

**Strike Energy
West Erregulla gas field project
Level 1 Fauna Assessment**



Lateritic breakaway in study area (Photo: Peter Smith)

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Executive Summary

Introduction

Strike Energy is proposing to further develop its West Erregulla gas field project approximately 300 km north of Perth and 50 km southeast of Dongara. Bamford Consulting Ecologists (BCE) was commissioned to provide information on the fauna values of the project area (particularly for significant species), to give an overview of the ecological function of the site within the local and regional contexts, and to provide discussion on the interaction of development on the site with these fauna values and functions.

BCE uses a 'values and impacts' assessment process with the following components:

- The identification of fauna values:
 - Assemblage characteristics: uniqueness, completeness and richness;
 - Species of conservation significance;
 - Recognition of ecotypes or vegetation/substrate associations (VSAs) that provide habitat for fauna, particularly those that are rare, unusual and/or support significant fauna;
 - Patterns of biodiversity across the landscape; and
 - Ecological processes upon which the fauna depend.
- The review of impacting processes such as:
 - Habitat loss leading to population decline;
 - Habitat loss leading to population fragmentation;
 - Degradation of habitat due to weed invasion leading to population decline;
 - Ongoing mortality from operations;
 - Species interactions including feral and overabundant native species;
 - Hydrological change;
 - Altered fire regimes; and
 - Disturbance (dust, light, noise).
- The recommendation of actions to mitigate impacts (if requested).

The project area was visited for a site inspection on the 22nd to 23rd June 2021 to gain a better understanding of the fauna values of the project area. The primary aims were to examine the vegetation and substrate associations present, conduct a Black-Cockatoo habitat assessment (comprising foraging, roosting and breeding assessment), and to record opportunistic observations of fauna. A review of fauna data for the general area was undertaken, accessing a range of databases but also utilising several detailed fauna surveys previously undertaken by BCE within and adjacent to the lease. The project area is located within an area and region which has been extensively studied by both BCE and other consultants, providing familiarity with the fauna assemblage in the area.

Description of project area

The project area consists of approximately 8 hectares of well-pads and tracks in addition to the existing well-pads and tracks. It is located within an area of mostly-undisturbed bushland with some agricultural clearing to the east. The vegetation is mostly low heath on sands with some lateritic breakaways. Three Vegetation and Substrate Associations (VSAs) were recorded within the project area – Heathland on lateritic breakaways (VSA 1), comprising less than 2% of the project area; Low

heath on white-grey sand (VSA 2), comprising 60-70% of the project area; and Low heath on yellow sand (VSA 3), comprising 30-40% of the project area. The majority of the site was burnt by a recent fire (within the past one to two years) with no leaf litter present on the ground, except for in a small unburnt band of *Allocasuarina*. The low heath comprised *Banksia* and *Hakea* species which are Black-Cockatoo foraging plants.

Key fauna values

Fauna values within the project area can be summarised as follows:

Fauna assemblage. The desktop study identified 202 vertebrate fauna species as potentially occurring in the project area, comprising ten frogs, 48 reptiles, 120 birds and 24 mammals (15 native and nine feral mammal species). It is expected that at least twelve mammals, and possibly an additional mammal, one bird and one reptile, have become locally extinct. The fauna assemblage is considered to be moderately rich but incomplete with some species locally extinct, mostly critical weight range mammals. The reptile assemblage in particular is rich and distinctive due to the biogeography of the region. There is a high proportion of non-resident birds, including many which are nectivorous and exploit seasonal abundance of nectar and pollen from the species-rich flora. Overall, the vertebrate fauna assemblage is likely to be well represented and typical of the Lesueur Sandplains subregion. The invertebrate fauna assemblage is more likely to include some species with restricted distributions (SREs) associated with particular landscape features in the lateritic breakaways.

Species of conservation significance. A total of seven invertebrate and eleven vertebrate species of conservation significance are expected to occur in the project area. The vertebrates comprise four CS1, three CS2 and four CS3 species from two reptiles, eight birds and one mammal. Twelve conservation significant mammal species may be locally extinct and are not included in species counts. Carnaby's Black-Cockatoo is important as it is likely to be a regular foraging visitor to the project area. There are roosting records for the species nearby, but the nearest confirmed breeding site is c. 100km to the south. Vegetation within the project area represents foraging habitat of at least moderate value for the species. The Western Ground Parrot may be locally extinct but because of its very high conservation significance (with the only known wild population estimated at c. 100 birds; A. Burbidge pers. comm.) and previous records within close proximity of the project area, the slight possibility of the species being extant in the general area is important. While significant invertebrates are poorly-documented, landscape interpretation suggest that VSA 1 may support SRE species and the entire project area may support a priority Trapdoor Spider (*Idiosoma kwongan*).

Vegetation and Substrate Associations (VSAs).

The project area encompasses three VSAs, all of which are intact. The most distinct of these are the lateritic breakaways of VSA 1. The most extensive across the project area are low heath on white-grey sand (VSA 2) and low heath on yellow sand (VSA 3), which are expected to support conservation significant species and a high diversity of birds and reptiles. All three VSAs are well-represented in the region.

Patterns of biodiversity. Within the project area all VSAs are intact and likely to support a high level of species richness. VSAs 2 and 3 (low heath) are by far the most extensive and likely to support a high

reptile and bird richness. VSA 1 may support some SREs and species associated with rocky areas due to the VSA being small in extent and distinctive.

Key ecological processes. The main processes which may affect the fauna assemblage are likely to be the fire regime, the presence of feral predators, and habitat loss/fragmentation.

Impact assessment

Impacts are considered to be mostly Negligible to Minor, largely because of the small development footprint. Potential impacts on the lateritic breakaways, which may support SRE species, are of greatest concern. Threatening processes which may be impacted include:

- Loss of habitat affecting population survival - Negligible to Minor. The disturbance footprint is small so proportional habitat loss is low, but loss of lateritic breakaways may affect some SRE species.
- Loss of habitat leading to population fragmentation – Negligible to Minor. The development footprint is narrow and linear; large remnant vegetation is continuous to west but to the east lies cleared agricultural land. Impact remains Minor as long as clearing does not become wider due to vegetation degradation, as can result if vehicles leave tracks or through weed invasion.
- Increased mortality – Negligible to Minor. The main source likely to be roadkill.
- Species interactions, including predation and competition – Minor. Feral species are already present in the project area and the increased development will attract more feral animals to the area through the inadvertent or deliberate provision of food and shelter and/or human activity. Of main concern are Feral Cats and Foxes which use cleared lines to access otherwise intact areas of native vegetation so this has the potential to increase predation pressure on native fauna, especially reptiles and small mammals. Reducing risk of increased predator activity would require management of waste and education/signage.
- Fire – Minor (with management). Increased human activity brings with it an increase in risk of fire, although the majority of the project area has been recently burnt so fuel load is low until vegetation recovers. Tracks can increase the risk of fire but also provide the potential for fire management.
- Disturbance: dust, light, noise, and vibration – Minor (with management). These effects would be very localised and can be minimised through directing light away from surrounding vegetated areas and minimising disturbance at all times.

