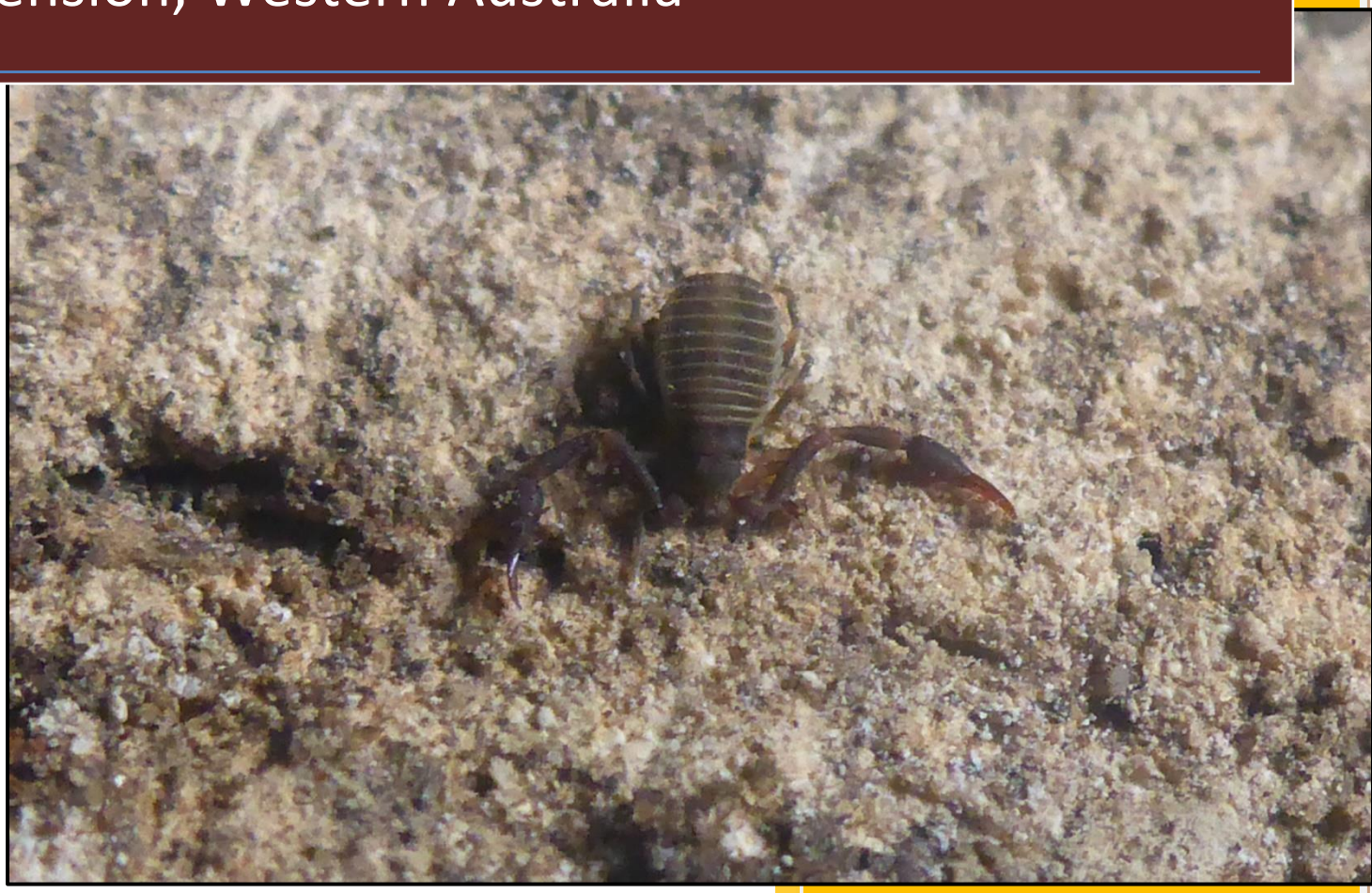
Desktop review and risk assessment of Subterranean Fauna for the Yanchep Rail Extension, Western Australia



Report by Invertebrate Solutions
for Public Transport Authority

May 2018

Dr Timothy Moulds
Invertebrate Solutions
PO Box 14
Victoria Park, WA 6979
Australia
tim@invertebratesolutions.com
www.invertebratesolutions.com

Invertebrate Solutions. (2018). Desktop review and risk assessment of subterranean fauna for the Yanchep Rail Extension, Western Australia.

Unpublished report to Public Transport Authority, May 2018.

Report Number 2018ISJ02_F01_20180531

Prepared for: Public Transport Authority, Western Australia

Frontispiece: The troglophilic pseudoscorpion *Protochelifer cavernerum* that inhabits caves in Yanchep National Park. Image copyright Invertebrate Solutions 2018.

Contents

List of Figures

List of Tables

List of Plates

Executive Summary

The Yanchep Rail Extension (YRE) project is a 14.5 kilometre (km) extension of the Joondalup railway line, which includes new stations at 3 locations; Alkimos, Eglinton and Yanchep. The YRE project's 143.11 hectare (ha) Development Envelope, which encompasses Part 1 and 2 development footprints (including railway extension and stations) and construction and access areas, generally lies between the suburbs of Butler and Yanchep and includes the suburbs of Alkimos and Eglinton. Part 1 of the project proposes to extend the existing Joondalup railway line by 7.3 kilometres from Butler Station to the suburb of Eglinton in the City of Wanneroo. Part 2 of the project proposes to extend the Joondalup railway line from Eglinton Station to Yanchep Station and includes a turnback facility to the north of the Yanchep Station to allow for the turning and stowage of trains.

Following referral of Part 1 of the YRE project to the Environmental Protection Authority (EPA) under Section 38 of the *Environmental Protection Act 1986* (EP Act), the EPA decided on 13 March 2018 that the proposal would be assessed on referral and additional information. The EPA issued a Notice Requiring Information for Assessment under section 40(2)(a) of the EP Act, which included the requirement for a desktop subterranean fauna (stygofauna and troglofauna) investigation.

The Study Area contains significant subterranean fauna habitat within the Yanchep National Park and immediately adjacent areas, however, the YRE Project Development Envelope intersects lower value habitat to the west of the high risk karst area. The Study Area contains the Threatened Aquatic Root Mat community within the Yanchep National Park, along with associated stygofauna and troglofauna species. None of these species, or aquatic root mat communities are known to occur in the YRE Project Development Envelope. Habitat for both stygofauna and troglofauna does occur within the YRE Project Development Envelope due to the presence of the karstic Tamala Limestone underlying the Safety Bay sands.

There is potentially a Low likelihood of overall impact to stygofauna and troglofauna from virtually all aspects of the project as cut and fill activities will generally occur within approximately five metres of the natural ground surface and dewatering is not anticipated to be required. The most significant impact, although still considered Moderate overall is from the excavation directly removing habitat and causing drying of adjacent troglofauna habitat.

Contamination of groundwater during construction and subsequent use may also impact significantly upon subterranean fauna habitat, but risks of contamination can be minimised by measures included in a Construction Environment Management Plan (CEMP). The potential for contamination during construction is limited to isolated areas of chemical storage and small quantities of hydro carbons where machinery or generators are working. The risk of contamination during operations is minimal as the passenger railway runs off overhead electrified wires rather than stored fuel on the trains themselves. The trains contain only small quantities of transmission oil with minimal risk of contamination impacts.

Cumulative impacts on the Swan Coastal Plain are expected to be minimal as the known subterranean diversity is low compared with other regions of Western Australia (Pilbara and Mid West). The primary cumulative impacts from this development is land clearance and altered hydrology, however, these are relatively small in the scale of northern Swan Coastal Plain. Given the

narrow linear nature of the project, and given similar or better subterranean habitat values are likely to be present in surrounding conservation estates such as Yanchep National Park, it is considered unlikely that the YRE project would result in local extinction.

The following recommendations are made with regard to the construction of the Yanchep Rail Extension project:

- If significant caves or voids are encountered during construction activities, work is suspended until their impact on subterranean fauna can be assessed by a suitably qualified person;
    - Engineering solutions to significant caves or voids that are encountered should be discussed with a suitably qualified subterranean biologist to ensure their suitability;
    - If significant cave or voids that contain potentially important subterranean biodiversity are to be destroyed then collection of specimens and genetic material for deposition into the WAM collections should be undertaken by a suitably qualified person;
- Management of Subterranean fauna is specifically included within a Construction Environment Management Plan (CEMP) to ensure site personnel are aware of potential impacts that may be caused by construction works and have management measures in place to minimise potential impacts.
- The risks to subterranean fauna and especially troglofauna should be re-examined following the detailed geotechnical site investigations.

1. Introduction

The Yanchep Rail Extension (YRE) project is a 14.5 kilometre (km) extension of the Joondalup railway line, which includes new stations at 3 locations; Alkimos, Eglinton and Yanchep. The YRE project forms an integral component of Perth's long term public transport network and will provide essential transportation services to the rapidly expanding northern coastal suburbs (RPS 2018). The YRE project is located within the City of Wanneroo, which is situated approximately 26 km north of Perth's Central Business District. The YRE project's 143.11 hectare (ha) Development Envelope, which encompasses Part 1 and 2 development footprints (including railway extension and stations) and construction and access areas, generally lies between the suburbs of Butler and Yanchep and includes the suburbs of Alkimos and Eglinton (RPS 2018).

Part 1 of the project proposes to extend the existing Joondalup railway line by 7.3 kilometres from Butler Station to the suburb of Eglinton in the City of Wanneroo. Part 1 of the proposal is to construct and operate the rail extension and includes two new intermodal (rail, bus, 'park and ride', 'kiss and ride', walk and cycle) transit stations at Alkimos and Eglinton. Part 2 of the project is yet to be referred to the EPA and proposes to extend the railway line from Eglinton Station to Yanchep Station and includes a turnback facility to the north of the Yanchep Station to allow for the turning and stowage of trains. The proposal also includes the construction of a new station at Yanchep with intermodal rail, bus, 'park and ride', 'kiss and ride' and active mode (cycling and walking) facilities at the Yanchep Station.

The main components of the overall project consist of the following:

- Underground and overhead utility service identification, relocations and protection.
- Construction of two new narrow gauge tracks (including associated infrastructure such as overhead line equipment, signalling and telecommunications), as part of extending the Butler line to Yanchep.
- Construction of nine road bridge crossings.
- Construction of three new stations; Alkimos Station, Eglinton Station and Yanchep Station.
- Connection of existing narrow gauge tracks to Butler at Butler Station, with infrastructure modifications (such as turnouts, overhead line equipment, signalling and telecommunications) to the station to accommodate for the newly imposed train operation.
- Upgrading existing traction sub-station from 15MVA to 25MVA either at Nowergup or Edgewater.

Following referral of Part 1 of the YRE project to the Environmental Protection Authority (EPA) under Section 38 of the *Environmental Protection Act 1986* (EP Act), the EPA decided on 13 March 2018 that the proposal would be assessed on referral and additional information. The EPA issued a Notice Requiring Information for Assessment under section 40(2)(a) of the EP Act, which included the requirement for a desktop subterranean fauna (stygofauna and troglofauna) investigation.

Part 1 of the proposal will require the clearing and disturbance of 70.22 hectares, including 1.12 hectares of the *Melaleuca huegelii – M. acerosa* (*M. systena*) shrublands on limestone ridges.

Invertebrate Solutions has been requested by the Public Transport Authority (PTA) to provide a desktop habitat and preliminary risk assessment for subterranean fauna (stygofauna and troglofauna) for the YRE (Part 1 and Part 2).

Subterranean fauna are comprised of stygofauna (aquatic subterranean dependent species) and troglofauna (air breathing subterranean dependent species) which are known to be relatively diverse on a worldwide scale in parts of Western Australia. Many species of subterranean fauna have highly restricted ranges, due to habitat connectivity issues and evolutionary history. Stygofauna and troglofauna are known to occur widely in much of Western Australia with many locally endemic species.

The high degree of local endemism and lack of habitat connectivity makes subterranean fauna susceptible to high level impacts from localised projects, with species extinction a real possibility if they are not adequately considered during project planning phases (EPA 2016a).

1.1 Purpose of this report

Invertebrate Solutions has been requested by PTA to undertake a desktop assessment for subterranean fauna in the proposed YRE Development Envelope (Parts 1 and 2) and specifically address the following scope of works:

- Review of the previous subterranean fauna assessment undertaken by GHD – Northern Suburbs Railway Alignment Butler to Yanchep Environmental Investigation (GHD 2012) and the more recent Advisian Geotechnical Investigation Report (2017);
- Provide further information about the suitable habitats for stygofauna and troglofauna within the YRE Project Development Envelope and in the local area;
- Provide a summary of the potential direct and indirect impacts to subterranean fauna as a result of the project;
- Provide an assessment of the significance of these impacts at a local (Yanchep National Park, Bush Forever Site 289 [Ningana bushland], and Neerabup National Park) and regional (Swan Coastal Plain) scale;
- Provide advice on management and/or mitigation measures that could be implemented;
- Identify gaps in the background information;
- Provide recommendations and suggested requirements for further work to comply with relevant legislation; and
- Provide a written report containing the above items.

