith and Shams, 2002) it may be possible during flooding events (**Figure 2**). Although the reviewed literature indicated that Black-Stripe Minnow presence is unlikely.

Western Power (2024) did not determine UFI 8,238 to be suitable habitat for Black-Stripe Minnow. Galeotti, McCullough and Lund (2010) reported that Black-Stripe Minnow have not been found in wetland habitats where surrounding vegetation has been cleared, which highlights the importance of riparian vegetation to habitat suitability. The proximity and potential impact of the surrounding pine plantation on composition and quality of the historical vegetation structure is unknown without ground truthing, although it has been described as heavily disturbed and degraded (Western Power, 2024). UFI 8,238 also falls outside of general inundation ranges of creek lines surrounding Melaleuca Park (**Figure 2**). As Black-Stripe Minnow populations appear to be sensitive to sudden, localised changes in water quality variables, and are usually found in areas of undisturbed riparian vegetation (Knott, Jasinka and Smith, 2002; Galeotti, McCullough and Lund, 2010), this is not considered suitable habitat.



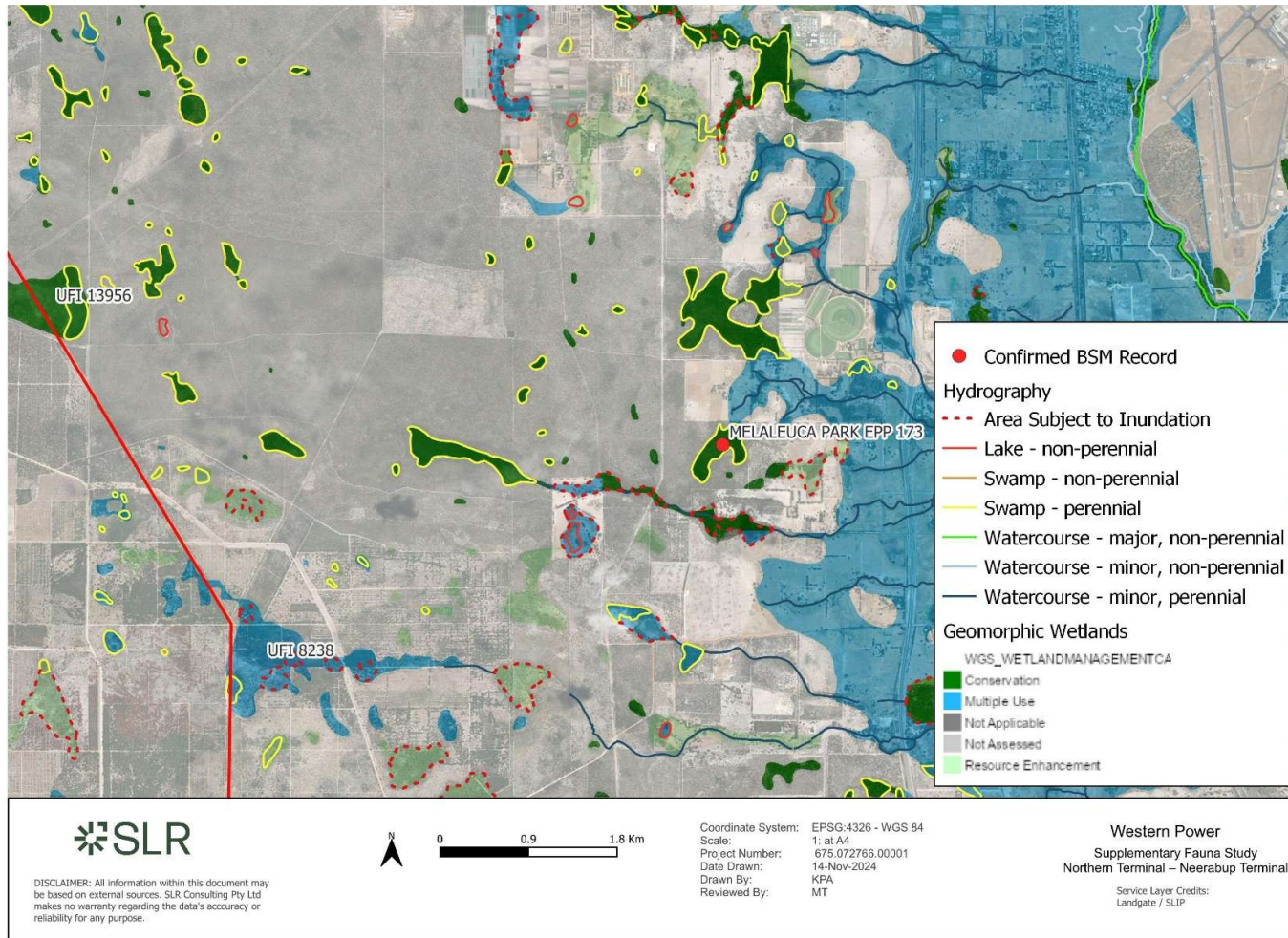


Figure 2. Hydrography of wetlands intersecting the Proposed Impact Area and the surrounding EBC.



3.3 Western Swamp Tortoise

3.3.1 Background

The Western Swamp Tortoise (*Pseudemydura umbrina*) is currently classified as Critically Endangered (ranking by WA Threatened Species Scientific Committee), Endangered (Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*), and listed as Critically Endangered in the IUCN 2000 Red List of threatened animals (Burbidge and Kuchling, 2004). The Western Power (2024) review reported that the Western Swamp Tortoise are known to inhabit two wetlands in the EBC, however, wetlands within the Impact Area may contain this species. The potential impact on this species was determined to be low as the likelihood of presence is only 'moderate' (Western Power, 2024).

The Western Swamp Tortoise has a very small geographic range and has only been recorded in a narrow strip of the SCP in Twin Swamps Nature Reserve and Ellen Brook Nature Reserve (Burbidge and Kuchling, 2004) (**Figure 3**). Surrounding these two sites, almost all this land is now cleared and either urbanised, used for intensive agriculture or mined for clay for brick and tile manufacture (Burbidge and Kuchling, 2004). Burbidge (1967) reports unsubstantiated sightings from near Mogumber (60 km north of Upper Swan), Pinjarra (100 km south) and Donnybrook (200 km south) (Burbidge and Kuchling, 2004).