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1 Introduction

Strike Energy is proposing to further develop its West Erregulla gas field project approximately 300 km north of Perth and 50 km southeast of Dongara. The proposed development consists of clearing approximately 8 hectares (ha) for additional tracks and well-pads. Bamford Consulting Ecologists (BCE) was commissioned to provide information on the fauna values of the project area (particularly for significant species), to give an overview of the ecological function of the site within the local and regional contexts, and to provide discussion on the interaction of development on the site with these fauna values and functions. This report presents the results of the investigations carried out by BCE. The purposes of this report are to provide information on the fauna values of the project area, a discussion on the interaction of proposed development on the site with these fauna values and functions, and to provide some regional context and assess the importance of project area for fauna.

1.1 General Approach to Fauna Impact Assessment

The purpose of impact assessment is to provide government agencies with the information they need to decide upon the significance of impacts of a proposed development, and to provide information to proponents to help them to develop appropriate strategies for avoiding and minimising impacts of their activities. This relies on information on the fauna assemblage and its environment, and BCE uses an approach with the following components:

1. The identification of **fauna values**:
 - Assemblage characteristics: uniqueness, completeness and richness;
 - Species of conservation significance;
 - Recognition of ecotypes or vegetation/substrate associations (VSAs) that provide habitat for fauna, particularly those that are rare, unusual and/or support significant fauna;
 - Patterns of biodiversity across the landscape; and
 - Ecological processes upon which the fauna depend.
- The review of **impacting processes** such as:
 - Habitat loss leading to population decline;
 - Habitat loss leading to population fragmentation;
 - Degradation of habitat due to weed invasion leading to population decline;
 - Ongoing mortality from operations;
 - Species interactions including feral and overabundant native species;
 - Hydrological change;
 - Altered fire regimes; and
 - Disturbance (dust, light, noise).
- The **recommendation** of actions to mitigate impacts (if requested).

1.2 Study Objectives

Based on the impact assessment process above, the objectives of the study are therefore to:

1. Conduct a desktop literature review and searches of Commonwealth and State databases for terrestrial fauna;

2. Undertake any field investigations necessary to supplement information obtained from the literature and database review, and to ensure familiarity with the project area;
3. Review the list of fauna expected to occur on the site in the light of environments present;
4. Identify significant or fragile fauna habitats within the project area;
5. Identify any ecological processes in the project area upon which fauna may depend;
6. Identify general patterns of biodiversity within or adjacent to the project area;
7. Identify potential impacts upon fauna and propose recommendations to minimise impacts;
and
8. Provide recommendations to mitigate impacts.

Descriptions and background information on these values and processes can be found in Appendices 1 to 4. In particular, Appendix 1 explains and defines the fauna values, including the recognition of three classes of species of conservation significance (CS): those listed under legislation (CS1), those listed as priority by the Department of Biodiversity, Conservation and Attractions (DBCA; CS2), and those that can be considered of local or other significance, but which have no formal listing (CS3). Appendix 2 outlines the legal definitions and classes of conservation significance. Appendices 3 and 4 provide background information on threatening processes.

1.3 Description of project area

The project area comprises a series of well-pads and tracks, some of which are existing. The area lies approximately 26 km south-west of Mingenew, and approximately 25 km east of Yandanogo Nature Reserve and 20 north-west of Wilson Nature Reserve (Figure 1). It is located within the Lesueur Sandplain sub-region of the Geraldton Sandplains Bioregion (see section 1.5.2 below). The project area overlies crown land consisting of remnant bushland and private farmland. The entire project area and surrounding areas appears to have been burnt during a bushfire approximately two years ago (MyFireWatch website, Landgate 2021).

1.4 Project Description

The project involves further development of Strike Energy's existing West Erregulla gas field project,. Currently, four well-pads and associated tracks exist in the area, and the proposed development involves clearing approximately 8 ha for two additional well-pads and associated tracks (Figure 2).