1.2 Study Area

The desktop Study Area is defined by a rectangle bounded by the northwest corner (31°21'00"S 115°30'00"E,) and the southeast corner (31°54'00"S 116°10'15"E). The desktop Study Area boundary and the YRE Project Development Envelope (Part 1 and Part 2) are shown in Figure 1.

1.3 Documents examined

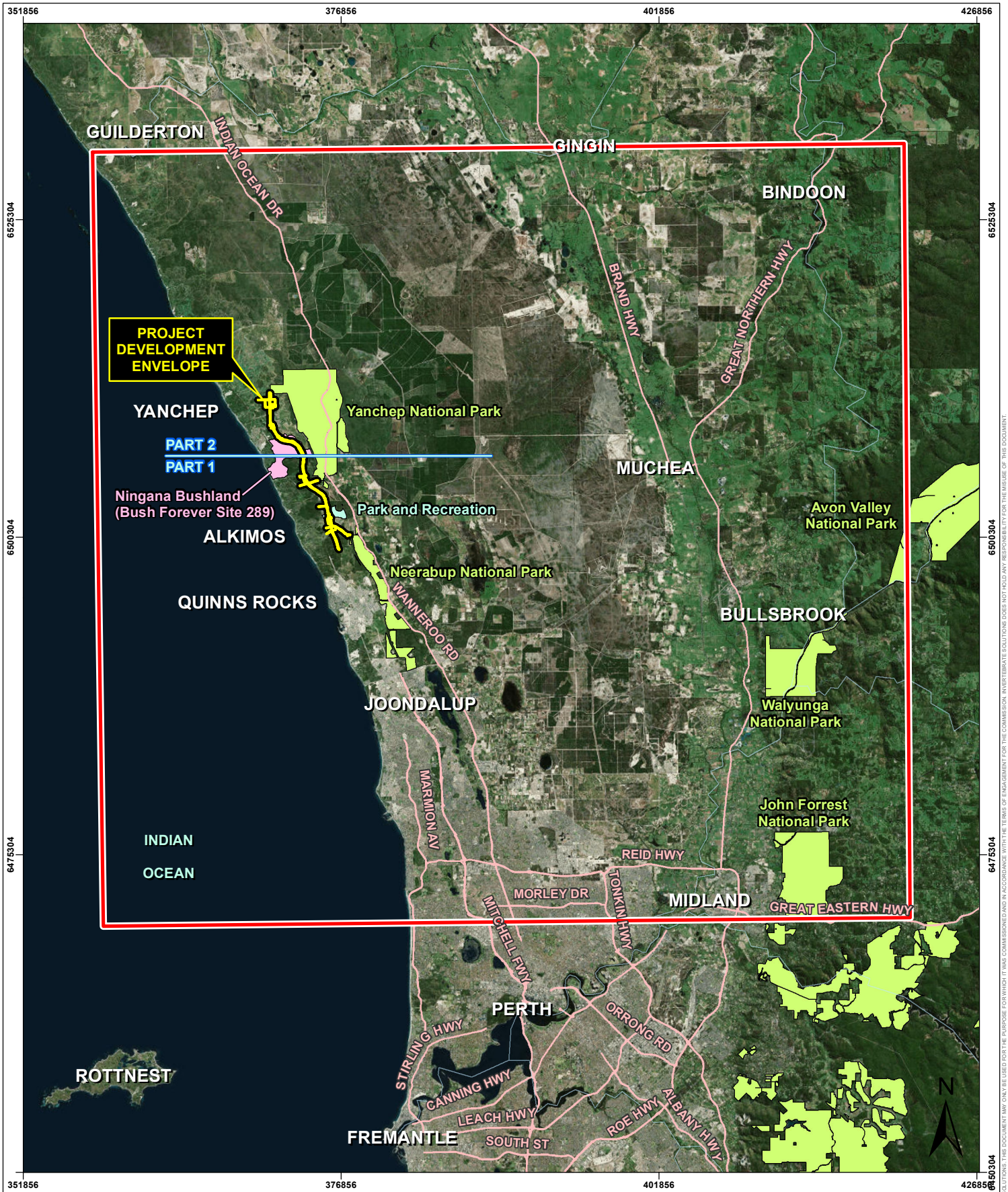
The following documents have been examined in the compilation of this report, along with other referenced scientific papers used to provide general background:

- Geological Survey of Western Australia (1978). Perth 1:250,000 Sheet SH 50-14 and part of SH 50-13 Geological Map, Geological Survey of Western Australia.
- English V, Blyth, J., Jasinska, E., et al. (2000). Interim Recovery Plan Aquatic Root Mat Community of Caves of the Swan Coastal Plain 2000-2003. Conservation and Land Management, Environment Australia, November 2000. Accessed 6th March 2018 at www.environment.gov.au/resource/interim-recovery-plan-aquatic-root-mat-community-caves-swan-coastal-plain-2000-2003
- Jasinska, E.J. and Knott, B. (2000). Chapter 15, Root driven faunas in cave waters. In Ecosystems of the World, Subterranean Ecosystems. Eds. Wilkens, H., Culver, D. C. and Humphreys, W. F. Amsterdam, Elsevier, p287 – 307.
- Bennelongia (2008). Literature review and monitoring program for stygofauna in the Gnangara Groundwater System. Unpublished report to Department of Environment and Conservation, 19p.
- GHD (2010). Report for Murray Wetland Study. Stygofauna Baseline Survey. Unpublished report to the Department of Water, 19p.
- GHD (2012). Northern Suburbs Railway Alignment Butler to Yanchep Environmental Investigation. Unpublished report to the Public Transport Authority, 147p.
- Advisian (2017). Geotechnical investigation report – Yanchep Rail Extension. Unpublished report to the Public Transport Authority, 282p.
- RPS (2018a). Environmental Impact Assessment Yanchep Rail Extension: Part 1 – Butler Station to Eglinton Station. Unpublished report to the Public Transport Authority, 794p.
- RPS (2018b). Yanchep Rail Extension Hydrology Assessment. Unpublished memorandum to the Public Transport Authority, May 2018, 19p.

This report has been prepared with regard to the Technical Guidance – subterranean fauna survey (EPA2016a), Technical Guidance – sampling methods for subterranean fauna (EPA2016b), and the Environmental Factor Guideline – Subterranean Fauna (EPA 2016c).

1.4 Conservation Legislation and Guidance Statements

Subterranean fauna species are protected under state legislation via the *Wildlife Conservation Act* (1950) (WC Act), the *Environmental Protection Act* (1986) and federally under the *Environmental Protection and Biodiversity Conservation Act* (1999) (EPBC Act). The assessment of subterranean fauna for environmental impact assessment (EIA) is undertaken in Western Australia with regard to the Technical Guidance – subterranean fauna survey (EPA2016a), Technical Guidance – sampling



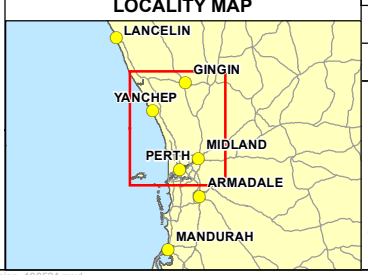
Legend

- Desktop Study Area
- Yanchep Rail Extension Project Development Envelope
- National Park
- Ningana Bushland (Bush Forever Site 289)
- Parks and Recreation Area

0 3.75 7.5 15
km
Scale: 1:400,000 @ A4

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY MAP



- LOCALITY MAP SOURCED FROM LANDGATE 2006
- STREET DIRECTORY MAP SOURCED STREETSMART 2008
- AERIAL PHOTOGRAPHY SOURCED ESRI WORLD IMAGERY

Invertebrate Solutions
m +61 (0) 429 792 834
s +61 (0) 405 561 978
e tim@invertebratesolutions.com
w www.invertebratesolutions.com

PROJECT ID	DATE
Yanchep Rail Extension Project	24/05/2018

HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 50

CREATED	CHECKED	APPROVED	REVISION
ENVIRONMAPS	TM	TM	0

Yanchep Rail Extension Project

Figure 1

Desktop Study Area for Subterranean Fauna Review Yanchep Rail Extension

C:\GIS\Jobs\Invertebrate Solutions\Yanchep Rail Extension Project\Figures\YREP_F01 Desktop Study Area for Subterranean Fauna Review Yanchep Rail Extension_180524.mxd

methods for subterranean fauna (EPA2016b), and the Environmental Factor Guideline – Subterranean Fauna (EPA 2016c).

At the state level, the Wildlife Conservation (WC) Act provides a list of species that have special protection as species listed under the Wildlife Conservation (Specially Protected Fauna) Notice 2018 (DBCA 2018). This notice is updated periodically by the Department of Biodiversity, Conservation and Attractions (DBCA) (formerly Department of Parks and Wildlife, DPaW) and the current list (January 2018) includes numerous subterranean species, mainly from the Cape Range and Pilbara regions, including crustaceans, arachnids and myriapods that are considered to be "rare or likely to become extinct, as critically endangered fauna, or declared to be fauna that is in need of special protection" (DPaW 2015). In addition to the specially protected fauna DBCA also maintains a list of Priority fauna that are considered to be of conservation significance but do not meet the criteria for formal listing under the WC Act as Scheduled species. The Priority fauna list is irregularly updated by DBCA and although it offers no formal legislative protection, these species are generally considered in the EIA process.

There is no current ability for the state government of Western Australia to formally list Threatened or Priority Ecological Communities (TECs/PECs), however, a list of such communities is maintained by DBCA and overseen by the Minister for the Environment. Several subterranean ecological communities are recognised as Threatened including the Bundera Cenote Anchialine community on Cape Range, Cameron's Cave near the townsite of Exmouth on Cape Range, stygal root mat communities in both the Yanchep and Margaret River regions and stygobionts in the Ethel Gorge aquifer in the Pilbara. Communities that are not considered by DBCA to be threatened but may be vulnerable to future impacts are classed as Priority ecological communities, and include numerous calcrete aquifers in the Yilgarn region where each calcrete has been shown to contain an endemic stygal community.

The WC Act is expected to be imminently replaced by the new Biodiversity Conservation Act that has yet to be enacted into law. This new act has been passed by the lower house of the State parliament and will be capable of protecting both species and ecological communities under legislation.

The federal Environmental Protection and Biodiversity Conservation (EPBC) Act protects both species and ecological communities. The most relevant listings for subterranean fauna include the Bundera Cenote on the western side of the Cape Range which contains a unique anchialine ecosystem including the stygal Cape Range Remipede *Kumonga exleyi* that is listed as Vulnerable. The Cape Range Gudgeon, *Milyeringa veritas* and the Cape Range blind eel *Ophisternon candidum* are also listed as Vulnerable species from subterranean habitats on the Cape Range.

1.5 Classifications of subterranean dependence

Subterranean fauna is a collective term that refers to both troglofauna (terrestrial subterranean fauna inhabiting air voids) and stygofauna (aquatic subterranean fauna) (Humphreys 2000). Extensive amounts of jargon have historically been associated with subterranean fauna and multiple forms of classification have been used through time (Sket 2008). The most commonly accepted and used terms divide troglofauna into categories that describe a particular species' degree of dependence upon the subterranean environment. Due to the reliance upon ecological information to determine if a species is a troglobite, the concept of troglomorphy (Christiansen 1962), specific

morphological adaptations to the subterranean environment, is used to define obligate subterranean species. The term troglomorphy, initially confined to morphology has since been used to describe both morphological or behavioural adaptations (Howarth 1973). This combination provides a practical system, easily applied in the field and with minimum of detailed ecological study required (Sket 2008). The level of subterranean dependency for different ecological groupings is described below:

- Troglobiont: animals that are obligate subterranean species, and mostly show morphological adaptation to subterranean habitats (troglomorphisms) including depigmentation, loss or reduction of eyes, elongation of appendages, complete loss of wings or wing reduction, and extra sensory hairs.
- Troglophiles: animals that can complete their entire lifecycle within a cave but possess no specific adaptations to the cave environment. These species are capable of living outside caves in suitably dark and moist epigean habitats.
- Trogloxenes: animals that use the subterranean environment, but require surface environments to complete part of their lifecycle (generally either feeding or breeding). Common trogloxenes are cave dwelling bats, cave swiftlets and cave crickets that leave subterranean habitats to feed.

The terms above refer to stygofauna when the prefix is altered to stygo (Humphreys 2000).

Species which inhabit the deep soil habitat (Edaphophiles) often exhibit convergent morphological adaptations to those animals found exclusively within caves, such as an absence of eyes, body flattening, loss of pigmentation etc. Soil dwelling species commonly do not show highly restricted distributions as they are less easily isolated in evolutionary timeframes, thus only true troglobitic animals are the focus of surveys for subterranean fauna. Taxa discussed in this study were assessed upon their combination of loss/reduction of eyes, and reduction in pigmentation, wing development, and elongation of appendages to assess if a taxa was an edaphophile or truly reliant upon the subterranean habitat (Troglobiont).