The Western Swamp Tortoise inhabits shallow, ephemeral, winter wet swamps on clay or sand over clay soils (Burbidge, 1967; 1981). They can be found in the water within these swamps, preying on living food (insect larvae, small crustaceans, worms, and tadpoles). They feed exclusively under water, therefore feeding is restricted to winter and spring months when wetlands have been filled following winter-rains (CSIRO, 2018). When swamps are dry, the tortoise moves into surrounding vegetation to aestivate during warmer months in naturally occurring holes or under leaf litter (Burbidge, 1967; 1981).

3.3.2 Historical Habitat Preferences

Western Swamp Tortoises have only been documented within a small geographical range along the Swan Coastal Plain, with underlying alluvial soils. This area runs roughly parallel to the Darling Scarp, extending from Perth Airport at Guildford to near Pearce Royal Australian Air Force Base at Bullsbrook (Burbidge and Kuchling, 2004).

Ellenbrook Nature Reserve is a Clay Pan Based Ecosystem (and is currently the only naturally and self-sufficient wild population (Burbidge et al., 2010). SLIP/Landgate (2024) classify Ellenbrook Nature Reserve as a gently sloping river margin existing on low flats with poorly drained soils, subject to inundation. The soils are composed of partly Gilgai and partly claypan components (Tareque, 2016). The vegetation complex is classed as open forest to tall open woodland with *Melaleuca spp.*, *Eucalyptus rudis* and *Casuarina obesa* on salt affected areas. Most hydroperiods at Ellenbrook Nature Reserve are between four to seven months and water temperatures range from 14-28°C (Tareque, 2016).

Twin Swamps Nature Reserve is a marginal habitat that requires the annual support of translocations to sustain population numbers. The system is a Groundwater Dependent Ecosystem (GDE) subject to inundation and only contains clay at depth (15-30cm) (Tareque,



2016). Twin Swamps Nature Reserve occurs over a flat plain with occasional low dunes and the soil system is mainly composed of sandy and solenetzic substrate, poorly drained and high in soluble salts (Tareque, 2016). The water quality, and quantity, of this site are significantly affected by increased aridity, climate change, and a lowered water table (Burbidge et al., 2010). The vegetation complex is classed as combination scrub, low open forest and open woodland with *Casuarina obesa* and salt tolerant grasses with scattered *Eucalyptus rudis*, *Melaleuca spp* and *Banksia spp* in less salty areas (SLIP/Landgate, 2024). Most hydroperiods at TSNR are between three to six months and water temperatures range from 14-28°C (Tareque, 2016).