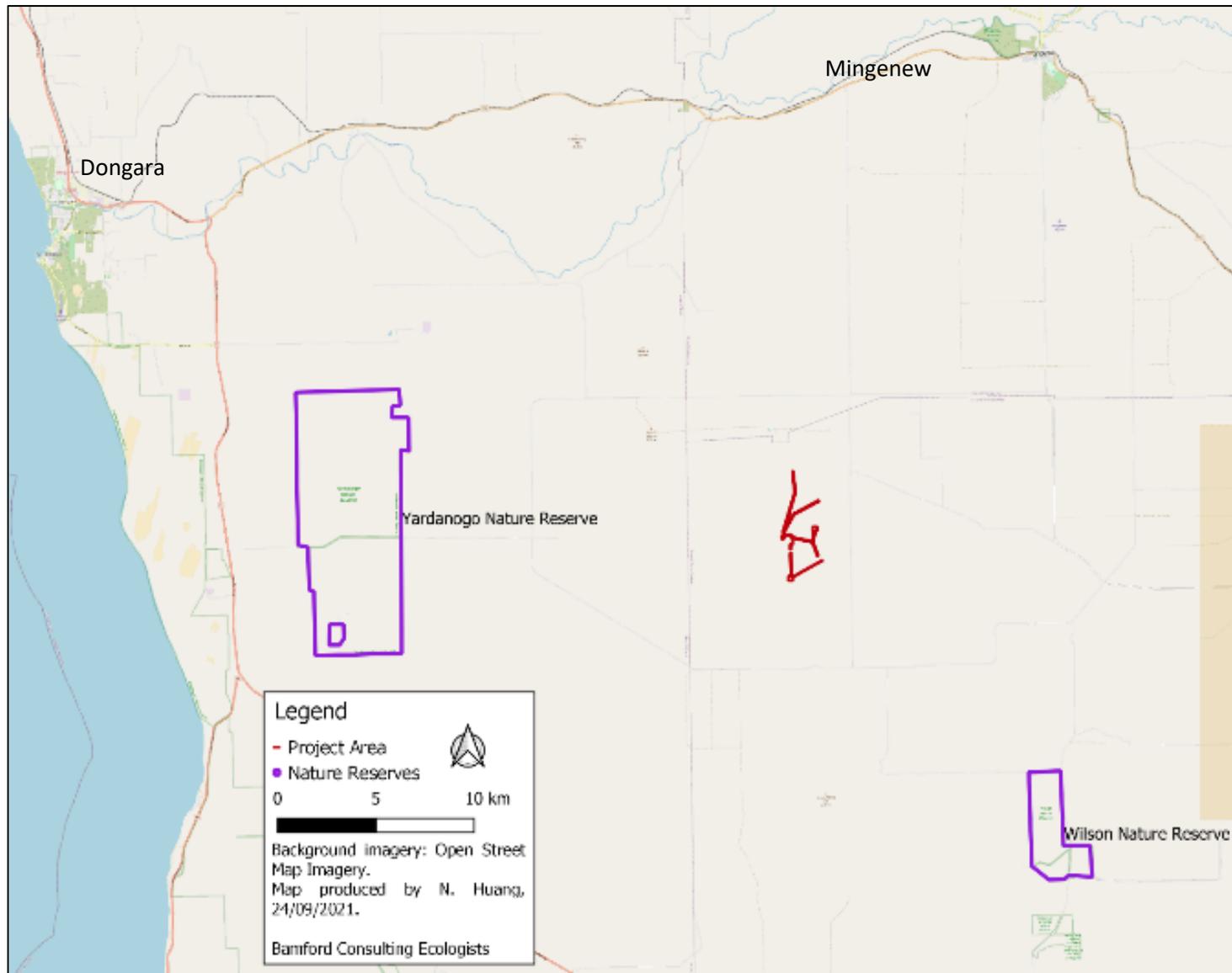


Figure 1. Location of project area in relation to nature reserves and towns.



Figure 2. Project area showing existing and proposed well-pads and tracks

1.5 Description of Existing Environment

1.5.1 Vegetation and Landform

A previous fauna assessment conducted in the same project area described six fauna habitats (Coffey 2013):

1. Cleared Land: agricultural land either crops or pasture.
2. Planted Eucalypts: isolated trees along roadsides.
3. Mixed shrubland with/without woodland species: mixed shrubland with or without low open woodland, on flats, in depressions and on slopes.
4. Laterite Breakaway: contain a mixture of shrubland with or without open mallee woodland on clear rises or ridges in the landscape.
5. Open Eucalyptus Forest: occurs in patches through the area with *Eucalyptus accedens* as the dominant species.
6. Minor Drainage: open shrubland in minor drainage lines and flats.

A large number of distinct, species-rich and geographically restricted floristic communities (Mt Lesueur and Coomallo area) are found in the Lesueur Sandplain sub-region, as well as a large number of rare flora, vertebrate fauna and stygofauna of cave communities (Beekeepers Nature Reserve area). This area is known Australia-wide and internationally as having a particularly high floristic diversity and level of endemism (Desmond and Chant 2001). However, only approximately 17.67% of the sub-region is in conservation reserves, with a high proportion of cleared land in the eastern portion of the region (Desmond and Chant 2001).

The vegetation of the Lesueur Sandplain subregion consists mainly of shrub-heaths rich in endemics on a mosaic of lateritic mesas, sandplains, coastal sands and limestone, with heath on lateritised sandplains along the north-eastern margins of the subregion (Desmond and Chant 2001). The vegetation of the Northern Sandplains Region is broadly described as scrub on heath on sandplains near the coast with *Acacia-Casuarina* thickets further inland and *Acacia* shrub with scattered trees of *Eucalyptus loxophleba* on hard-setting loams.

1.5.2 IBRA Region Description

The Interim Biogeographic Regionalisation of Australia (IBRA) has identified 26 bioregions in Western Australia which are further divided into subregions (DAWE 2021). Bioregions are classified on the basis of climate, geology, landforms, vegetation and fauna (Thackway and Cresswell 1995). IBRA Bioregions are affected by a range of different threatening processes and have varying levels of sensitivity to impact (EPA 2020). The project area is located in the Lesueur Sandplain sub-region, within the Geraldton Sandplains bioregion (Figure 3), which is rich in endemics, composed mainly of proteaceous scrub-heaths, on the sandy earths of an extensive, undulating, lateritic sandplain (Desmond and Chant 2001). The Lesueur Sandplain sub-region comprises of coastal Aeolian and limestones, Jurassic siltstones and sandstones of central Perth Basin. Alluvials are associated with drainage systems and there are extensive yellow sandplains in south-eastern parts. Shrub-heaths rich in endemics occur on a mosaic of lateritic mesas, sandplains, coastal sands and limestones. The dominant land uses in this bioregion are agriculture, conservation reserves and crown reserves (Desmond and Chant 2001).



Figure 3. Bioregions across Western Australia; project area is located in the Lesueur Sandplain subregion (indicated by red dot).

1.5.3 Climate Information

The project area typically has a dry, warm Mediterranean climate, with winter precipitation of 300-500 mm and 7-8 dry months per year (Beard 1980). Average maximum and minimum temperatures, rainfall and sunshine data from the nearest weather station (Eneabba (site 008225); Bureau of Meteorology 2021) are shown in Table 1.

Table 1: Climate averages for the project area (BOM 2021).

Site name = Eneabba, Site number = 008225

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature												
Mean Max Temp (°C)	36.4	36.5	33.8	29.3	24.3	20.9	19.7	20.8	23.0	26.8	30.2	33.6
Mean Min Temp (°C)	18.7	19.6	18.1	15.3	12.2	10.1	8.9	9.0	9.6	11.4	13.9	16.1
Rainfall												
Mean Rainfall (mm)	7.5	13.5	13.7	27.6	69.3	99.0	93.6	75.4	45.7	23.1	14.8	8.9
Other Daily Elements												
Mean No of Clear Days	14.7	12.0	11.8	8.4	8.1	7.1	6.9	7.6	8.3	9.9	10.5	13.1
Mean No of Cloudy Days	2.5	3.6	4.1	5.8	7.8	8.0	8.7	7.8	6.5	6.4	5.6	2.9

2 Methods

2.1 Overview

This approach to fauna impact assessment has been developed with reference to guidelines and recommendations set out by the Western Australian Environmental Protection Authority (EPA) on fauna surveys and environmental protection (EPA 2002, 2016c, 2016b, 2020), and Commonwealth biodiversity legislation (DotE 2013; DSEWPaC 2013a). The EPA (2020) recommends three levels of investigation that differ in their approach for field investigations:

- **Basic** – a low-intensity survey, conducted at the local scale to gather broad fauna and habitat information (formerly referred to as ‘Level 1’). The primary objectives are to verify the overall adequacy of the desktop study, and to map and describe habitats. A basic survey can also be used to identify future survey site locations and determine site logistics and access. The results from the basic survey are used to determine whether a detailed and/or targeted survey is required. During a basic survey, opportunistic fauna observations should be made and low-intensity sampling can be used to gather data on the general faunal assemblages present. While referred to as ‘basic’, this level of survey is involved and powerful, and should be considered the primary level of assessment. Other levels of assessment (where deemed necessary) add information to inform this primary level.
- **Detailed** – a detailed survey to gather quantitative data on species, assemblages and habitats in an area (formerly referred to as ‘Level 2’). A detailed survey requires comprehensive survey design and should include at least two survey phases appropriate to the biogeographic region (bioregion). Surveys should be undertaken during the seasons of maximum activity of the relevant fauna and techniques should be selected to maximise the likelihood that the survey

will detect most of the species that occur, and to provide data to enable some community analyses to be carried out.