1.6 Report Limitations and Exclusions

This study was limited to the written scope provided to the client by Invertebrate Solutions (1st March 2018) and in Section 1.1. This study was limited to the extent of information made available to Invertebrate Solutions at the time of undertaking the work. Information not made available to this study, or which subsequently becomes available may alter the conclusions made herein. Assessment of potential impacts to subterranean fauna was based on proposed development plans provided by the client.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. Invertebrate Solutions has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by Invertebrate Solutions described in this report (this section and throughout this report). Invertebrate Solutions disclaims liability arising from any of the assumptions being incorrect.

Invertebrate Solutions has prepared this report on the basis of information provided by the Public Transport Authority and others (including Government authorities), which Invertebrate Solutions has not independently verified or checked beyond the agreed scope of work. Invertebrate Solutions does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information. Searches of the Western Australian Museum's database records may not return all species present in a search area as database records are sometimes incomplete, or missing. Invertebrate Solutions does not accept liability in connection with such omissions.

Site conditions may change after the date of this report. Invertebrate Solutions does not accept responsibility arising from, or in connection with, any change to the site conditions. Invertebrate Solutions is also not responsible for updating this report if the site conditions change.

1.7 Assumptions

Invertebrate Solutions has made the following assumptions in the writing of this report and its subsequent conclusions:

- Abstraction of groundwater from the superficial aquifer for construction purposes will be minor, resulting in drawn down of less than 1m, and will not result in a significant reduction in regional or local groundwater levels and will cease following project completion.
- There is a large separation between the formation level of the YRE and the groundwater level, therefore dewatering is not anticipated during the construction of the YRE project. Therefore, impacts to subterranean fauna due to groundwater abstraction are not anticipated.

2. Desktop Methods

The subterranean fauna desktop review comprises of two distinct sections:

- An assessment of the likelihood that subterranean species are present in the habitats located within the Study Area.
- Consideration of the potential impacts to subterranean species that may occur as a result of the proposal.

2.1 Likelihood of Subterranean fauna occurrence

The likelihood of stygofauna and troglofauna species occurring in the Study Area was assessed using a combination of regional information, geological, hydrogeological and database searches including:

- Analysis of published and unpublished reports concerning subterranean fauna from the region.
- Available geological maps.
- Geological, geotechnical and hydrogeological information available for the Study Area.
- Results of a Protected Matters Search from the Federal Government's Department of the Environment and Energy (DEE) website.
- Records of fauna held by the Western Australian Museum.

When considering the likelihood of SRE invertebrates at the local scale the Yanchep National Park, Bush Forever Site 289 (Ningana bushland), and Neerabup National Park were specifically investigated whilst assessments at the regional scale included the entire Swan Coastal Plain.

Based on the analysis of all available information the Study Area was assigned a level of likelihood to support subterranean fauna of either 'Low', 'Moderate', 'High',' or 'Definite' (Table 1).

Table 1 Subterranean species likelihood of occurrence definitions

Subterranean Fauna Likelihood of occurrence	Definition
Definite	The species is confirmed to occur within the Study Area
High	Habitat for the species/community is known to occur within the Study Area and/or known records of the species are within 20 km
Moderate	Habitat for the species/community is known to occur within the Study Area and/or known records of the species are within 50 km
Low	The species/community has been recorded from within 50 km, however, no habitat is present for the species within the Study Area
Very low	No habitat exists for the species/community within the Study Area and no records of the species are within 50 km

2.2 Potential Impacts to Subterranean Fauna

The potential impacts of the installation of infrastructure and general construction activities on subterranean fauna may be categorised as being either direct or indirect impacts.

Direct impacts are the obvious and unavoidable destruction or degradation of habitat that occurs in excavation for footings and other subsurface excavations, including associated aquifer dewatering (EPA 2016a).

Indirect impacts are generally gradational, and more difficult to predict and manage because they may occur at moderate to large distances from the project footprint. These impacts may be expressed some time after development has been undertaken. Some examples include changes to hydrology, nutrient and microclimate regimes, contamination, reduced habitat area, water quality, and population viability. The zone of influence for indirect impacts may be considerably larger than the immediate area of the disturbance area. Potential indirect impacts of development include:

- Alteration of surface hydrology that affects groundwater recharge regimes, sedimentation, and water quality (e.g. under and adjacent to infrastructure areas, roads and hard packed surfaces).
- Reduction in organic inputs beneath areas cleared of vegetation and sealed surfaces.
- Vibration disturbance from construction and operational activities.
- Surface and groundwater contamination from plant equipment and infrastructure (e.g. chemical pollutants, hydrocarbons or waste water of lower quality).
- Changes to subterranean microclimate in rock masses surrounding clearing areas (exposure of subterranean habitat to desiccation).
- Risk of species extinction from reduction and/or fragmentation in habitat.
- Cumulative impacts from nearby developments.

The proposed Project alignment and cut and fill plans contained with the Advisian (2017) geotechnical report and the EIA documentation (RPS 2018) were reviewed to assess the potential severity of impact to potential subterranean habitats. In evaluating the relevance of these factors to the Project, consideration was given to the magnitude, duration and spatial extent of the impacts, where known. This assessment has taken the approach of considering these broad categories of potential impacts and evaluating their occurrence and relative severity. The impacts were then assigned a level of either ‘Low’, ‘Moderate’, or ‘High’ according to their potential degree to adversely affect the EPA’s objective to maintain representation, diversity, viability and ecological function at the species, population and assemblage level for subterranean fauna.

Where an impact is designated as ‘Low’ no further consideration to this factor is required if all assumptions made throughout this report are correct.

3. Desktop Subterranean Fauna Review

3.1 Subterranean fauna of the Swan Coastal Plain

Knowledge of subterranean fauna within the northern Swan Coastal Plain is less than the more comprehensively surveyed areas of the Pilbara and Yilgarn. Sporadic surveys for troglofauna have been undertaken from the limestone caves further north at Cervantes and Eneabba from the 1970s to recent years (Moulds 2007a, 2007b, WASG 2016). To the east of the karstic calcarenite coastal band some pilot surveys for stygofauna have been undertaken in other lithologies including quartzite near Moora (Knott and Goater 2005).

Within the northern Swan Coastal Plain the most data are available for the Yanchep Caves, centred around the Yanchep National Park and the aquatic root mat communities associated with root mats from Tuart trees (*Eucalyptus gomphocephala)* in pools and streams fed by groundwater from the Gnangara Mound (Jasinska and Knott 2000, English et. al. 2000). These root mat communities were previously found in six caves (YN99, Cabaret Cave, Carpark Cave, Twilight Cave, Water Cave and, in the past, Gilgie Cave) and although considered a single community, each cave contains at least one species found in no other cave (English et al. 2000).

Stygofauna has been sampled within the superficial Gnangara Mound as part of regional stygofauna sampling (Bennelongia 2008). This sampling has shown that stygofauna do occur within the unconfined aquifer, but with low species richness. A moderately extensive regional sampling program recorded 11 species from within the Gnangara Mound between Guilderton in the north, east to the Darling fault and south to the Swan River (Bennelongia 2008). Stygofauna sampling in the Yanchep area has also shown low species richness (Bennelongia 2008).

The southern Swan Coastal Plain was sampled by GHD (2010) as part of a drainage and water management plan for the Murray River catchment for the then Western Australian Department of Water (now Department of Water and Environment Regulation (DWER)). The regional survey for stygofauna within the superficial aquifer in the Shire of Murray sampled 20 bores from five different wetland areas and recorded stygofauna from two bores during a single phase sampling survey. A single new species of cyclopoid copepod (*Mixocyclops* sp. nov.) and two species of parabathynellid? were recorded. The copepod specimens from near Pinjarra are closely related to species recorded from Yanchep National Park in the north of the Swan Coastal Plain (GHD 2010).

Troglofauna are known to occur throughout the karstic areas of the coastal Tamala Limestones (Moulds 2007a, 2007b). These are moderately diverse when considering total faunal assemblages (troglobionts and no-troglobionts) although the diversity of troglobionts is low. Several species of troglofauna do appear to be restricted in range to this limestone band although sampling at a regional scale has been ad hoc and further research is required to confirm this.

When stygofauna is present in an aquifer it does, however, show high levels of endemism with 98% of the stygobites and 83% of the other non stygobiont groundwater species occur only within the Pilbara (Halse et al. 2014). Recent analysis by Halse et al. (2014) has shown that there is little correlation between water quality and geology for predicting the presence of stygofauna, however, the non-random siting of groundwater wells in highly transmissive locations within various geologies

has undoubtedly created a bias in the data. The use of predictive modelling has shown that some of the highest diversity areas in the Pilbara for stygofauna are within Quaternary alluvial aquifers (Halse et al. 2014).

3.2 Conservation Significant Fauna and Habitats

A list of conservation significant fauna for the Study Area was compiled from the DBCA Wildlife Conservation (Specially Protected Fauna) Notice 2018 (DBCA 2018) and the Protected Matters Search Tool (PMST) of the Australian Government's Department of the Environment and Energy (DEE). Subterranean species that are listed under the WC Act and/or the EPBC Act and are likely to occur or have known habitat within the desktop Study Area are shown in Table 2 along with their conservation code. The PMST results listed no known subterranean fauna within the Study Area. A full description of the WC and DBCA conservation codes are shown in Appendix 1. The full list of species obtained from the PMST search is shown in Appendix 2.

Many of the species that appear in the Study Area are restricted to the caves within Yanchep National Park to the east of the YRE Project Development Envelope. The Study Area also contains a TEC related to the subterranean environment (Table 3, Appendix 2, DEE 2018), that is only known from six caves within the Yanchep National Park.

The Aquatic Root Mat Community TEC is a very important subterranean wetland site with numerous endemic stygobitic species present (refer Table 3 and Appendix 3). Aquatic cavernicoles (cave animals) at Yanchep include night fish, gilgies, leeches, microscopic worms, snails and insects and crustaceans although few are stygobionts, with most species representing stygophilic species. Some of the species appear to be endemic to these cave streams, and some are confined to a single cave (Jasinska 1996, 1997). A total of 100 species of fauna have been located in the six caves that contain the root mat community (Appendix 3). Few of the species can be regarded as stygobionts although four of the five amphipod species present, and the janirid isopod, are likely to have restricted ranges (Bennelongia 2008). Currently all sites where the Aquatic Root Mat Community TEC occur in Yanchep are completely dry, primarily due to a continuously declining regional watertable upon which the communities rely. It is unknown if this community is now extinct. None of the identified locations of the Aquatic Root Mat Community TEC occur in the YRE Project Development Envelope.

Table 2 Conservation significant species that may occur in the Study Area.

Name	Common Name	WC Act/DPaW Status	EPBC Act Status	Presence
Amphipoda: Hurleya sp. (WAM C23193)	Crystal Cave crangonyctoid, cave shrimp	CR	-	Only known from Yanchep Aquatic Root Mat Community

Table 3 Listed TECs relevant to the subterranean environment within the Study Area.

Name	Category	Description
Aquatic Root Mat Community in Caves of the Swan Coastal Plain	**Threatened ecological community**	At Yanchep, permanent streams and pools occur in caves and some support dense growths of root mats that provide a constant and abundant primary food source for rich aquatic cave communities. In Yanchep National Park, six caves (YN99, Cabaret Cave, Carpark Cave, Twilight Cave, Water Cave and, in the past, Gilgie Cave) are known to contain streams or pools fed by groundwater from the Gnangara Mound that contain root mats from Tuart trees (*Eucalyptus gomphocephala*). These caves are defined as containing one community type because there is considerable overlap of animal species between the five caves. Nevertheless the faunal assemblages vary both in species composition and relative abundance of species.

3.3 Subterranean Fauna Habitat in the Study Area

The broad Study Area encompasses the caves and karst of the Yanchep National Park that contains extensive habitat for subterranean fauna within the many caves and other subterranean voids formed within the karstic Tamala Limestone (Plate 1).

The Tamala Limestone extends north of Perth (Playford et al. 1976) and was formed in several stages over the past 600,000 years with the youngest parts adjacent to the Indian Ocean on the western side. The coastal aeolian calcarenite that hosts the Tamala Limestone has karstified simultaneously with the lithification of the original calcareous rich dune system, resulting in syngenetic karst i.e. caves and karst features form at the same time as the loose sediment is being cemented into rock that is generally soft and porous (White 2000, Grimes 2006).