Dade, Pauli and Mitchell (2014) reported on the suitability of habitat within the SCP for translocation (assisted colonization) of endangered species such as the Western Swamp Tortoise (**Table 4**), based on a spatially explicit, three-stage multiple criteria analysis (MCA). They determined the following habitat components:

Table 4. Western Swamp Tortoise habitat components with description of parameters and preferences.

HABITAT COMPONENT	DESCRIPTION OF PARAMETERS AND PREFERENCES
Hydroperiod	7–10-month optimal wet season and remainder dry so they can lay eggs and aestivate (Burbidge, 1981). A shorter period of 3-6 months may still be suitable for population survival although not optimal for population growth (Tareque, 2016).
Temperature	Between 14-28 degrees dependent on vegetation shading, depth of water, solar heating, conductivity of soil (Burbidge, 1981).
Soil Type	Western Swamp Tortoise aestivate underground over summer, requiring water-holding soils. Current habitat occurs on the Gilgai clay complex, or on sandy duplex soils (Schoknecht and Pathan, 2002; Burbidge et al., 2010). Peat soils may be suitable, due to high water-holding capacity.
Native Vegetation	Intact native vegetation can be used as an indicator of disturbance and potential habitat suitability. Western Swamp Tortoise require medium density vegetation for aestivation and protection from predators but will avoid very dense vegetation. Vegetation canopy height must be low enough to prevent excessive shading and reduction in water temperature. Current habitat is characterized by Banksia woodland and Melaleuca shrubland.
Aestivation Habitat	Within Ellen Brook Nature Reserve there are naturally occurring holes in the Gilgai clay. During the 1960s and 70s at Twin Swamps Nature Reserve most aestivated under Banksia leaf litter or fallen branches, but a few found holes in the ground dug by other animals or left by a rotting tree root (Burbidge 1967; 1981). Radio tracking data from 1994 to 2001 showed that nearly all individuals at Twin Swamps Nature Reserve spent the summer months underground in rabbit burrows but emerged during April/May and spent the latter part of the autumn under leaf litter, fallen branches or dense, low bushes.



Food Availability	Western Swamp Tortoise require abundant, diverse prey in spring and summer. Prey includes aquatic invertebrates, including crustaceans and insect larvae, as well as tadpoles (Burbidge et al., 2010) Captive-bred individuals can adapt to dietary change.
Site Size	Existing reserves for Western Swamp Tortoise are 80 and 141 ha (Burbidge et al., 2010). Individuals have been recorded moving outside reserve boundaries, suggesting that larger sites of at least 200 ha are required. Western Swamp Tortoise are not territorial, and individuals use all suitable habitat in the nature reserves. Homing behaviour suggests that they do have home ranges, but that individual home ranges may potentially be larger than the nature reserves. At Twin Swamps Nature Reserve movements of up to 600 m have been recorded in two days. At Ellen Brook Nature Reserve the area of suitable habitat is much smaller, and most movements are correspondingly shorter (Burbidge, 1981); however, one animal was recorded moving 450 m in 24 hours. Twin Swamps animals have been found up to 1 km outside the nature reserve boundary, especially in dry years, suggesting that there may have been movements between swamps some distance apart (Burbidge and Kuchling, 2004).
Distance From Roads	Individuals have been killed on roads within range of existing reserves, regardless of fencing, therefore main roads within 5 km of sites pose a threat.
Predators	Western Swamp Tortoise predators include foxes, cats, pigs, raptors, rats, waterbirds, bandicoots (Burbidge et al., 2010). Baiting for feral animals has reduced deaths through predation.
Salinity	Groundwater is generally fresh (between 200 and 3000 mg/L TDS) but is locally saline at the water table (Smith and Shams, 2002). Secondary salinization threatens the ecological integrity of freshwater wetlands in the SCP (Burbidge et al., 2010; Wallace et al., 2011).