- **Targeted** – to gather information on significant fauna and/or habitats, or to collect data where a desktop study or field survey has identified knowledge gaps. Because impacts must be placed into context, targeted surveys are not necessarily confined to potential impact areas. A targeted survey usually requires one or more site visits to detect and record significant fauna and habitats. For areas with multiple significant species there may not be a single time of year suitable to detect all species. In these cases, multiple visits, each targeting different species or groups, should be conducted.

The level of assessment recommended by the EPA (2020) is determined by geographic position, with a generic statement that detailed surveys are expected across all of the state except the south-west, but also recommending that site and project characteristics be considered, such as the survey objectives, existing available data, information required, the scale and nature of the potential impacts of the proposal and the sensitivity of the surrounding environment in which the disturbance is planned. These aspects should be considered in the context of the information acquired by the desktop study. When determining the type of survey required, the EPA (2020) suggested that the following be considered:

- level of existing regional knowledge
- type and comprehensiveness of recent local surveys
- degree of existing disturbance or fragmentation at the regional scale
- extent, distribution and significance of habitats
- significance of species likely to be present
- sensitivity of the environment to the proposed activities
- scale and nature of impact.

A 'basic' level survey (desktop review, fauna habitat identification and a site inspection) is considered appropriate for the Strike Energy Project. This is based upon the level of existing knowledge, the extent, distribution and significance of habitats (widespread) and the significance of species likely to be present (generally a limited assemblage of significant species with very specific habitat requirements).

The approach and methods utilised in this report are divided into three groupings that relate to the stages and the objectives of impact assessment:

- **Desktop assessment.** The purpose of the desktop review is to produce a species list that can be considered to represent the vertebrate fauna assemblage of the project area based on unpublished and published data using a precautionary approach.
- **Field investigations.** The purpose of the field investigations carried out for a Basic assessment is to gather information on the vegetation and soil associations ('habitats') that support the fauna assemblage and place the list generated by the desktop review into the context of the environment of the project area. The brief field investigations that form part of a Basic assessment also allow for some fauna observations to be made and assist the consultant to

develop an understanding of the ecological processes that may be operating in the project area.

- **Impact assessment.** Determine how the fauna assemblage may be affected by the proposed development based on the interaction of the project with a suite of ecological and threatening processes.

2.2 Identification of Vegetation and Substrate Associations (VSAs)

Vegetation and substrate associations (VSAs) combine vegetation types, the soils or other substrate with which they are associated, and the landform. In the context of fauna assessment, VSAs are the environments that provide habitats for fauna.

BCE deliberately makes the distinction between 'habitat' (a species-specific term that may encompass the whole or part of one or more VSAs and is the physical subset of an ecosystem that a given species, or species group, utilises) and 'VSA' (a general, discrete and mutually exclusive spatial division of a target area, based on soil, vegetation and topography). It is recognised, however, that, within the broader EIA literature/guidance, the former term is used more or less synonymously to indicate the latter (e.g. 'habitat assessment' used by EPA 2020). Further discussion is provided in Appendix 1. Explanation of fauna values.

For the current assessment, VSAs were identified based on the consultants' previous experience in the area and on observations made during the field investigations.

2.3 Desktop Assessment

2.3.1 Sources of information

Information on the fauna assemblage of the project area was drawn from a wide range of sources. These included state and federal government databases and results of regional studies. Databases accessed were the Atlas of Living Australia (ALA), the WA Department of Biodiversity, Conservation and Attractions (DBCA) NatureMap, the Western Australian Museum's FaunaBase (from 2005), BirdLife Australia's Birddata (Atlas) Database (BA), the EPBC Protected Matters Search Tool and the BCE database (Table 2). BCE has conducted eleven previous fauna surveys in the general area between Eneabba and Dongara which have included basic and targeted fauna assessments; these are detailed in the following section. Information from the above sources was supplemented with species expected in the area based on general patterns of distribution. Sources of information used for these general patterns are listed in Table 3. Details of the previous BCE fauna surveys conducted in the general area are given in Table 4.

Table 2. Sources of information used for the 2021 desktop assessment; BCE surveys detailed in following section.

Database/Literature	Type of records held on database	Area searched
Atlas of Living Australia (ALA 2021)	Records provided by collecting institutions, individual collectors and community groups.	29.39868°S, 115.30903° E – plus 25 km buffer.
NatureMap (DBCA 2021)	Records in the WAM and DBCA databases. Includes historical data and records on Threatened and Priority species in WA.	21.9128°S, 113.9782° E – plus 25 km buffer.
BirdLife Australia Birdata (Atlas Database) 2019	Records of bird observations in Australia, 1998-2018.	21.9128°S, 113.9782° E – plus 20 km buffer.
EPBC Protected Matters 2021	Records on matters of national environmental significance protected under the EPBC Act.	21.9128°S, 113.9782° E – plus 20 km buffer.

Table 3. Sources of information used for general patterns of terrestrial fauna distribution.

Taxa	Sources
Frogs	Tyler <i>et al.</i> (2000), and Anstis (2013).
Reptiles	Storr <i>et al.</i> (1983, 1990, 1999 and 2002), and Wilson and Swan (2020-6 th Edition).
Birds	Blakers <i>et al.</i> (1984), Kendrick (1993), Johnstone and Storr (1998, 2004), Barrett <i>et al.</i> (2003), and Menkhorst <i>et al.</i> (2017).
Mammals	Kendrick (1993), Menkhorst and Knight (2004), Churchill (2008), and Van Dyck and Strahan (2008).

2.3.2 Previous fauna surveys

The project area is located within an area and region which has been extensively studied, with eleven surveys conducted by BCE alone within a 30 km radius of the project area over the past 13 years (Figure 4), providing familiarity with the fauna assemblage in the area. These have included basic fauna assessments (formerly referred to as 'Level 1'), and targeted fauna assessments and detailed fauna assessments (formerly referred to as 'Level 2'). There have also been studies by other consultants in the region, particularly for the Eneabba mineral sands mine (results collated in BCE desktop reviews). Species records from these studies are contained in the NatureMap database which was consulted as part of the desktop assessment. BCE also maintains a detailed database and annotated species lists for all its previous assessment (some of which pre-date NatureMap) and these were consulted for reference as part of the desktop assessment. Previous BCE fauna studies for the area are summarised below in Table 4 and their locations in relation to the project area are shown in Figure 4. The previous studies used a range of techniques as they as they were carried out for different purposes but were consistent with guidance at the time. In combination, they are consistent with current (EPA 2020) guidance in the range of techniques used.