Syngenetic karst has a distinctive morphology where cave systems are shallow and horizontal with a general lack of directed conduits instead low irregular chambers occur (Grimes 2006). Caves are often clustered at the margins of topographic highs or along the coast and contain paleosoil horizons and have vertical solution pipes which locally form dense fields (Grimes 2006). Syngenetic caves also contain extensive breakdown and subsidence in the form of collapse-dominated cave systems, along with a variety of surface and subsurface breccias and locally large collapse dolines and cenotes and with limited surface sculpturing such as karren (Grimes 2006). These features are best developed in host sediments that have well developed primary matrix permeability and limited secondary cementation (and hence limited mechanical strength), for example dune calcarenites. These syngenetic karst systems provide extensive and often seemingly stochastic habitat for subterranean fauna, especially troglofauna.

3.4 Subterranean Fauna Habitat in the YRE Project Development Envelope area

The YRE Project Development Envelope (Figure 1) is composed broadly of Safety Bay Sand, Tamala Sand and Tamala Limestone (Advisian 2017). These units are described in detail in Table 4. The Safety Bay Sand and the Tamala Sand provide limited habitat potential for subterranean fauna due to their unconsolidated nature and lack of interstitial voids. The Tamala Limestone (LS1), however, is known to contain abundant dissolution features (voids and cavities), which probably relate to alternate precipitation and dissolution associated with paleo-groundwater levels (Advisian 2017). These voids and cavities provide a High level of potential habitat to both troglofauna (above the water table) and stygofauna (in saturated zones).

The majority of the medium risk karst areas that host the most likely subterranean fauna habitat, crossed by the YRE Project Development Envelope are within the Part 1 portion of the Project, and to the south of the proposed Eglington station area (refer Plate 1). The field investigation by Advisian (2017) identified no particular engineering risk associated with larger karst features or unexpected / deleterious soils, although due to the extreme variability of these units locally there remains potential for these geohazards to be present throughout the entire YRE Project Development Envelope. Although larger karst voids and/or features are a potential engineering risk, it is mostly the smaller, micro and meso (1 mm – 20 cm) caverns that often provide habitat for subterranean fauna, due to their higher and constant humidity and these can occur throughout the Tamala Limestone (LS1) unit, thus all consolidated Tamala Limestone should be considered to have high habitat value for subterranean fauna despite an absence of human sized voids in many areas.

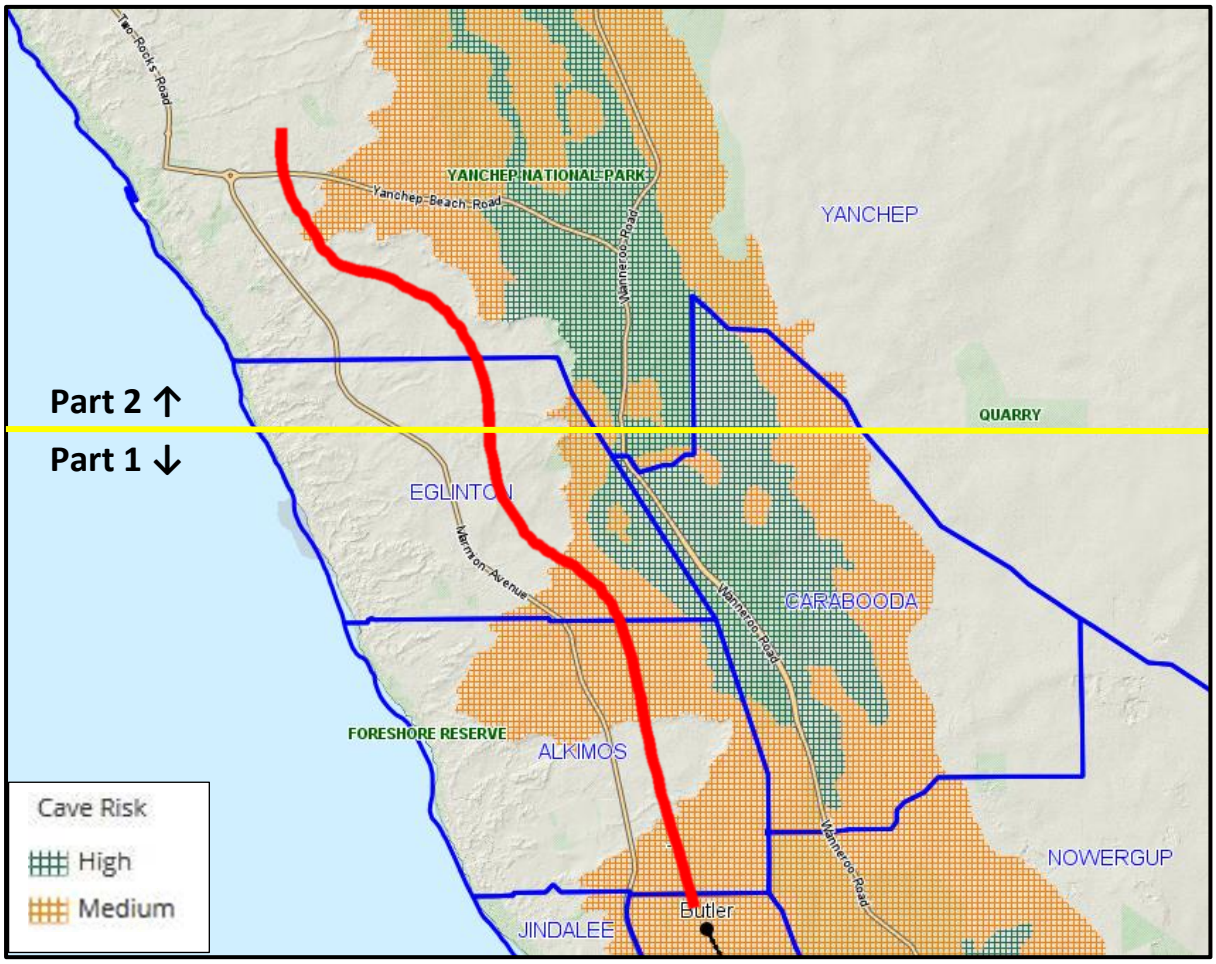


Plate 1 Karst risk map from City of Wanneroo based upon cave location data from Western Australian Speleological Group Inc. Unshaded areas are all Low risk. The approximate alignment of the YRE Project Development Envelope is shown in red. Parts 1 and 2 refer to the location of the two Parts of the YRE Project (RPS 2018).

Table 4 Geological units (after Advisian 2017) in the YRE Project Development Envelope and Assessment of Subterranean fauna habitat potential.

Geological Unit (as defined by Advisian 2017)	Description / Remarks	Assessment of Subterranean Fauna Habitat Suitability
Safety Bay Sand (S2)	Safety Bay Sand unit comprises relatively recent wind-blown material that has accumulated naturally as part of the coastal dune system. Typically very loose to medium dense.	Low for stygofauna and troglofauna.
Cemented Safety Bay Sand (LS4)	Patchy to intermittent carbonate cementation, resulting in the formation of very weakly cemented and very low strength siliceous calcarenite.	Low for stygofauna and troglofauna.
Tamala Sand (S7)	The Tamala Sand unit is widespread throughout the YRE Project Area, occurring almost everywhere as a surficial layer of variable thickness overlying Tamala Limestone. The Tamala Sand mostly comprises sand derived from the weathering of Tamala Limestone, but is likely to also represent relatively older coastal dune systems that have remained uncemented over time.	Low for stygofauna and troglofauna.
Tamala Limestone (LS1)	Leached karstic calcarenites. Siliceous carbonate sand is also commonly interbedded (i.e. encountered within) the Tamala Limestone. The presence of sand often reflects wholesale leaching and dissolution of carbonate from parts of the Tamala Limestone, which has resulted in the rock-mass essentially being reduced to soil *in situ*, or can also be as a result of downward migration of overlying sands into the rockmass and infilling open cavities or voids.	High for stygofauna (when saturated). High for troglofauna (above local water table).

Table 5 Listed TEC likelihood of occurrence within the YRE Project Development Envelope.

Name	Description	Likelihood of occurrence within the YRE Project Development Envelope
Aquatic Root Mat Community in Caves of the Swan Coastal Plain	Aquatic cave communities fed by groundwater from the Gnangara Mound that contain root mats from Tuart trees (*Eucalyptus gomphocephala*).	Low

The Aquatic Root Mat Community in Caves of the Swan Coastal Plain TEC is considered to have a low likelihood of occurrence within the YRE Development Envelope due to the extensive surveys of the Yanchep karst to located additional records this community since the mid 1990s. Despite extensive searching by both the then Conversation and Land Management (CALM) staff and amateur speleologists this TEC is known from only six locations, all within the Yanchep National Park, and within the High karst risk area as shown in Plate 1. The Aquatic Root Mat Community TEC is directly associated with Tuart tree roots and these trees are virtually completely absent from the YRE Development Envelope, making up less than 0.32 ha (0.22 %) of the total area and all occurrences are on Low karst risk areas (GHD 2018, Plate 1). It is therefore extremely unlikely that this TEC occurs within the YRE Development Envelope.

The regional decline in the water table has largely removed all habitat for this TEC in the region as Aquatic Root Mat Community TEC is reliant upon flows of groundwater for its existence. This TEC therefore has a low likelihood of occurring within the YRE Development Envelope as the confidence in this communities regional extent is high and the declining regional watertable has essentially already resulted in the local extinction of the known locations of this TEC.

3.5 Likelihood of stygofauna presence

A search was undertaken of the Western Australian Museum databases for Crustaceans (WAM 2018a) and Arachnids/Myriapods (WAM 2018b). The searches were undertaken as an approximate 50 km x 65 km rectangle centred on the Project Development Envelope (31°21'00"S 115°30'00"E, 31°54'00"S 116°10'15"E). The results of these filtered for subterranean stygofauna species are shown in Table 6.

The Gnangara Mound that occurs throughout the Study Area (on the Swan Coastal Plain) is known to contain stygofauna where sampling has occurred (Bennelongia 2008). No stygofauna sampling has previously occurred in the deeper Yarragadee formation, although habitat is likely to be present.

The Tamala limestone is highly likely to contain stygofauna due to its karstic nature if it is within the saturated zone and water quality is suitable. Diversity of stygofauna is not high within the Swan Coastal Plain from the limited sampling that has occurred (Bennelongia 2008, GHD 2010). The stygofauna records contained within the WAM Crustacean Department database is shown in Table 6 is invariably not complete with many records listed in unpublished survey reports either absent or incomplete. All the records in Table 6 are associated with the Yanchep Caves, however due to the decline in the regional water table in this area, these species have not been observed in several years within caves and may be locally extinct within the Study Area.

Overlying alluvium and colluvium have a low likelihood of containing stygofauna due to the absence of suitable voids.

No stygofauna records are present within the YRE Project Development Envelope.

Table 6 Stygofauna in WAM databases recorded from within the Study Area.

Order	Family	Genus and Species	Known occurrence within Study Area	Likelihood of occurrence within the YRE Development Envelope
Amphipoda	Neonipharidae	*Wesniphargus yanchepensis*	Yanchep Area Cave, YN256	Low
	Paramelitidae	*Hurleya* sp.	Crystal Cave, Yanchep	Low
Copepoda	Cyclopidae	*Australoeucyclops darwini*	Lot 51 Cave (YN555) Yellagonga Cave (YN438)	Moderate
		Paracyclops fimbriatus	Groundwater monitoring wells	Moderate

3.6 Likelihood of troglofauna presence

A search was undertaken of the Western Australian Museum databases for Crustaceans (WAM 2018a) and Arachnids/Myriapods (WAM 2018b). The searches were undertaken as an approximate 50 km x 65 km rectangle centred on the Project Development Envelope (31°21'00"S 115°30'00"E, 31°54'00"S 116°10'15"E). The results of these filtered for subterranean troglofauna species are shown in Table 7.

Three species of cavernicolous species have been recorded from the Study Area, all from the caves within and adjacent to Yanchep National Park (WAM 2018a and 2018b, refer Table 7). No obligate species of troglofauna are known to occur in Yanchep caves and the majority of species recorded from WAM records are not obligate cave fauna, but rather troglophiles or accidental species associated with the entrance areas of caves, rather than the deep cave environment. These species have been excluded from Table 7 as they are terrestrial species and occur more widely than karst terrains.

Troglofauna are known to occur within void spaces or fractured geological units, especially where transmissivity is high such as in karst. There is a low likelihood of troglofauna being present within the Safety Bay (S2, LS4), and Tamala Sands (S7) due to a lack of interconnected voids, however, the YRE Project Development Envelope (Figure 1) overlays Tamala Limestone (LS1) virtually along the entire alignment. The Tamala Limestone, due to its karstic nature, provides a High to very high likelihood for some troglofauna to be present, although most likely in low abundance and diversity.

No troglofauna records are present within the YRE Project Development Envelope.

Table 7 Troglofauna in WAM databases recorded from within the Study Area.