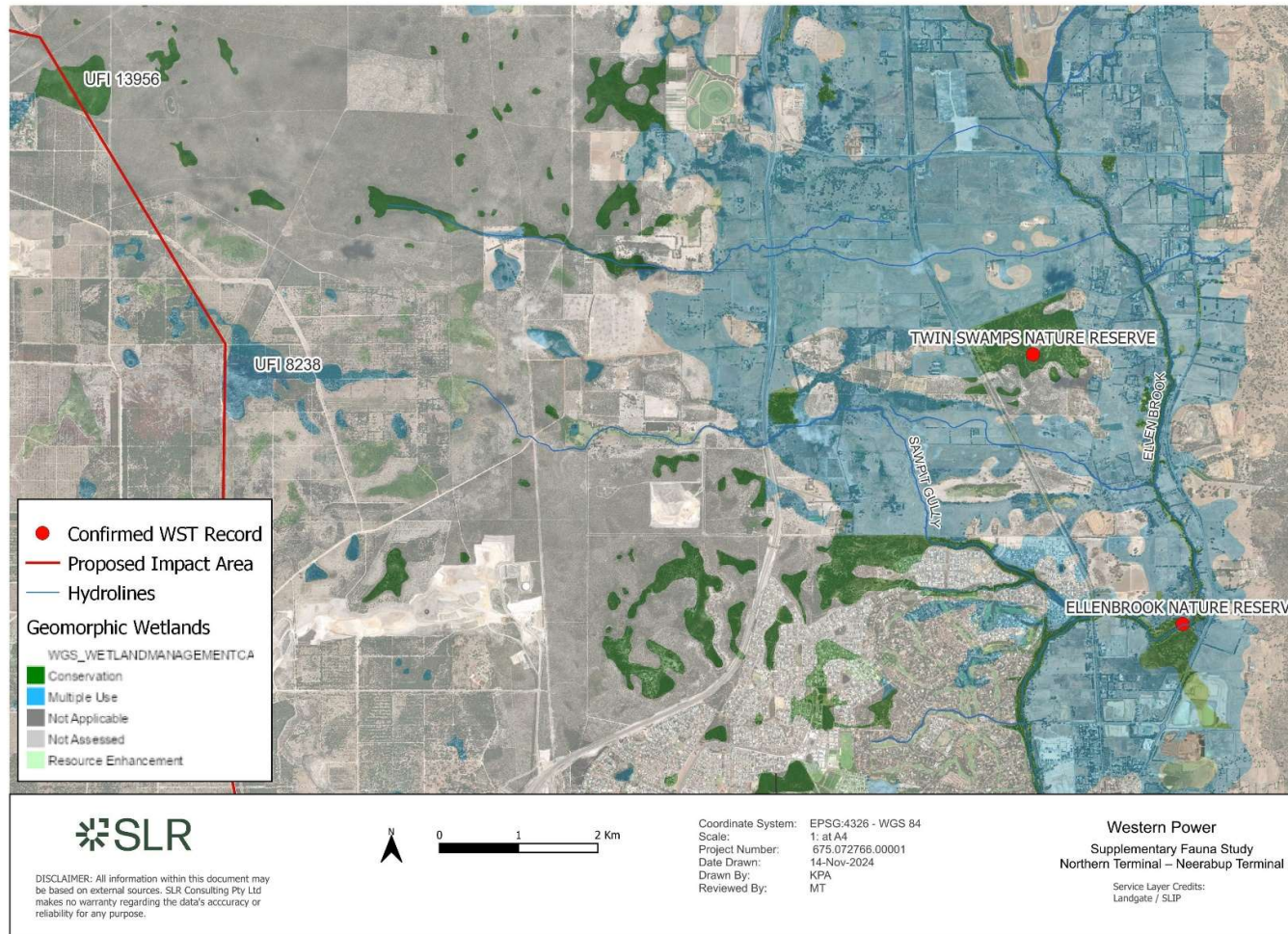


Figure 3. Western Swamp Tortoise populations of the SCP and Proposed Impact Area.