Table 4. Previous BCE surveys within c. 20-25km of project area (except where noted).

Authors	Description	Alignment with current guidance (EPA 2020)	Limitations
Harris <i>et al.</i> 2008	Survey for threatened fauna in the Tronox Mt Adams project area. Hand-searching and aural surveys targeting the Millipede <i>Antichiropus</i> 'Eneabba 1' (previously found in the Mt Adams project area (Metcalf and Bamford 2008)), the Phasmid-mimic Cricket <i>Phasmodes jeeba</i> (uncertainty about past records in the Mt Adams area) and Western Ground Parrot (unconfirmed but well-regarded sighting in Mt Adams area in 1992). Survey involved hand-searching and aural survey in spring 2008.	Targeted survey (<i>sensu</i> EPA 2020). Methods based on survey approaches described by Rentz (1996) for invertebrates and based on advice from DBCA for Western Ground Parrot.	No limitations except uncertainly always surrounds surveys for rare species and absence can rarely be confirmed.
Metcalf and Bamford 2008	Basic, Detailed and Targeted surveys in the Tronox Mt Adams project area, including a site inspection (September 2002), and late winter and spring surveys (2007). Investigations included hand-searching for SRE invertebrates, aural surveys for Western Ground Parrot, pitfall trapping (900 trapnights), Elliott and cage trapping (240 trapnights each), bird censusing, harp-traps for bats and opportunistic observation.	Basic, targeted and detailed surveys. A wide range of sampling techniques used as outlined by the EPA (2020). Traps were run for five nights in each survey as was standard at the time.	No limitations. Motion-sensitive cameras were not used as is standard practice now but were used at a nearby site by Bamford and Chuk (2015-2017).
Bamford 2009	A desktop review and site inspection carried out for Iluka from ca. Beekeepers' Road to Arrowsmith River, west of Brand Highway. Included some aural survey work for Western Ground Parrot.	Basic survey.	No limitations.
Everard and Bamford 2014	A desktop review and site inspection around and south of Eneabba for Iluka. Over 20km south of Arrowsmith North project area, but a comprehensive review of multiple fauna surveys around Eneabba across similar landscapes.	Basic survey.	No limitations.
Bamford 2012	Targeted surveys for the Western Ground Parrot in the Tronox Mt Adams Project area and nearby Beekeepers' Nature Reserve. Surveys carried out in May 2008 and June 2012 with up to eight observers over up to five evenings and mornings.	Targeted survey. Methods based on advice from DBCA for Western Ground Parrot.	No limitations except uncertainly always surrounds surveys for rare species and absence can rarely be confirmed. Possible calls were heard in June 2012, but this was not followed up.
Bamford <i>et al.</i> 2015	Desktop review and site inspection of Waitsia project area for AWE; northern edge of Yandanogo Nature Reserve. Included targeted surveys for Western Ground Parrot and observations on roosting Carnaby's Black-Cockatoo.	Basic and targeted survey.	No limitations.
Bamford and Chuk 2015-2017	Use of motion-sensitive cameras (baited) to detect fauna activity along drill-lines just west of Arrowsmith, targeting feral species but also appropriate for detecting significant species such as Malleefowl, Chuditch, Western Ground Parrot and Quenda. Total effort was 904 camera-nights over three years (about 10 days each autumn in 2015, 2016 and 2017). Opportunistic observations on other fauna made.	Targeted survey. Methods complement Metcalf and Bamford (2008).	No limitations.

Authors	Description	Alignment with current guidance (EPA 2020)	Limitations
Bamford and Chuk 2019	Desktop review and site inspection of the VRX Silica Arrowsmith Central project area.	Basic survey.	No limitations.
Bancroft and Bamford 2020	Desktop review, site inspection and some targeted survey across a broad area from just east of the Arrowsmith North project area to south of Eneabba; for Beach Energy. Included an update of previous desktop reviews across this area and field investigations to confirm black-cockatoo roosts and black-cockatoo foraging habitat.	Basic and some targeted survey.	No limitations.
Bamford 2020	Desktop review, site inspection and some targeted survey of the Beharra Spring Silica Project (Adams Road immediately west of Tronox project area) for Perpetual Resources. Targeted survey included searching for SRE invertebrates and assessing habitat for Carnaby's Black-Cockatoo.	Basic and some targeted survey.	No limitations.
Bamford <i>et al.</i> 2021	Desktop review, site inspection and some targeted surveys of the Arrowsmith North project area for VRX Silica Ltd (located east of Brand Highway between Dongara and Eneabba). Targeted survey included searching for and assessing habitat for Carnaby's Black-Cockatoo and Western Ground Parrot.	Basic and some targeted survey.	No limitations.