Order	Family	Genus and Species	Known occurrence within Study Area	Likelihood of occurrence within the YRE Development Envelope
Araneae: Araneomorphae	Stiphidiidae	*Baiami tegenarioides*	Various Yanchep Caves	Moderate
Pseudoscorpiones	Cheliferidae	*Protochelifer cavernarum*	Various Yanchep Caves	High
Chilopoda	Cryptopidae	*Cryptops sp.*	Various Yanchep Caves	High

4. Subterranean Fauna Preliminary Impact Assessment

This preliminary impact assessment is based primarily upon alignment and cut and fill plans contained with the Advisian (2017) geotechnical report, the EIA documentation (RPS 2018) and the project components as outlined by the PTA (Appendix 4). The main components of the overall project consist of the following:

- Underground and overhead utility service identification, relocations and protection.
- Construction of two new narrow gauge tracks (including associated infrastructure such as overhead line equipment, signalling and telecommunications), as part of extending the Butler line to Yanchep.
- Construction of nine road bridge crossings.
- Construction of three new stations; Alkimos Station, Eglinton Station and Yanchep Station.
- Connection of existing narrow gauge tracks to Butler at Butler Station, with infrastructure modifications (such as turnouts, overhead line equipment, signalling and telecommunications) to the station to accommodate for the newly imposed train operation.
- Upgrading existing traction sub-station from 15MVA to 25MVA either at Nowergup or Edgewater.

4.1 Groundwater impacts

The Perth Groundwater Map identifies the minimum depth from ground level to the water table to be approximately 10 metres within Bush Forever Site 289: Ningana Bushland and ranging between 28 metres and 48 metres across the remainder of the YRE Development Envelope. Within the Part 1 Development Envelope, the average depth to ground water from the natural ground surface (approximately 31 m) is significantly greater than the average cutting works required. Similarly for Part 2, the average depth to ground water from the natural ground surface (approximately 23 m) is significantly greater than the average cutting works required.

Given the large separation between the formation level of the YRE and the groundwater level, dewatering is not required during the construction of the YRE project, thus indirect impacts to subterranean fauna due to dewatering are not anticipated.

For both Part 1 and Part 2, groundwater abstracted from the superficial aquifer for construction purposes will be minor, resulting in drawn down of less than 1m and will not result in a significant reduction in regional or local groundwater levels (RPS 2018b). Therefore, impacts to subterranean fauna due to groundwater abstraction are not anticipated

4.2 Local impacts during construction and operation

The potential direct and indirect impacts to subterranean fauna within the YRE Development Envelope are summarised in Table 8 and Table 9. The assessment of the overall impact to subterranean fauna from each disturbance mechanism takes into account both the likelihood of the impact occurring, its duration and severity, the potential consequence to both stygofauna and troglofauna and the likelihood of subterranean fauna being present. The local geology and proximity to the TEC of aquatic root mat communities in the Yanchep National Park would indicate a very High likelihood of subterranean fauna being present in the YRE Development Envelope (refer Section 3), however, the overall diversity is considered low. Given the narrow linear nature of the project, and given similar or better subterranean habitat values are likely to be present in surrounding conservation estates, it is considered unlikely that the YRE project would result in local extinction.

Impacts that have been assessed as being Low risk to subterranean fauna combined with a low likelihood of occurrence such as Piling and drilling, alteration of hydrological regimes, vibration risk and habitat fragmentation are not considered further.

Direct impacts

Excavation for the YRE will be the most significant direct impact to subterranean fauna, however, it is still considered to be a Low (stygofauna) to Moderate (troglofauna) overall impact due to the generally shallow depths of excavation (Advisian 2017, RPS 2018). It is anticipated that the majority of impacts will be experienced during ground works, including excavations which will be approximately 25 m above the local water table (RPS 2018). The maximum depth of excavation from the natural surface is 13m at Chainage 51.5km, which is located in the northern section of Bush Forever Site 289, whilst the average depth is between 5 - 6 m (Advisian 2017, RPS 2018). The anticipated excavation will directly remove habitat for troglofauna, and indirectly affect troglofauna due to increased drying of rock surrounding excavation areas. These impacts are generally considered to be moderate as impact will be limited generally to the upper few metres below natural ground level and mostly will be removing sand units that contain no troglofauna habitat.

The destruction of significant caves or large voids during construction or excavation works may also have potential impacts upon subterranean fauna, especially troglofauna. The discovery of significant caves or voids during excavation should be specifically addressed in the Construction Environment Management Plan (CEMP).

The clearing of native vegetation associated with previously unknown aquatic root mat communities within the YRE Project Development Envelope would have High impact upon stygofauna and a Moderate impact upon troglofauna. It is, however, extremely unlikely, as no areas of High Likelihood for karst and caves are intercepted by the YRE Project Development Envelope (refer Plate 1 which contains all previously identified aquatic root mat communities). The Aquatic Root Mat Community TEC is directly associated with Tuart tree roots and these tree are virtually completely absent from the YRE Development Envelope, making up less than 0.32 ha total and all occurrences are on Low karst risk areas (GHD 2018, Plate 1). It is therefore extremely unlikely that this TEC occurs within the YRE Development Envelope. In addition all the known aquatic root mat communities are currently completely dry due to the decline in the regional water table upon which they are reliant. It is

therefore considered to be a Low overall impact, due to the extremely low probability of occurrence within the YRE Project Development Envelope.

Table 8 Risk of direct impacts to subterranean fauna from YRE Project development works

Direct disturbance mechanism	Likelihood of impact occurring	Risk of Impact to Stygofauna or Troglofauna Community if present	Assessment of overall potential impact to subterranean fauna
Vegetation clearing, removing root mat communities	Low	High for stygofauna Moderate for troglofauna	Low
Excavation works	High	Low for stygofauna due to depth to water table. Moderate for troglofauna	Low for stygofauna Moderate for troglofauna
Piling/drilling works	Low	Low	Low
Groundwater contamination due to spills during earth and construction works	Low	High for stygofauna Moderate for troglofauna	Low
Groundwater contamination due to spills during operations	Low	High for stygofauna Moderate for troglofauna	Low

Indirect impacts

Clearing of vegetation is an indirect impact that will reduce the amount of organic carbon that enters the subterranean environment that acts as a primary energy source for the subterranean environment. This indirect impact will be mitigated by the potential for winter rain events to wash vegetative material from outside cleared portions of the YRE Project Development Envelope into the subterranean environment. The clearing of native vegetation on the surface from the YRE Project is unlikely to pose significant impact to subterranean fauna due to the very limited clearing footprint in relation to the potential extent of subterranean habitat and hence the risk of this impact is considered low.

The alteration of surface and subsurface hydrology from excavation and construction of roads, buildings and other hard stand areas may potentially increase sedimentation into the subsurface environment. These indirect impacts have the potential to have a Moderate impact upon troglofauna by filling micro and meso caverns habitats, although due to appropriate stormwater design incorporating Water Sensitive Urban Design initiatives and the implementation of a CEMP the overall severity is considered to be Low.

Contamination of groundwater during construction and operations may also impact significantly upon subterranean fauna habitat, but risks of contamination can be minimised by employing management and mitigation measures to minimise and prevent contamination of groundwater. The potential for contamination during construction is limited to isolated areas of chemical storage and small quantities of hydro carbons where machinery or generators are working. Risks will be minimised by measures included in a CEMP. The risk of contamination during operations is minimal as the passenger railway runs off overhead electrified wires rather than stored fuel on the trains themselves. The trains contain only small quantities of transmission oil with minimal risk of contamination impacts. Where management measures are implemented, the risk of hydrocarbon

contamination to subterranean fauna is anticipated to be Low, however, should a major spill occur and not be adequately contained and remediated, the resulting impacts would be significant.

Vibration and noise from the construction and ongoing operation of the rail line is expected to be minimal, especially beyond the immediate vicinity of the rail line itself. These impacts are considered to be Low.

Table 9 Risk of indirect impacts to subterranean fauna from YRE Project development works

Indirect disturbance mechanism	Likelihood of impact occurring	Risk of Impact to Stygofauna or Troglofauna Community if present	Assessment of overall potential impact to subterranean fauna
Vegetation clearing reducing amount of organic carbon entering the subterranean environment	High	Low	Low
Alteration of existing hydrological regimes due to the construction of roads, buildings and other hard stand areas that will restrict the infiltration of water into the subterranean environment.	Low	Low	Low
Vibrations due to excavations/piling/operation of machinery	Moderate	Low	Low
Vibrations due to ongoing rail operation	Low	Low	Low
Alteration of surface hydrology that affects, sedimentation, and water quality (e.g. under and adjacent to infrastructure areas, roads and hard packed surfaces).	Low	Moderate	Low
Changes to subterranean microclimate in rock masses surrounding clearing areas	Moderate	Low for stygofauna Moderate for troglofauna	Low for stygofauna Moderate for troglofauna
Risk of species extinction from reduction and/or fragmentation in habitat.	Low	Low	Low

4.3 Regional significance and cumulative impacts

Diversity of subterranean fauna is generally very low per bore on the Swan Coastal Plain with less than five species recorded from any single bore, whilst bores in the Mid West and Pilbara region can support upwards to 30 to 50 species in some cases (Bennelongia 2008, Humphreys 2008, GHD 2010, Guzik et al. 2010). Stygofauna diversity is, however, very sensitive to sampling effort (Allford et al. 2008) and so additional sampling may find higher diversity in some areas of the Swan Coastal Plain. Many of the subterranean species previously recorded in other surveys are undescribed and it is likely that further undescribed, possibly restricted species occur, particularly among groups such as amphipods and isopods, and some of these may have significant conservation values (Bennelongia 2008, GHD 2010). Given the narrow linear nature of the project, and given similar or better subterranean habitat values are likely to be present in surrounding conservation estates such as Yanchep National Park, it is considered unlikely that the YRE project would result in local extinction.

Cumulative impacts on the Swan Coastal Plain are expected to be minimal as the known subterranean diversity is low compared with other regions of Western Australia (Pilbara and Mid-West). The primary cumulative impacts from this development is land clearance and altered hydrology, however, these developments are relatively small in the scale of northern Swan Coastal Plain, so cumulative impacts are assessed as being low. The abstraction of groundwater from the superficial aquifer for construction purposes will not result in a significant reduction in regional or local groundwater levels (RPS 2018b). It is not anticipated that the YRE Project will add significantly to the cumulative impacts to subterranean fauna in the local area.

5. Conclusions and Recommendations

The Study Area contains significant subterranean fauna habitat within the Yanchep National Park and immediately adjacent areas, however, the YRE Project Development Envelope intersects lower value habitat to the west of the high risk karst area. The Study Area contains the Threatened Aquatic Root Mat community within the Yanchep National Park, along with associated stygofauna and troglofauna species. None of these species or aquatic root mat communities are known to occur in the YRE Project Development Envelope. Habitat for both stygofauna and troglofauna does occur within the YRE Project Development Envelope due to the presence of the karstic Tamala Limestone underlying the Safety Bay sands.

There is potentially a Low likelihood of overall impact to stygofauna and troglofauna from virtually all aspects of the project as cut and fill activities will be generally occur within approximately five metres of the natural ground surface and dewatering is not anticipated to be required. The most significant impact, although still considered Moderate overall is from the excavation directly removing habitat and causing drying of adjacent troglofauna habitat. Contamination of groundwater during Project construction and operations may also impact significantly upon subterranean fauna habitat, but risks of contamination will be minimised by management and mitigation measures through the construction and operation of the project.

Cumulative impacts on the Swan Coastal Plain are expected to be minimal as the known subterranean diversity is low compared with other regions of Western Australia (Pilbara and Mid West). The primary cumulative impacts from this development is land clearance and altered hydrology, however, these are relatively small in the scale of northern Swan Coastal Plain. Given the narrow linear nature of the project, and given similar or better subterranean habitat values are likely to be present in surrounding conservation estates such as Yanchep National Park, it is considered unlikely that the YRE project would result in local extinction.

5.1 Recommendations

The following recommendations are made with regard to the construction of the YRE Project:

- If significant caves or voids are encountered during construction activities, work is suspended until their impact on subterranean fauna can be assessed by a suitably qualified person;
    - Engineering solutions to significant caves or voids that are encountered should be discussed with a suitably qualified subterranean biologist to ensure their suitability;
    - If significant cave or voids that contain potentially important subterranean biodiversity are to be destroyed then collection of specimens and genetic material for deposition into the WAM collections should be undertaken by a suitably qualified person;
- Management of Subterranean fauna is specifically included within a Construction Environment Management Plan (CEMP) to ensure site personnel are aware of potential impacts that may be caused by construction works and have management measures in place to minimise potential impacts.

- The risks to subterranean fauna and especially troglofauna should be re-examined following the detailed geotechnical site investigations.

6. References

Advisian (2017). Geotechnical investigation report – Yanchep Rail Extension. Unpublished report to the Public Transport Authority, 282p.

Allford A, Cooper SJB, Humphreys WF, Austin AD (2008). Diversity and distribution of groundwater fauna in a calcrete aquifer: does sampling method influence the story? Invertebrate Systematics 22: 127–138.