3.3.3 Potential Habitat within Impact Area

The Project is approximately 10 km from the closest mapped habitat (**Figure 3**). The soil types of these wetlands have lower clay levels than Western Swamp Tortoise habitats, being Bassendean sand and peat. Despite this, based on soil composition of Twin Swamp Nature Reserve and the water holding capacity of peat (Dade, Pauli and Mitchell, 2014), the summer soil moisture content has potential to support Western Swamp Tortoise aestivation. Additionally, due to the range of hydroperiod, temperature and salinity parameters they can tolerate (**Table 4**) UFI 13,956 and UFI 8,238 have potential to support Western Swamp Tortoise specifically regarding these limits (Dade, Pauli and Mitchell, 2014). Dade, Pauli and Mitchell (2014) reported on the suitability of habitat within the SCP for translocation of endangered species such as the Western Swamp Tortoise and concluded that the system of wetlands up to 10km west of Twin Swamp Nature Reserve would be generally suitable to support a translocated population, although this assumes assisted colonisation, based on a spatially explicit, three-stage multiple criteria analysis. It is noted that this data is part of an initial screening process and was not ground truthed.

The vegetation structure of UFI 8,238 is heavily disturbed and degraded, being within a pine plantation, and is not considered suitable habitat for Western Swamp Tortoise that rely on medium density native vegetation for aestivation and protection from predators (Dade, Pauli and Mitchell, 2014). The intact riparian vegetation within UFI 13,936 may have greater potential to support Western Swamp Tortoise, although, the conservation area is bordered by urban development to the southwest, with potential for disturbance. UFI 13,956 is also notably smaller (49 ha) than EBNR and TSNR (80 and 141 ha respectively) (Burbidge et al., 2010). Predation by European Red Fox and introduced rats (*Rattus rattus* and *R. norvegicus*) within EDNR and TSNR is greatly reduced due to active baiting, trapping and monitoring activities (Burbidge et al., 2010), therefore predation risk is much higher for UFI 8,238 and UFI 13,956, especially considering proximity to urban development. Although Dade, Pauli and Mitchell (2014) suggest the Western Swamp Tortoise can move over long distances (5-10km), no other published works explored in this review report movement greater than 5km from EBNR and TSNR. It is implausible that Western Swamp Tortoise would travel from TSNR ~10km to UFI 8,238 and ~12km to UFI 13,956 or from EBNR ~12km to UFI 8,238 and ~15km to UFI 13,956, which includes crossing fragmented habitats and major roads such as Tonkin Hwy (**Figure 3**). Although hydroperiod, temperature and salinity parameters may be within Western Swamp Tortoise range, based on comparison of broadscale habitat and vegetation classification, predation risk and distance from existing populations it is highly unlikely Western Swamp Tortoise would inhabit UFI 13,956 or UFI 8,238.



4.0 Conclusions and Recommendations

The results of the literature review and data base searches indicate that Black-Stripe Minnow presence is unlikely in UFI 8,238, given the lack of wetland connectivity to known Black-Stripe Minnow habitat and the potential disturbance of natural vegetation surrounding the system. Although UFI 13,956 supports intact riparian vegetation, it differs from known Black-Stripe Minnow habitat (Melaleuca Park) in that it is not spring fed and its year-round water holding capacity is therefore unknown. Additionally, UFI 13,956 falls outside of the inundation range of creek lines surrounding Melaleuca Park which reduces the likelihood of population movement. Additionally, aerial imagery indicates that UFI 13,956 is not seasonally inundated, which is necessary for the lifecycle of the Black-Stripe Minnow. It is unlikely that this system will be connected to known locations of Black-Stripe Minnows, meaning there is no opportunity for Black-Stripe Minnow to establish within UFI 13,956. Black-Stripe Minnow presence is therefore unlikely in UFI 13,956, given the lack of wetland connectivity, habitat disturbance and potential physio-chemical variability within this system.

The results of the literature review and data base searches indicate that Western Swamp Tortoise presence is highly unlikely in UFI 13,956 and UFI 8,238, given the distance and fragmentation between these wetlands and known populations, habitat disturbance, size of habitat and increased predation risk within these systems.

For both Black-Stripe Minnow and Western Swamp Tortoise although unlikely to occur within the Development Envelope, as there are no targeted studies published for these wetland systems, it is not possible to determine complete species absence.