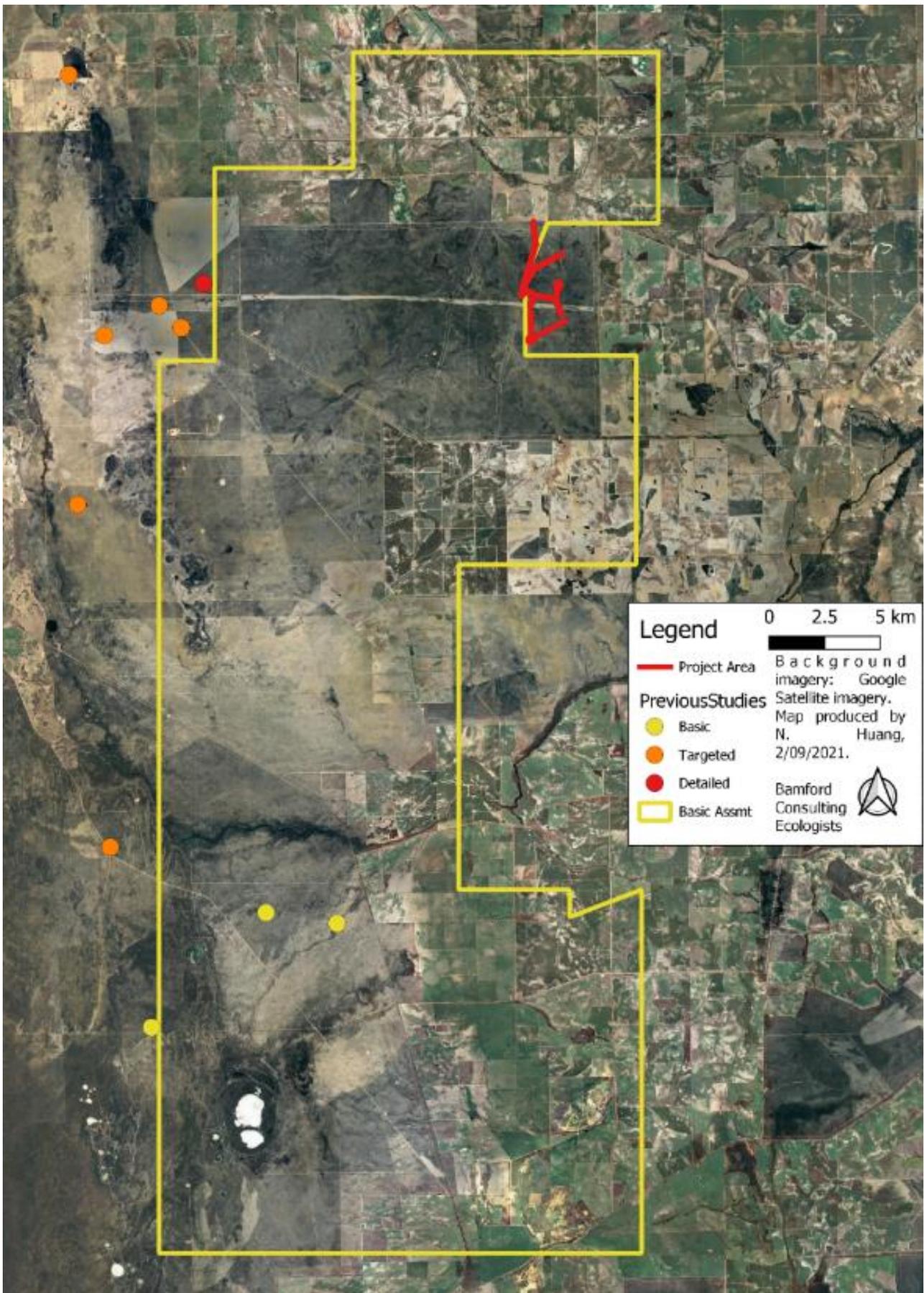


Figure 4. Previous studies conducted by BCE within the vicinity of the project area; Basic, Targeted and Detailed Assessments indicated.

2.3.3 Nomenclature and taxonomy

As per the recommendations of the EPA (2004), the nomenclature and taxonomic order presented in this report are based on the Western Australian Museum's (WAM) Checklist of the Fauna of Western Australia 2016. The authorities used for each vertebrate group were: amphibians (Doughty *et al.* 2019a), reptiles (Doughty *et al.* 2019b), birds (Johnstone and Darnell 2016), and mammals (Travouillon 2016). In some cases, more widely-recognised names and naming conventions have been followed, particularly for birds where there are national and international naming conventions in place, including the use of the group name 'Black-Cockatoo' (e.g. the BirdLife Australia working list of names for Australian Birds). English names of species where available are used throughout the text; Latin species names are presented with corresponding English names in tables in the appendices.

2.3.4 Interpretation of species lists

2.3.4.1 Expected occurrence

Species lists generated from the review of sources of information are generous as they include records drawn from a large region and possibly from environments not represented in the project area. Therefore, some species that were returned by one or more of the database and literature searches have been excluded because their ecology, or the environment within the project area, determine that it is highly unlikely that these species will be present. Such species can include, for example, seabirds that might occur as extremely rare vagrants at a terrestrial, inland site, but for which the site is of no importance. Species returned from the databases and not excluded on the basis of ecology or environment are therefore considered potentially present or expected to be present in the project area at least occasionally, whether or not they were recorded during field surveys, and whether or not the project area is likely to be important for them. This list of expected species is therefore subject to interpretation by assigning each a predicted status, the expected occurrence, in the project area. The status categories used are:

- **Resident:** species with a population permanently present in the project area;
- **Regular migrant or visitor:** species that occur within the project area regularly in at least moderate numbers, such as part of an annual cycle;
- **Irregular Visitor:** species that occur within the project area irregularly such as nomadic and irruptive species. The length of time between visitations could be decades but when the species is present, it uses the project area in at least moderate numbers and for some time;
- **Vagrant:** species that occur within the project area unpredictably, in small numbers and/or for very brief periods. Therefore, the project area is unlikely to be of importance for the species; and
- **Locally extinct:** species that would have been present but has not been recently recorded in the local area and therefore is almost certainly no longer present in the project area.

These status categories make it possible to distinguish between vagrant species, which may be recorded at any time but for which the site is not important in a conservation sense, and species which use the site in other ways but for which the site is important at least occasionally. This is particularly useful for birds that may naturally be migratory or nomadic, and for some mammals that can also be mobile or irruptive, and further recognises that even the most detailed field survey can fail to record species which will be present at times. The status categories are assigned conservatively based on the precautionary principle. For example, a lizard known from the general area is assumed to be a resident unless there is very good evidence the site will not support it, and even then, it may be classed as a vagrant rather than assumed to be absent if the site

might support dispersing individuals. It must be stressed that these status categories are predictions only and that often very intensive sampling would be required to confirm a species' status.

The results of the database searches were reviewed and interpreted, and obvious errors and out of date taxonomic names were deleted.

2.3.4.2 Conservation significance

All expected species were assessed for conservation significance as detailed in Appendix 1. Three broad levels of conservation significance are used in this report:

- Conservation Significance 1 (CS1) – species listed under State or Commonwealth Acts such as the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Western Australian Biodiversity Conservation Act 2016* (BC Act);
- Conservation Significance 2 (CS2) – species listed as Priority by DBCA but not listed under State or Commonwealth Acts; and
- Conservation Significance 3 (CS3) – species not listed under Acts or in publications but considered of at least local significance because of their pattern of distribution.

See Appendix 1 for an expanded discussion of these categories and Appendix 2 for a description of the categories used in the legislation (EPBC and BC Acts) and by the DBCA.

2.4 Field Assessment

2.4.1 Overview

The purpose of the site inspection was to gain a better understanding of the fauna values of the project area, and to place the expected species list generated from the desktop assessment into the context of the environment of the project area. This involved traversing the project area to examine vegetation and substrate present (and consequent habitat available for fauna), and to record opportunistic observations of fauna. This enabled:

- identification of VSAs (that provide fauna habitats);
- targeted searches for significant fauna and an assessment of their likelihood of occurrence based on VSAs present;
- Black-Cockatoo foraging, roosting and breeding habitat assessment; and
- opportunistic fauna observations.

2.4.2 Black-Cockatoos

2.4.2.1 Breeding tree and roosting assessment

The only species of conservation significant black-cockatoo that is likely to occur within the vicinity of the project area is Carnaby's Black-Cockatoo. The entire study area was traversed and searched for potential Black-Cockatoo breeding trees, defined according to DAWE recommendations – Eucalypt trees with diameter at breast height (DBH) of greater than 500 mm, or greater than 300 mm for Salmon Gums and Wandooos. The surrounding landscape was also searched for features that could support roosting Black-Cockatoos. A vantage point survey was conducted on one evening at two locations to watch for any evening movements of Black-Cockatoos, which can reveal roosting and nesting sites.