Bennelongia (2008). Literature review and monitoring program for stygofauna in the Gnangara Groundwater System. Unpublished report to Department of Environment and Conservation, 19p.

Christiansen, K. A. (1962). Proposition pour la classification des animaux cavernicoles. Spelunca Mem. 2: 76-78.

English V, Blyth, J., Jasinska, E., et al. (2000). Interim Recovery Plan Aquatic Root Mat Community of Caves of the Swan Coastal Plain 2000-2003. Conservation and Land Management, Environment Australia, November 2000. Accessed 6th March 2018 at www.environment.gov.au/resource/interim-recovery-plan-aquatic-root-mat-community-caves-swan-coastal-plain-2000-2003

EPA (2016a). Technical guidance subterranean fauna survey. Environmental Protection Authority: Perth. 24 pp.

EPA (2016b). Technical guidance Sampling methods for subterranean fauna. Environmental Protection Authority: Perth. 37 pp.

EPA (2016c). Environmental factor guideline. Subterranean Fauna. Environmental Protection Authority: Perth. 5 pp.

Geological Survey of Western Australia (1978). Perth 1:250,000 Sheet SH 50-14 and part of SH 50-13 Geological Map, Geological Survey of Western Australia.

GHD (2010). Report for Murray Wetland Study. Stygofauna Baseline Survey. Unpublished report to the Department of Water, 19p.

GHD (2012). Northern Suburbs Railway Alignment Butler to Yanchep Environmental Investigation. Unpublished report to the Public Transport Authority, 147p.

GHD (2018). Yanchep Rail Extension Biological Assessment, Unpublished report to the Public Transport Authority, 219p.

Grimes, K. G. (2006). Syngenetic karst in Australia: A review. *Helictite* **39**: 27-38.

Guzik, M.T., Austin, A.D., Cooper, S.J.B., Harvey, M.S., Humphreys, W.F., Bradford, T., Eberhard, S.M., King, R.A., Leys, R., Muirhead, K.A. and Tomlinson, M. (2010). Is the Australian subterranean fauna uniquely diverse? Invertebrate Systematics 24: 407–418.

Halse S.A., Scanlon M.D., Cocking J.S., Barron H.J., Richardson J.B. and Eberhard S.M. (2014). Pilbara stygofauna: deep groundwater of an arid landscape contains globally significant radiation of biodiversity. Records of the Western Australian Museum, Supplement 78: 443–483

Howarth, F. G. (1973). The cavernicolous fauna of Hawaiian lava tubes, 1. Introduction. Pacific Insects 15: 139-151.

Humphreys, W.F. (1999). Relict stygofaunas living in sea salt, karst and calcrete habitats in arid northwestern Australia contain many ancient lineages. In: The other 99%. The conservation and biodiversity of invertebrates. Ed W. Ponder and D. Lunney Transactions of the Royal Zoological Society of New South Wales, Mosman. Pp.219-227

Humphreys, W. F. (2000). Background and glossary. Ecosystems of the world. Subterranean ecosystems. Wilkens, H., Culver, D. C. and Humphreys, W. F. Amsterdam, Elsevier. 30: 3-14.

Humphreys, W.F. (2008). Rising from Down Under: developments in subterranean biodiversity in Australia from a groundwater fauna perspective. Invertebrate Systematics 22: 85–101.

Jasinska, E.J. and Knott, B. (2000). Chapter 15, Root driven faunas in cave waters. In Ecosystems of the World, Subterranean Ecosystems. Eds. Wilkens, H., Culver, D. C. and Humphreys, W. F. Amsterdam, Elsevier, p287 – 307.

Knott, B. and Goater, S. (2005) Moora quartzite mine: Stygofauna pilot survey Perth, Australia: Simcoa Operations.

Moulds, T.A. (2007a). Subterranean fauna of the Eneabba, Jurien and South Hill River (Nambung) karst areas, Western Australia. Unpublished report to the Department of Environment and Conservation Mid West Region, 27p.

Moulds, T.A. (2007b). October sampling of subterranean invertebrate fauna of the Eneabba, Jurien and South Hill River (Nambung) karst areas, Western Australia. Unpublished report to the Department of Environment and Conservation Mid West Region, 10p.

Ortuño VM, Gilgado JD, Jiménez-Valverde A, Sendra A, Pérez-Suárez G, Herrero-Borgoñón JJ. (2013). The “Alluvial Mesovoid Shallow Substratum”, a New Subterranean Habitat. PLoS ONE 8(10): e76311. doi:10.1371/journal.pone.0076311

Playford, P.E., Cockbain, A.E., Low, G.H. (1976). Geology of the Perth Basin, Western Australia. Western Australian Geological Survey Bulletin 124.

RPS (2018a). Environmental Impact Assessment Yanchep Rail Extension: Part 1 – Butler Station to Eglinton Station. Unpublished report to the Public Transport Authority, 794p.

RPS (2018b). Yanchep Rail Extension Hydrology Assessment. Unpublished memorandum to the Public Transport Authority, May 2018, 19p.

Western Australian Museum (WAM). (2018a). Crustacean database search, March 2018.

Western Australian Museum (WAM). (2018b). Arachnida and Myriapoda database search, March 2018.

Western Australian Speleological Group (Inc.) (WASG). (2016). Eneabba caves and cave fauna. http://wasg.org.au/index.php/2015-09-05-08-05-32/eneabba (Accessed 6 March 2018)

White, S. (2000). Syngenetic karst in coastal dune limestone: A review. Chapter 5.1.1 in Speleogenesis. Evolution of karst aquifers. Eds. Klimchouk, A.B., Ford, D.C., Palmer, A.N. and Dreybrodt, W. National Speleological Society Inc. Huntsville, Alabama, USA. 234-237p.

Appendix 1

Department of Parks and Wildlife Conservation Codes (November 2015)

Department of Parks and Wildlife

CONSERVATION CODES

For Western Australian Flora and Fauna

Specially protected fauna or flora are species* which have been adequately searched for and are deemed to be, in the wild, either rare, at risk of extinction, or otherwise in need of special protection, and have been gazetted as such.

Categories of specially protected fauna and flora are:

T **Threatened species**

Published as Specially Protected under the *Wildlife Conservation Act 1950,* and listed under Schedules 1 to 4 of the Wildlife Conservation (Specially Protected Fauna) Notice for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora (which may also be referred to as Declared Rare Flora).

Threatened fauna is that subset of 'Specially Protected Fauna' declared to be 'likely to become extinct' pursuant to section 14(4) of the Wildlife Conservation Act.

Threatened flora is flora that has been declared to be 'likely to become extinct or is rare, or otherwise in need of special protection', pursuant to section 23F(2) of the Wildlife Conservation Act.

The assessment of the conservation status of these species is based on their national extent and ranked according to their level of threat using IUCN Red List categories and criteria as detailed below.

CR **Critically endangered species**

Threatened species considered to be facing an extremely high risk of extinction in the wild. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 1 of the Wildlife Conservation (Specially Protected Fauna) Notice for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora.

EN **Endangered species**

Threatened species considered to be facing a very high risk of extinction in the wild. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 2 of the Wildlife Conservation (Specially Protected Fauna) Notice for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora.

VU **Vulnerable species**

Threatened species considered to be facing a high risk of extinction in the wild. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 3 of the Wildlife Conservation (Specially Protected Fauna) Notice for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora.

EX **Presumed extinct species**

Species which have been adequately searched for and there is no reasonable doubt that the last individual has died. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 4 of the Wildlife Conservation (Specially Protected Fauna) Notice for Presumed Extinct Fauna and Wildlife Conservation (Rare Flora) Notice for Presumed Extinct Flora.

IA **Migratory birds protected under an international agreement**

Birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and the Bonn Convention, relating to the protection of migratory birds. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 5 of the Wildlife Conservation (Specially Protected Fauna) Notice.

CD Conservation dependent fauna

Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 6 of the Wildlife Conservation (Specially Protected Fauna) Notice.

OS Other specially protected fauna

Fauna otherwise in need of special protection to ensure their conservation. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 7 of the Wildlife Conservation (Specially Protected Fauna) Notice.

P Priority species

Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened flora or fauna.

Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring.

Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.

1 Priority 1: Poorly-known species

Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.

2 Priority 2: Poorly-known species

Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.

3 Priority 3: Poorly-known species

Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.

4 Priority 4: Rare, Near Threatened and other species in need of monitoring

(a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands.
(b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for Vulnerable, but are not listed as Conservation Dependent.
(c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

*Species includes all taxa (plural of taxon - a classificatory group of any taxonomic rank, e.g. a family, genus, species or any infraspecific category i.e. subspecies or variety, or a distinct population).

Appendix 2

Protected Matters Search Tool results

Australian Government
Department of the Environment and Energy

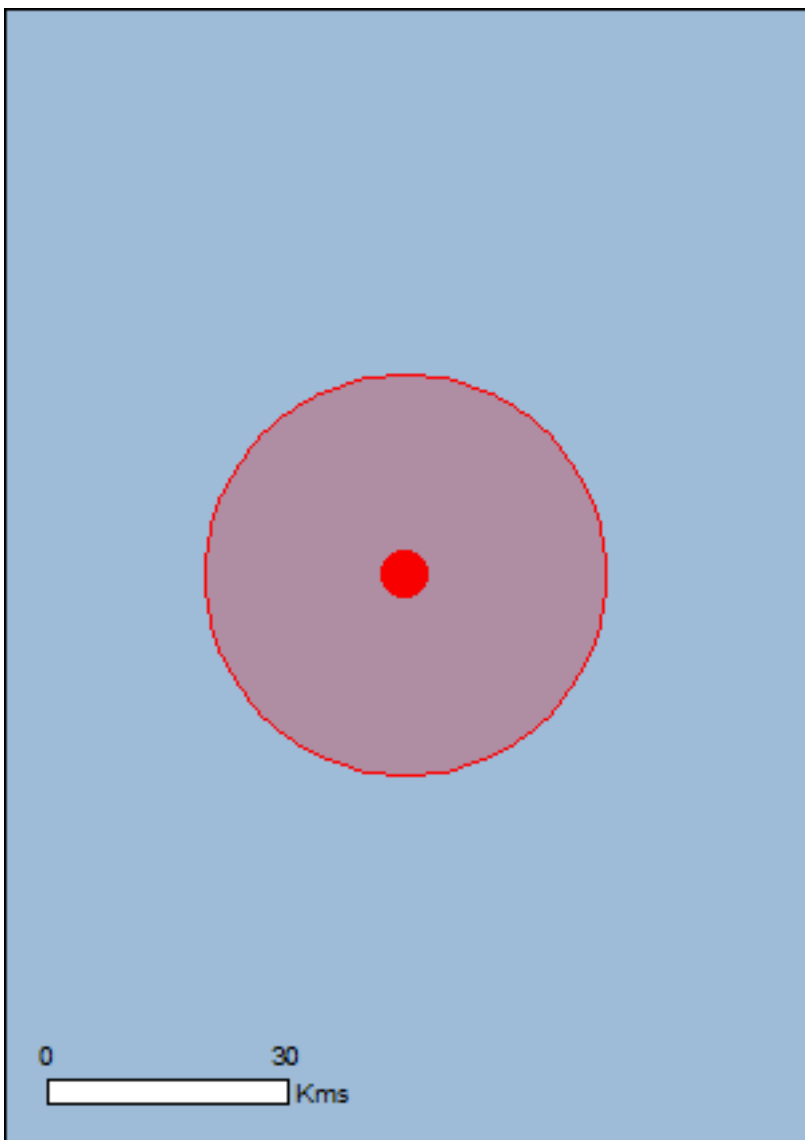
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

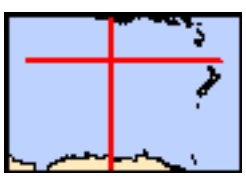
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 05/03/18 16:24:28



Coordinates
Buffer: 25.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	3
Listed Threatened Species:	54
Listed Migratory Species:	42

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	3
Commonwealth Heritage Places:	None
Listed Marine Species:	78
Whales and Other Cetaceans:	12
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	2

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	10
Regional Forest Agreements:	None
Invasive Species:	43
Nationally Important Wetlands:	2
Key Ecological Features (Marine)	2

Details

Matters of National Environmental Significance

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
South-west

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Aquatic Root Mat Community in Caves of the Swan Coastal Plain	Endangered	Community known to occur within area
Banksia Woodlands of the Swan Coastal Plain ecological community	Endangered	Community likely to occur within area
Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Endangered	Community known to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Species or species habitat may occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat likely to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo, Karrak [67034]	Vulnerable	Species or species habitat likely to occur within area
Calyptorhynchus latirostris Carnaby's Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat may occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Halobaena caerulea Blue Petrel [1059]	Vulnerable	Species or species habitat may occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat likely to occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat likely to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta cauta Shy Albatross, Tasmanian Shy Albatross [82345]	Vulnerable	Species or species habitat may occur within area