5.0 References

Allen, G.R., Midgley, S.H. and Allen, M. (2002) 'Field Guide to the Freshwater Fishes of Australia.' Western Australian Museum, Perth WA. Retrieved from:
https://www.researchgate.net/publication/280722574_A_Field_Guide_to_the_Freshwater_Fishes_of_Australia

Boon, P. (2024). 'Hydrology of urban freshwater wetlands.' *Institute for Sustainability & Innovation*, Chapter 2.2, p.72. Retrieved from:
<https://www.sydneyolympicpark.nsw.gov.au/sites/default/files/2024-05/202%20Hydrology%20of%20urban%20freshwater%20wetlands.pdf>

Burbidge, A. A. (1981) 'The ecology of the western swamp tortoise *Pseudemydura umbrina* (Testudines: Chelidae).' *Wildlife Research*, 8(1), pp.203–223.
<https://doi.org/10.1071/wr9810203>.

Burbidge, A. A. (1967) 'The biology of south-western Australian tortoises.' PhD dissertation, The University of Western Australia, Perth. Retrieved from:
https://www.researchgate.net/publication/35227691_The_biology_of_South-western_Australian_tortoises_microform

Burbidge, A. and Kuchling, G. (2004) 'Western Swamp Tortoise Recovery Plan 2004,' Department of Conservation & Land Management.
<https://doi.org/10.13140/RG.2.1.2559.8486>.

Burbidge, A. A. *et al.* (2010) 'Western swamp tortoise (*Pseudemydura umbrina*) recovery plan.' Perth, Western Australia. Retrieved from:
<https://www.dcceew.gov.au/sites/default/files/documents/western-swamp-tortoise-recovery-plan.pdf>

Chessman, B.C., Trayler, K.M. and Davis, J.A. (2002). 'Family- and species-level biotic indices for macroinvertebrates of wetlands on the Swan Coastal Plain, Western Australia,' *Marine and Freshwater Research*, 53(5), p. 919. <https://doi.org/10.1071/mf00079>.

CSIRO, Bureau of Meteorology (2018) 'State of the climate 2018.' CSIRO and Bureau of Meteorology, Perth. Retrieved from: <http://www.bom.gov.au/>

Dade, M. C., Pauli, N. and Mitchell, N. J. (2014) 'Mapping a new future: using spatial multiple criteria analysis to identify novel habitats for assisted colonization of endangered species.' *Animal Conservation*, 17(S1), pp.4–17. <https://doi.org/10.1111/acv.12150>

DBCA. (n.d.). 'Swan Coastal Plain.' Department of Biodiversity and Conservation Attractions, Western Australia. Retrieved from:
<https://Library.Dbca.Wa.Gov.Au/Static/FullTextFiles/021926/021926-020.Pdf>.

Galeotti, D.M., McCulloch, C.D. and Lund, M.A. (2008) 'Current state of knowledge of the black-stripe minnow *Galaxiella nigrostriata* (Pisces: Galaxiidae) in Western Australia.' Centre for Ecosystem Management report 2008- 12. Retrieved from:
https://www.researchgate.net/publication/262224307_Current_state_of_knowledge_of_the_black-stripe_minnow_Galaxiella_nigrostriata_Pisces_Galaxiidae_in_Western_Australia



Galeotti, D. M., McCullough, C. D., and Lund, M. A. (2010). 'Black-stripe minnow *Galaxiella nigrostriata* (Shipway 1953) (Pisces: Galaxiidae), a review and discussion.' *Journal of the Royal Society of Western Australia*, pp.13–20. Retrieved from:

https://www.researchgate.net/publication/262224397_Black-stripe_minnow_Galaxiella_nigrostriata_Shipway_1953_Pisces_Galaxiidae_a_review_and_discussion

Galeotti, D. M. (2013). 'Metapopulation theory explains Black-stripe Minnow (Pisces: Galaxiidae, *Galaxiella nigrostriata*) distribution in seasonal wetlands in south-west Western Australia.' Edith Cowan University. Retrieved from: <https://ro.ecu.edu.au/theses/708>

IUCN. (2024). 'The IUCN Red List of Threatened Species'. Version 2024-1. Retrieved from: <https://www.iucnredlist.org>

Knott, B., Jasinska, E.J. and Smith, K.D. (2002). 'Limnology and aquatic fauna of EPP 173, Melaleuca Park, refuge for an outlier population of the Black-stripe minnow *Galaxiella nigrostriata* (Galaxiidae), in southwestern Australia,' *Records of the Western Australian Museum*, 21(3), p. 291. [https://doi.org/10.18195/issn.0312-3162.21\(3\).2002.291-298](https://doi.org/10.18195/issn.0312-3162.21(3).2002.291-298).