2.4.2.2 *Foraging habitat assessment*

The project area was assessed for foraging value for Carnaby's Black-Cockatoos by inspecting the vegetation (during the site visit) and calculating a foraging score as outlined in Appendix 3. The foraging score provides a numerical value that reflects the significance of vegetation as foraging habitat, and this numerical value is designed to provide the sort of information needed by the Federal Department of Agriculture, Water and the Environment (DAWE) to assess impact significance and offset requirements. The foraging value of the vegetation depends upon the type, density and condition of trees and shrubs in an area, and can be influenced by the context such as the availability of foraging habitat nearby. The BCE scoring system for value of foraging habitat has three components as detailed in Appendix 3. These three components are drawn from the DAWE offset calculator but with the scoring approach developed by BCE:

- A score out of six for the vegetation composition, condition and structure.
- A score out of three for the context of the site.
- A score out of one for species density.

Foraging value can thus be assigned a score out of six, based upon site vegetation characteristics, or a score out of 10 if context and species density are also considered. The score out of 10 is calculated only for vegetation of at least Low to Moderate foraging value (vegetation characteristics score of ≥ 3). Vegetation with No, Negligible or Low foraging value is effectively assigned both context scores and species density scores of '0'. This is because the context and species density are of little relevance if the vegetation does not support regular foraging by the birds. Foraging value scores can be calculated differently for the three black-cockatoo species (Appendix 3) depending upon the vegetation present, but was only calculated for Carnaby's Black-Cockatoo as this is the only species expected in the project area. Site context is influenced by the extent of habitat regionally and the presence or absence of nearby breeding, while the species density score is based upon the apparent level of black-cockatoo activity in the area.

2.4.3 *Conservation significant invertebrates*

Throughout the site visit, a habitat assessment for conservation significant invertebrates was conducted, including opportunistic searches for the Trapdoor Spider. The Trapdoor Spiders build a distinctive camouflaged burrow entrances using leaf litter which can be detected by the trained eye. When a burrow was found, a milliscope was inserted into the burrow to determine if it was occupied by a Trapdoor Spider, and details of the burrow, included GPS location, were recorded. Several specimens of Trapdoor Spider, millipede and slater were collected for lab identification.

2.4.4 Dates and Personnel

The project area was visited on the 22nd to 23rd June 2021. Personnel involved in the field investigations and report preparation (including desktop review) are listed in Table 5.

Table 5. Personnel involved in field assessment and report preparation.

Personnel	EIA Experience	Field Investigations	Report Preparation
Dr Mike Bamford <i>BSc. (Biol.), Hons. (Biol.), PhD. (Biol.)</i>	40 years		+
Mr. Peter Smith <i>Ass.Dip. (Agric.)</i>	30 years	+	
Ms. Sarah Smith <i>BSc. (Biol.)</i>	40 years	+	
Dr Kristen Bleby <i>BSc. and Hons. (Nat Res Mgmt), PhD (Zool.)</i>	17 years		+
Ms. Natalia Huang <i>BSc. (Zool.), Hons. (Cons.Biol.), MBA</i>	15 years		+

2.4.5 Survey limitations

The EPA Guidance Statement 56 (EPA 2004) and the EPA (2020) outline a number of limitations that may arise during field investigations for Environmental Impact Assessment. These survey limitations are discussed in the context of the BCE investigation of the project area in Table 6. No limitations were identified.

The lack of detailed survey (i.e. intensive sampling of the fauna assemblage) on the precise project area is not considered a limitation as this assemblage is well-understood in the area due to multiple previous field investigations (see Figure 4). Furthermore, EPA guidance does not consider limitations related to the effectiveness of field sampling for fauna but appears to make an assumption that the purpose of such sampling is to confirm the fauna assemblage. This is implicit in the EPA (2020) technical guidance that does provide suggestions for sampling techniques, but the level of field investigations suggested cannot confirm the presence of an entire assemblage, or confirm the absence of a species. This requires far more work than is possible (or recommended) for studies contributing to the EIA process because fauna assemblages vary seasonally and annually, and often have high levels of variation even over short distances (Beta diversity). For example, in an intensive trapping study, How and Dell (1990) recorded in any one year only about 70% of the vertebrate species found over three years. In a study spanning over two decades, Bamford *et al.* (2010) found that the vertebrate assemblage varies over time and space, meaning that even complete sampling at a set of sites only defines the assemblage of those sites at the time of sampling. In the latter study, an annual sampling effort of over 2,000 trapnights (pitfall traps) along two transects about 400 m apart recorded 42 species of frogs, reptiles and small mammals, but only 74% of these were recorded from both transects. A further 11 species were not recorded in the pitfalls but were detected by hand-searching and/or additional pitfall trapping over a broader area (12 km radius) in the same vegetation and soils (Bamford *et al.* 2013). The limited effectiveness of short periods of fauna sampling is not a limitation for impact assessment *per se*, as long as database information is interpreted effectively, and field investigations are targeted appropriately. That is the approach taken by BCE.

Table 6. Survey limitations as outlined by EPA (2020).

EPA Survey Limitations	BCE Comment
Availability of data and information	Abundant information from databases and multiple previous studies (see Table 2). Not a limitation.
Competency/experience of the survey team, including experience in the bioregion surveyed	The ecologists have had extensive experience in conducting desktop reviews and reconnaissance surveys for environmental impact assessment fauna studies, and have undertaken a number of studies within the immediate region (see Table 2). Not a limitation.
Scope of the survey (e.g. were faunal groups were excluded from the survey)	The survey focused on terrestrial vertebrate fauna and fauna values. Not a limitation.
Timing, weather and season	Timing is not of great importance for Basic level field investigations in this region. Conditions were ideal for a site inspection. Not a limitation.
Disturbance that may have affected results	Recent fire meant little vegetation was present to allow assessment of habitat for some fauna species, such as the Trapdoor Spider, Black-Cockatoo foraging assessment. However, vegetation types in the project area were consulted and extensive work has been conducted nearby to be able to make a robust assessment.
The proportion of fauna identified, recorded or collected	All fauna observed were identified. Not a limitation.
Adequacy of the survey intensity and proportion of survey achieved (e.g. the extent to which the area was surveyed)	The site was adequately surveyed to the level appropriate for a Basic level assessment. Fauna database searches covered a 25 km radius beyond the centroid of the project area. The Basic level assessment was completed. Not a limitation.
Access problems	There were no access problems encountered. Not a limitation.
Problems with data and analysis, including sampling biases	There were no data problems. Not a limitation.