Name	Status	Type of Presence
Thalassarche cauta steadi		
White-capped Albatross [82344]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida		
Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris		
Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Mammals		
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Dasyurus geoffroii		
Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat likely to occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Breeding known to occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Neophoca cinerea		
Australian Sea-lion, Australian Sea Lion [22]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Plants		
Andersonia gracilis		
Slender Andersonia [14470]	Endangered	Species or species habitat may occur within area
Anigozanthos viridis subsp. terraspectans		
Dwarf Green Kangaroo Paw [3435]	Vulnerable	Species or species habitat likely to occur within area
Caladenia huegelii		
King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid [7309]	Endangered	Species or species habitat likely to occur within area
Chamelaucium sp. Gingin (N.G.Marchant 6)		
Gingin Wax [88881]	Endangered	Species or species habitat may occur within area
Diuris micrantha		
Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat likely to occur within area
Diuris purdiei		
Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat may occur within area
Drakaea elastica		
Glossy-leafed Hammer Orchid, Glossy-leaved Hammer Orchid, Warty Hammer Orchid [16753]	Endangered	Species or species habitat known to occur within area
Drakaea micrantha		
Dwarf Hammer-orchid [56755]	Vulnerable	Species or species habitat may occur within area
Eleocharis keigheryi		
Keighery's Eleocharis [64893]	Vulnerable	Species or species habitat may occur within area
Eucalyptus argutifolia		
Yanchep Mallee, Wabling Hill Mallee [24263]	Vulnerable	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Grevillea curviloba subsp. curviloba Curved-leaf Grevillea [64908]	Endangered	Species or species habitat may occur within area
Grevillea curviloba subsp. incurva Narrow curved-leaf Grevillea [64909]	Endangered	Species or species habitat may occur within area
Lepidosperma rostratum Beaked Lepidosperma [14152]	Endangered	Species or species habitat likely to occur within area
Marianthus paralius [83925]	Endangered	Species or species habitat known to occur within area
Thelymitra dedmaniarum Cinnamon Sun Orchid [65105]	Endangered	Species or species habitat may occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sharks		
Carcharias taurus (west coast population) Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat known to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Foraging, feeding or related behaviour likely to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Diomedea epomophora		
Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans		
Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Hydroprogne caspia		
Caspian Tern [808]		Foraging, feeding or related behaviour known to occur within area
Macronectes giganteus		
Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli		
Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Onychoprion anaethetus		
Bridled Tern [82845]		Breeding known to occur within area
Phoebetria fusca		
Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Sterna dougallii		
Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Thalassarche cauta		
Tasmanian Shy Albatross [89224]	Vulnerable*	Species or species habitat may occur within area
Thalassarche melanophris		
Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Migratory Marine Species		
Balaena glacialis australis		
Southern Right Whale [75529]	Endangered*	Breeding known to occur within area
Balaenoptera edeni		
Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Caperea marginata		
Pygmy Right Whale [39]		Species or species habitat may occur within area
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Lamna nasus		
Porbeagle, Mackerel Shark [83288]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat may occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Migratory Terrestrial Species		
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area
Calidris subminuta Long-toed Stint [861]		Species or species habitat known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Tringa glareola		
Wood Sandpiper [829]		Species or species habitat known to occur within area
Tringa nebularia		
Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -
Defence - GIN GIN SATELLITE AIRFIELD
Defence - MUCHEA ARMAMENT RANGE

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus		
Common Noddy [825]		Species or species habitat likely to occur within area
Anous tenuirostris melanops		
Australian Lesser Noddy [26000]	Vulnerable	Species or species habitat may occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area
Calidris subminuta Long-toed Stint [861]		Species or species habitat known to occur within area
Catharacta skua Great Skua [59472]		Species or species habitat may occur within area
Charadrius ruficapillus Red-capped Plover [881]		Species or species habitat known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat may occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Halobaena caerulea Blue Petrel [1059]	Vulnerable	Species or species habitat may occur within area
Himantopus himantopus Black-winged Stilt [870]		Species or species habitat known to occur within area
Larus novaehollandiae Silver Gull [810]		Breeding known to occur within area
Larus pacificus Pacific Gull [811]		Foraging, feeding or related behaviour may occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat likely to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Species or species habitat may occur within area
Puffinus assimilis Little Shearwater [59363]		Foraging, feeding or related behaviour known to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Foraging, feeding or related behaviour likely to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Sterna anaethetus Bridled Tern [814]		Breeding known to occur within area
Sterna caspia Caspian Tern [59467]		Foraging, feeding or related behaviour known to occur within area
Sterna dougallii Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area

Name	Threatened	Type of Presence
Thinornis rubricollis Hooded Plover [59510]		Species or species habitat may occur within area
Tringa glareola Wood Sandpiper [829]		Species or species habitat known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Fish		
Acentronura australe Southern Pygmy Pipehorse [66185]		Species or species habitat may occur within area
Campichthys galei Gale's Pipefish [66191]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		Species or species habitat may occur within area
Hippocampus breviceps Short-head Seahorse, Short-snouted Seahorse [66235]		Species or species habitat may occur within area
Hippocampus subelongatus West Australian Seahorse [66722]		Species or species habitat may occur within area
Lissocampus fatiloquus Prophet's Pipefish [66250]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Mitotichthys meraculus Western Crested Pipefish [66259]		Species or species habitat may occur within area
Nannocampus subosseus Bonyhead Pipefish, Bony-headed Pipefish [66264]		Species or species habitat may occur within area
Phycodurus eques Leafy Seadragon [66267]		Species or species habitat may occur within area
Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area
Pugnaso curtirostris Pugnose Pipefish, Pug-nosed Pipefish [66269]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Stigmatopora argus Spotted Pipefish, Gulf Pipefish, Peacock Pipefish [66276]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Stigmatopora olivacea a pipefish [74966]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Mammals		
Arctocephalus forsteri Long-nosed Fur-seal, New Zealand Fur-seal [20]		Species or species habitat may occur within area
Neophoca cinerea Australian Sea-lion, Australian Sea Lion [22]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Reptiles		
Aipysurus pooleorum Shark Bay Seasnake [66061]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans		[Resource Information]
Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within

Name	Status	Type of Presence
		area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Caperea marginata Pygmy Right Whale [39]		Species or species habitat may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Breeding known to occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Commonwealth Reserves Marine	[Resource Information]
Name	Label
Two Rocks	Marine National Park Zone (IUCN II)
Two Rocks	Multiple Use Zone (IUCN VI)

Extra Information

State and Territory Reserves	[Resource Information]
Name	State
Jandabup	WA
Lake Joondalup	WA
Neerabup	WA
Neerabup	WA
Unnamed WA21176	WA
Unnamed WA43290	WA
Unnamed WA49994	WA
Woodvale	WA
Yanchep	WA
Yeal	WA

Invasive Species

[Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Streptopelia senegalensis Laughing Turtle-dove, Laughing Dove [781]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Funambulus pennantii Northern Palm Squirrel, Five-striped Palm Squirrel [129]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Asparagus declinatus Bridal Veil, Bridal Veil Creeper, Pale Berry Asparagus Fern, Asparagus Fern, South African Creeper [66908]		Species or species habitat likely to occur within area
Asparagus plumosus Climbing Asparagus-fern [48993]		Species or species habitat likely to occur within area
Brachiaria mutica Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Genista linifolia Flax-leaved Broom, Mediterranean Broom, Flax Broom [2800]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Olea europaea Olive, Common Olive [9160]		Species or species habitat may occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur

Name	Status	Type of Presence within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Protasparagus densiflorus Asparagus Fern, Plume Asparagus [5015]		Species or species habitat likely to occur within area
Protasparagus plumosus Climbing Asparagus-fern, Ferny Asparagus [11747]		Species or species habitat likely to occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Tamarix aphylla Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area
Ramphotyphlops braminus Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat likely to occur within area

Nationally Important Wetlands [Resource Information]

Name	State
Joondalup Lake	WA
Loch McNess System	WA

Key Ecological Features (Marine) [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Commonwealth marine environment within and	South-west
Western rock lobster	South-west

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-31.59493 115.68048

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

Department of the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

Appendix 3

Fauna collected from five caves with aquatic root mat habitats and a surface stream in close proximity to YN 99 (Boomerang Gorge stream) in the Yanchep National Park (Jasinska, 1997 in English et al. 2000).

TAXON	Boomerang Gorge stream	Cabaret Cave	Carpark Cave	Gilgie Cave	Twilight Cave	YN 99 cave	Total occur
INVERTEBRATA							
ACARINA							
Acaridida							
Acaridae sp.1		1*					1
Prostigmata							
HALACARIDA							
Lobohalacarus sp. nov. 1 (eyeless)	1	1	1		1	1	5
Soldanellonyx sp. 1	1	1	1	1	1	1	6
HYDRACARINA							
Tillia sp. nov. 1						1*	1
ORIBATIDA							
Hydrozetes sp. 1		1				1	2
Trimalaconothrus sp. 1 (eyeless)	1					1	2
Trhypochthoniellus sp. 1		1*	1	1	1		4
Oribatida sp. 1		1*			1*		2
Oribatida sp. 2				1*			1
Oribatida sp. 3				1*			1
ANNELIDA							
Hirudinea							
Erpobdellidae sp. 1		1				1	2
Oligochaeta							
Aeolosomatidae sp. 1				1			1
Aeolosoma sp. 1				1		1	2
Aeolosoma aff. leidyi Cragin					1		1
Aeolosoma tracanvorense Aiyer		1	1	1	1	1	5
Aeolosoma sp. 2					1		1
Pristina longiseta Ehrenberg		1	1	1		1	4

TAXON	Boomerang Gorge stream	Cabaret Cave	Carpark Cave	Gilgie Cave	Twilight Cave	YN 99 cave	Total occur
Pristina aequiseta Bourne						1	1
Pristina sp. 1				1		1	2
Pristina sp. 2			1				1
Pristina sp. 3				1			1
Enchytraeidae sp. 1		1		1	1		3
Enchytraeidae sp. 2				1		1	2
Enchytraeidae sp. 3			1				1
Phreodrillidae sp. 1		1	1		1		3
Phreodrillidae sp. 2				1			1
Insulodrilus ?*lacustris* Benham		1	1		1		3
Tubificidae ('group A') sp. 1		1		1		1	3
Tubificidae (?*Aulodrilus*) sp. 2	1	1**		1			2
CNIDARIA							
Hydra sp. 1						1	1
Hydra sp. 2						1*	1
CRUSTACEA							
Amphipoda							
Austrochiltonia subtenuis (Sayce)	1	1		1		1	4
Paramelitidae (gen. nov.) sp. nov. 1			1*		1		2
Hurleya sp. 1		1	1		1		3
Perthia sp. nov. 1		1*			1		2
Perthia sp. nov. 2					1		1
Copepoda							
CYCLOPOIDA							
Ectocyclops rubescens Brady	1						1
Eucyclops sp. 1	1						1
Eucyclops linderi Lindberg		1**					1
Macrocyclops sp. 1						1*	1
Paracyclops sp. 1	1				1	1	3
Paracyclops sp. 2		1	1	1	1		4
HARPACTICOIDA							
Attheyella sp.1	1					1	2
Bryocamptus		1	1	1	1		4

TAXON	Boomerang Gorge stream	Cabaret Cave	Carpark Cave	Gilgie Cave	Twilight Cave	YN 99 cave	Total occur
(*Limnocamptus*) sp. 1							
Elaphoidella sp. 1	1					1	2
?gen. nov. aff. *Elaphoidella*/ *Bryocamptus* sp. 1				1	1	1	3
Parastenocaris sp.1			1	1	1		3
?gen. nov. aff. *Epactophanes* sp. 2					1		1
Harpacticoida sp. 1				1			1
Harpacticoida sp. 2			1		1		2
Decapoda: PARASTACIDAE							
Cherax quinquecarinatus (Gray)	1	1	1	1	1	1	6
Isopoda							
Janiridae sp. nov. 1	1	1	1	1	1	1	6
Ostracoda							
Darwinula sp. 1	1					1	2
Gomphodella aff. maia De Dekker		1	1	1	1	1	5
Candona sp. 1			1		1		2
Candoniidae sp.1		1*					1
Cyprididae sp. 1	1						1
ENTOGNATHOUS HEXAPOD sp. 1		1*					1
INSECTA							
Coleoptera: DYTISCIDAE							
Sternopriscus sp. 1	1	1	1	1	1	1	6
Diptera (larvae)							
CHIRONOMIDAE			1*	1*			2
Corynoneura sp. 1						1	1
Paramerina levidensis (Skuse)	1					1	2
Polypedilum sp. 1		1				1	2
CERATOPOGONIDAE sp. 1	1				1	1	3
CULICIDAE							
Anopheles sp. 1	1						1
Tipulidae sp. 1		1*		1*	1*		3
Trichoptera							