MBS Environmental. (2009). 'Kemerton Silica Sand: Public Environmental Review Extension of Kemerton Silica Sand, Dredge Mining.' A report prepared for Kemerton Silica Sand Pty. Ltd. Retrieved from:

https://www.epa.wa.gov.au/sites/default/files/PER_documentation/A1494_R1425_Kemerton%20Silica%20Sand%20Dredge%20Mining%20Extension_PER%20Final%20Vol%201%20Main%20Doc%202009.pdf

McLure, N. and Horwitz, P. (2009). 'An investigation of aquatic macroinvertebrate occurrence and water quality at Lake Chandala, Western Australia.' Centre for Ecosystem Management, Edith Cowan University: Perth, Western Australia. Retrieved from: <https://library.dbca.wa.gov.au/FullTextFiles/070452.pdf>

Morgan, D.L., Gill, H.A. and Potter, I.C. (1998) 'Distribution, identification and biology of freshwater fishes in south-western Australia.' *Records of the Western Australian Museum*. Supplement No. 56. Western Australian Museum, Perth. Retrieved from: <https://museum.wa.gov.au/sites/default/files/1.%20Morgan,%20Gill,%20Potter%20.pdf>

Morgan, D.L. and Gill, H.S. (2000) 'Fish associations within the different inland habitats of lower south-western Australia.' *Records of the Western Australian Museum* 20: pp.31-37. Retrieved from:

<https://museum.wa.gov.au/sites/default/files/FISH%20ASSOCIATIONS%20WITHIN%20THE%20DIFFERENT%20INLAND%20HABITATS%20OF%20LOWER%20SOUTH-WESTERN%20AUSTRALIA.pdf>

Morgan, D.L. *et al.* (2011) 'A field guide to freshwater fishes, crayfishes and mussels of southwestern Australia. SERCUL and Freshwater Fish Group, Perth WA. Retrieved from: https://www.researchgate.net/publication/229150802_A_Field_Guide_to_Freshwater_Fishes_Crayfishes_Mussels_of_South_Western_Australia



Semeniuk, C. A. (1988) 'Consanguineous wetlands and their distribution in the Darling system, southwestern Australia.' *Journal of the Royal Society of Western Australia*, 70(3). Retrieved from: <https://www.biodiversitylibrary.org/part/238297>

Semeniuk, V., and Glassford, D. (1989). 'Bassendean and Spearwood Dunes: their geomorphology, soils and stratigraphy as a basis for habitats of Banksia woodlands.' *Journal of the Royal Society of Western Australia*, pp. 87–88. Retrieved from: https://www.researchgate.net/publication/293402567_Bassendean_and_Spearwood_Dunes_their_geomorphology_soils_and_stratigraphy_as_a_basis_for_habitats_of_Banksia_woodlands

Schoknecht, N. R and Pathan, S. (2013) 'Soil groups of Western Australia: a simple guide to the main soils of Western Australia (4th edn).' Department of Agriculture and Food, Western Australia, Perth. Report 380. Retrieved from: <https://library.dbca.wa.gov.au/static/Journals/080316/080316-380.pdf>

Slip/Landgate. *SLR Enviro Map*. Layers used: Soil Landscape Subsystems, Vegetation Complexes. Scale unknown. (Accessed October 15, 2024)

Smith, R. A. and Shams, R. (2002). 'Hydrogeological information for management planning in the Ellen Brook catchment: Western Australia', *Salinity and Land Use Impacts Series*, Water and Rivers Commission, Report No. SLUI 11. Retrieved from: <https://www.wa.gov.au/system/files/2023-03/Hydrogeological-information-for-management-planning-in-the-Ellen-Brook-catchment.pdf>

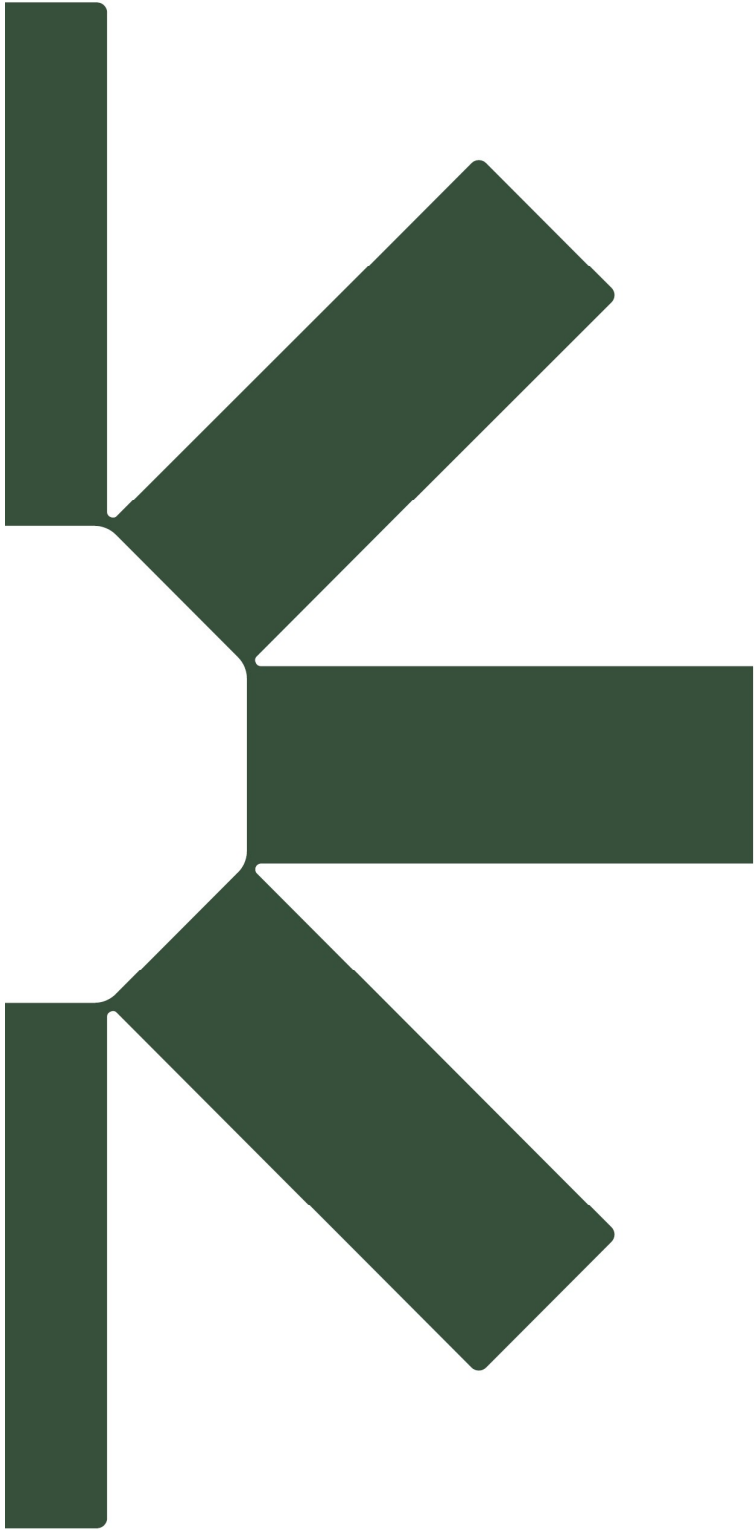
Tareque, A. M. H. B. (2016) 'An integrated eco-hydrological approach for assessing critical wetland habitats and conservation reserves in a changing climate.' The University of Western Australia, Perth. Retrieved from: <https://research-repository.uwa.edu.au/en/publications/an-integrated-eco-hydrological-approach-for-assessing-critical-we>

Wallace, K. *et al.* (2011) 'Natural diversity recovery catchment program: 2010 review.' Department of Environment and Conservation, Perth. Retrieved from: <https://library.dbca.wa.gov.au/FullTextFiles/922967.pdf>

Western Power. (2024) 'Environmental Impact Assessment - Northern Terminal (NT) to Neerabup Terminal (NBT)' Environment, heritage and planning. Version 3.0.

WRM. (2019) 'Bunbury Outer Ring Road Northern and Central Investigation Area: Targeted Conservation Significant Aquatic Fauna Survey 2018'. Unpublished final report by Wetland Research & Management to BORR Team Pty Ltd. April 2019.





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