TAXON	Boomerang Gorge stream	Cabaret Cave	Carpark Cave	Gilgie Cave	Twilight Cave	YN 99 cave	Total occur
Leptoceridae sp. 1		1*					1
MOLLUSCA: Gastropoda							
Hydrobiidae sp. 1	1			1		1	3
NEMATODA							
Araeolaimida							
Aphanolaimus sp. 1		1					1
Araeolaimida sp. 1			1				1
Chromadorida							
Chromadorida sp. 1		1	1	1	1	1	5
Chromadorida sp. 2			1		1		2
Chromadorinae sp. 1			1				1
Dorylaimida							
Amphidelus sp. 3		1	1	1			3
Iotonchus sp. 1		1	1	1	1	1	5
Mesodorylaimus sp. 1		1		1			2
Mesodorylaimus sp. 2					1	1	2
Alaimoidea sp. 1		1	1				2
Dorylaimidae sp. 1			1				1
Enoplida							
Ironus sp. 1	1	1	1	1	1	1	6
Tobrilus sp. 1	1		1				2
Tobrilus sp. 2			1				1
Monohysterida							
Monohystera sp. 1			1	1	1	1	4
Monohysterida sp. 1			1	1	1		3
Tylenchida							
Atylenchus sp. 1			1		1		2
Hemicycliophora sp. 1		1	1	1			3
Nematoda sp. 1						1	1
Nematoda sp. 2		1					1
Nematoda sp. 3		1					1
PLATYHELMINTHES: Turbellaria							
CATENULIDA							
Stenostomum sp. 1		1	1	1	1	1	5
Stenostomum sp. 2		1	1		1	1	4

TAXON	Boomerang Gorge stream	Cabaret Cave	Carpark Cave	Gilgie Cave	Twilight Cave	YN 99 cave	Total occur
MACROSTOMIDA							
Macrostomum sp. 1		1				1	2
Macrostomum sp. 2				1	1		2
Macrostomum sp. 3	1	1				1	3
RHABDOCOELA							
Dalyellioida sp. 1	1		1	1	1	1	5
Gyratrix hermaphroditus Ehrenberg			1		1		2
Stenostomum sp. 1		1	1	1	1	1	5
Stenostomum sp. 2		1	1		1	1	4
MACROSTOMIDA							
Temnocephala sp. 1		1					1
Typhloplanidae sp. 1		1					
ROTIFERA							
Bdelloidea sp. 1	1					1	3
Philodina sp. 1		1	1	1	1	1	5
Rotifera spp.	1			1	1		3
TARDIGRADA: Eutardigrada							
HYPSIBIIDAE							
Hypsibius sp. 1			1			1	2
VERTEBRATA							
OSTEICHTHYES: Percichthyidae							
Bostockia porosa Catelnau		1					1

Bold = Gilgie Cave stream fauna collected both before and after the drying.

Rare species (less than four individuals collected in total) are marked with an asterisk.

Total occur = Total number of sites at which the species occurred.

Appendix 4

Components of the Yanchep Rail Extension Project Part 1 and 2

The main components of the overall project consist of the following:

- Underground and overhead utility service identification, relocations and protection.
- Construction of two new narrow gauge tracks (including associated infrastructure such as overhead line equipment, signalling and telecommunications), as part of extending the Butler line to Yanchep.
- Construction of nine road bridge crossings, eight of which will be funded by the PTA.
- Construction of three new stations; Alkimos Station, Eglinton Station and Yanchep Station.
- Connection of existing narrow gauge tracks to Butler at Butler Station, with infrastructure modifications (such as turnouts, overhead line equipment, signalling and telecommunications) to the station to accommodate for the newly imposed train operation.
- Upgrading existing traction sub-station from 15MVA to 25MVA either at Nowergup or Edgewater.

Horizontal Design

The horizontal alignment complies with the recommended parameters in PTA Code of Practice for Narrow Gauge and minimum radius of curve is 1100m. Because of this the horizontal geometry allows for maximum design speeds of 140 km/hr on tangent track and 130km/h for curved track in majority of the extension.

Vertical Design

It was intended in the DPI study that the railway will be in a cutting of four to five meters deep throughout the future residential areas. This will assist in minimising the noise and vibration effect, improve the visual aesthetics and allow future grade separated crossings to be constructed without major modifications. However, cuttings for the majority of the alignment would result in a large excess of spoil. The alignment has sought to balance earthwork quantities where possible by incorporating desirable limit gradients and vertical curves.

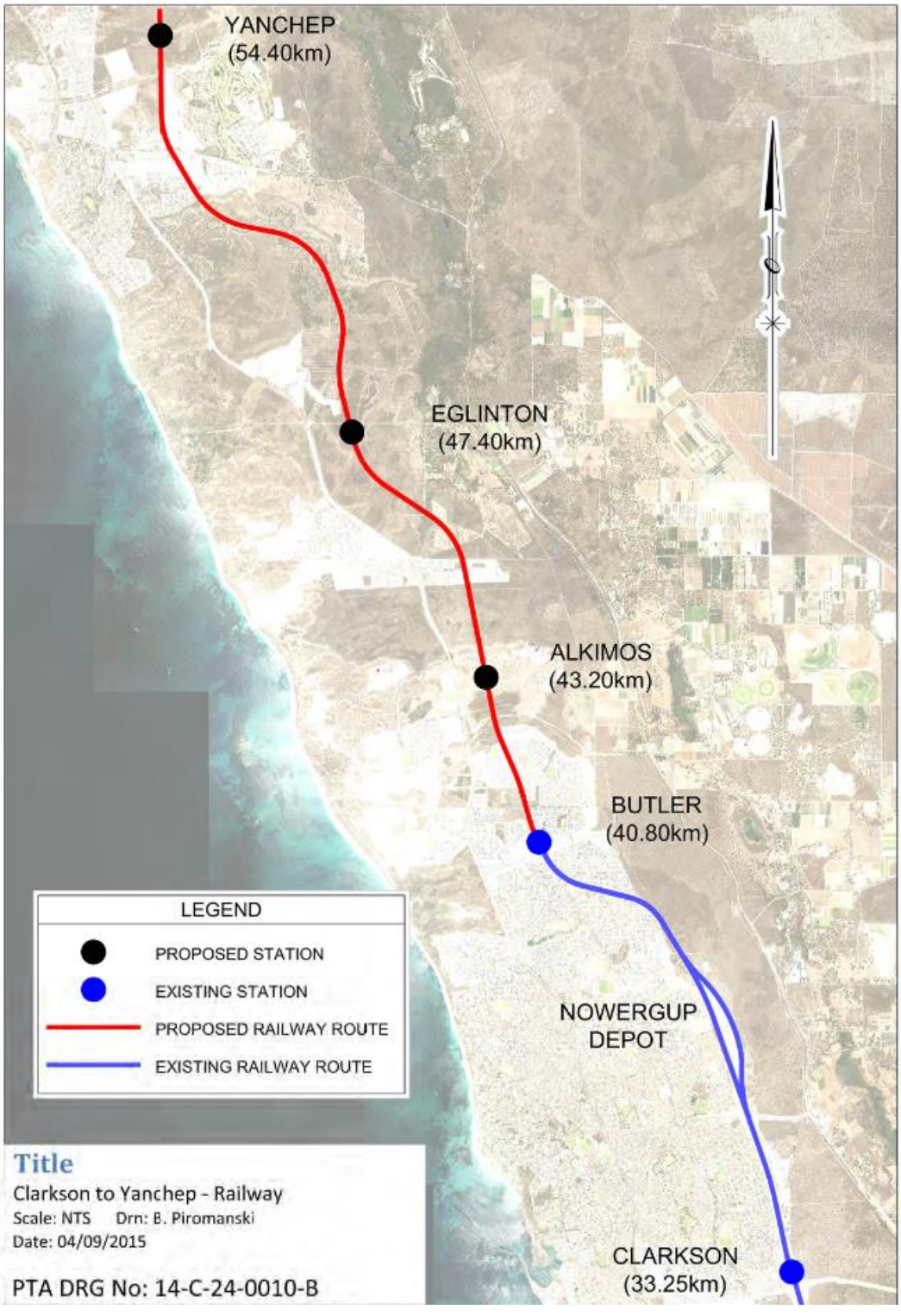
Butler to Alkimos

From Butler (Ch. 40.8) to Alkimos (Ch. 43.2) the alignment mostly passes through the urban development on both sides with developer's roads running parallel to the corridor. The section is mostly in cut with approximate depths ranging from 4m to 7m. Alkimos is a secondary centre with a station at Ch. 43.3.

Alkimos to Eglinton

North of Alkimos from Ch. 43.2 to Ch. 47.4, the route passes through a Parks and Recreation reserve which is proposed for conversion to Bush forever. The majority of the railway alignment is in cut excluding a short section of 190m from Ch. 43.7 to Ch. 43.85, which is on an embankment of approximately 5m in height. This continues before transitioning into cut again due to proposed higher earthworks levels by the developer on both sides. Eglinton station at Ch. 47.4 is within

Eglinton District Centre just south of Pipidinny Road. Drainage basins No. 1 to 3 are situated in this section.



Eglinton to Yanchep

Urban development has been proposed north of Eglinton station up to Ch. 49.02. The section from Ch. 49.0 to Ch. 81.9 passes through bush forever and an effort has been made to balance the earthwork quantity in cut and fill in this section. The urban development commences south of

Yanchep Beach Road and continues up to Yanchep. Yanchep station is located in the Yanchep city centre. Drainage basins 4 to 7 are situated in this section.

Yanchep and beyond

Yanchep station is also in cut similar to Alkimos and Eglinton. The adjacent developer has proposed financial contribution for covering Yanchep station to create green walking areas on top. The proposal is currently under review by PTA. Two stowage roads, with a dead end at Ch. 55.15 have been planned north of Toreopango Ave with the capacity to store 4 train sets for morning service provisions. A future traction substation has also been proposed adjacent to the stowage roads. Drainage basin No. 8 has been relocated from Ch. 53.99 to Ch. 55.18.

Part 2

The proposal is to extend the Joondalup railway line from Eglinton Station to Yanchep Station and includes a turnback facility to the north of the Yanchep Station to allow for the turning and stowage of trains. The proposal also includes the construction of a new station at Yanchep with intermodal rail, bus, 'park and ride', 'kiss and ride' and active mode (cycling and walking) facilities at the Yanchep Station.

- Part 2: Eglinton Station to Yanchep Station includes the northern portion of the YRE project area to the north of the Eglinton Station and generally coincides with the land reserved "Railway" under the MRS before terminating within the northern section of the Yanchep City LSP. The Part 2 development footprint includes a turnback facility to the north of the Yanchep Station to allow for the turning and stowage of trains. The 72.89 Part 2 Development Envelope is comprised of a 60.31 ha development footprint and 12.58 ha of construction and access areas.

Yanchep Rail Extension: Part 2 – Eglinton Station to Yanchep Station Infrastructure Layout and Extent of Physical and Operational Elements

Element	Location	Proposed Extent / Description
Physical Elements		
Railway Extension	The dual narrow-gauge track will begin from a connection with the Joondalup railway line, north of the Eglinton Station. The railway will generally follow the land reserved "Railway" under the MRS before terminating with the northern section of the Yanchep City LSP.	The 7.19 km of dual narrow-gauge track will be located within a 60.31 ha Part 2 development footprint. The railway will generally be cut approximately 5 metres (m) below the surrounding ground level. The railway corridor will be constrained either through battering the excavation or using retaining walls. The corridor is approximately 40m wide. Within Bush Forever Site No. 289: *Ningana Bushland, Yanchep/Eglinton* the railway is not situated adjacent to any sensitive premises. Hence the railway will be constructed at grade (rather than being cut below the ground level to

Element	Location	Proposed Extent / Description
		mitigate noise and vibration impacts) to reduce engineering and sand excavation requirements. The railway corridor increases to be approximately 73 metres wide through Bush Forever Site No. 289: *Ningana Bushland, Yanchep/Eglinton* to allow for the railway to be constructed at grade.
Yanchep Station	The proposed Yanchep station is located within the north of the Yanchep City LSP area.	Yanchep Station will be an at grade station which will serve the Yanchep locality and surrounding future suburbs. Yanchep Station development footprint is included within the Part 2 development footprint and is approximately 6.37 ha in extent. Provision has been made for an intermodal rail, bus, 'park and ride', 'kiss and ride' and active mode facilities.
Construction and Access Areas	Construction and access areas have been selected to coincide with proposed future urban development or roads either reserved by the MRS or as detailed within approved and draft LSPs.	The construction and access areas will be located within a 12.58 ha extent outside of the Part 2 development footprint but within the Part 2 Development Envelope.
Operational Elements		
Railway Line	The dual narrow-gauge track will begin from a connection with the Joondalup railway line, north of the Eglinton Station. The railway will generally follow the land reserved "Railway" under the MRS before terminating with the northern section of the Yanchep City LSP.	The constructed railway line will operate train services between the Eglinton and Yanchep stations.
Yanchep Station	The proposed Yanchep station is located within the north of the Yanchep City LSP area.	Bus and train services will operate from the Yanchep station.