2.5 Presentation of Results for Impact Assessment

While some impacts are unavoidable during a development, of concern are long-term, deleterious impacts upon biodiversity. This is reflected in documents such as the Significant Impact Guidelines provided by DSEWPaC (2013b) (see Appendix 5 for list of threatening processes). Significant impacts may occur if:

- There is direct impact upon a VSA and the VSA is rare, a large proportion of the VSA is affected and/or the VSA supports significant fauna.
- There is direct impact upon conservation significant fauna.
- Ecological processes are altered, and this affects large numbers of species or large proportions of populations, including significant species.

The impact assessment process therefore involves reviewing the fauna values identified through the desktop assessment and field investigations with respect to the project and impacting processes. The severity of

impacts on the fauna assemblage and conservation significant fauna can then be quantified based on predicted population change.

The presentation of this assessment follows the general approach to impact assessment as given in Section 1.1, but modified to suit the characteristics of the site. Key components to the general approach to impact assessment are addressed as follows:

Fauna values

This section presents the results of the desktop and field assessments in terms of key fauna values (described in detail in Appendix 1) and includes:

- Recognition of ecotypes or vegetation/substrate associations (VSAs);
- Assemblage characteristics (uniqueness, completeness and richness);
- Species of conservation significance;
- Patterns of biodiversity across the landscape; and
- Ecological processes upon which the fauna depend.

Impact assessment

This section reviews impacting processes (as described in detail in Appendix 3) with respect to the proposed development and examines the potential effect these impacts may have on the faunal biodiversity of the project area. It thus expands upon Section 1.1 and discusses the contribution of the project to impacting processes, and the consequences of this with respect to biodiversity. A major component of impact assessment is consideration of threats to species of conservation significance as these are a major and sensitive element of biodiversity. Therefore, the impact assessment section includes the following:

- Review of impacting processes; will the proposal result in:
 - Habitat loss leading to population decline, especially for significant species;
 - Habitat loss leading to population fragmentation, especially for significant species;
 - Weed invasion that leads to habitat degradation;
 - Ongoing mortality;
 - Species interactions that adversely affect native fauna, particularly significant species;
 - Hydrological change;
 - Altered fire regimes; or
 - Disturbance (dust, light, noise)
- Summary of impacts upon significant species, and other fauna values.

The impact assessment concludes with recommendations for impact mitigation, based upon predicted impacts. Note that the terms direct and indirect impacts are not used in this report; for further explanation see Appendix 3.

2.5.1 Criteria for impact assessment

Impact assessment criteria are based on the severity of impacts on the fauna assemblage and conservation significant fauna, and quantified on the basis of predicted population change (Table 7). Population change can be the result of direct habitat loss and/or impacts upon ecological processes.

The significance of population change is contextual. The EPA (2020) suggested that the availability of fauna habitats within a radius of 15 km can be used as a basis to predict low, moderate or high impacts. In this

case, a high impact is where the impacted environment and its component fauna are rare (less than 5% of the landscape within a 15 km radius or within the Bioregion), whereas a low impact is where the environment is widespread (e.g. >10% of the local landscape). Under the Ramsar Convention, a wetland that regularly supports 1% of a population of a waterbird species is considered to be significant. These provide some guidance for impact assessment criteria. In the following criteria (Table 7), the significance of impacts is based upon percentage population decline within a 15 km radius (effectively local impact) and upon the effect of the decline upon the conservation status of a recognised taxon (recognisably discrete genetic population, sub-species or species). Note that percentage declines can usually only be estimated on the basis of the distribution of a species derived from the extent of available habitat while for a few species, such as the Black-Cockatoos, there is guidance for the assessment of impact significance.

The impact assessment concludes with recommendations based upon predicted impacts and designed to mitigate these.

Table 7. Assessment criteria for impacts upon fauna.

Impact Category	Observed Impact
Negligible	Effectively no population decline; at most few individuals impacted and any decline in population size within the normal range of annual variability.
Minor	Population decline temporary (recovery after end of project such as through rehabilitation) or permanent, but < 1% within 15 km radius of centre-point of impact area (or within bioregion if this is smaller). No change in viability or conservation status of taxon.
Moderate	Permanent population decline 1-10% within 15 km radius. No change in viability or conservation status of taxon.
Major	Permanent population decline 10-50% within 15 km radius. No change in viability or conservation status of taxon.
Critical	Taxon decline > 50% (including local extinction) within 15 km and/or change in viability or conservation status of taxon.

3 Results

3.1 Vegetation and Substrate Associations (VSAs)

Vegetation and substrate associations within the project area were difficult to ascertain due to the majority of the project area being affected by recent fire. However, three VSAs were identified during the site visit, and consideration of vegetation types identified prior to fire is included in the fauna assessment (see following section for Vegetation Types identified by Woodman Environmental, including locations of aligning VSAs). The VSAs identified also aligned with two fauna habitats identified in the project area by Coffey (2013): (A) Low shrubland with/without woodland species (across majority of the project area); and (B) Mixed shrubland on laterite breakaways and slopes. The three VSAs identified in the project area are:

VSA 1. Heathland on lateritic breakaways. Low laterite breakaway recently burnt (1+ year). Heathland, gravel, mixed low shrubs of *Allocasuarina*, *Acacia*, low percentage Proteaceous to 2 metres, most 0.5 metre. This VSA comprises less than 2% of the project area and is well-represented in the region. See Plate 1. (Equivalent to fauna habitat B identified by Coffey (2013) and Vegetation Types 7a, 7b, 8).

VSA 2. Low heath on white-grey sand. Deep white sand with low heath to 0.5m. Isolated *Banksia attenuata* shrub form to 0.75m and *Xylomelum angustifolia* to 3 m. This VSA comprises 60-70% of the project area and is well-represented in the region. See Plate 2. (Equivalent to fauna habitat A identified by Coffey (2013) and Vegetation Types 13a and 14).

VSA 3. Low heath on yellow sand. Yellow sand, very low burnt *Hakea*, understorey to 300 mm, and yellow sand low heath with band of *Allocasuarina campestris* to 2.5 m and mallee Eucalypts of less than 150 mm DBH. This VSA comprises less than 30-40% of the project area and is well-represented in the region. See Plates 3 and 4. (Equivalent to fauna habitat A identified by Coffey (2013) and Vegetation Types 10, 11, 13b).

There were no wetlands or drainage areas recorded in the project area, although there was an inundated gravel pit at the base of a laterite breakaway. Areas outside the project area were visited to assess suitability for Black-Cockatoo roost sites; these contained a small band of Wandoo trees (approximately 6 to 8 m tall with a small number of > 500 mm DBH).

The majority of species present in the project area were myrtaceous with several bands of *Allocasuarina campestris*. A few *Banksia sessilis* and *B. telmatiaea* were present, with some isolated low shrub form of *B. attenuata* and some low *Hakea* species. There were no Marri (*Corymbia calophylla*) or tree banksias and very little other proteaceous shrubs, but there were some *Banksia attenuata* (tree form) present in remnant vegetation adjacent to the project area. A number of low lateritic breakaways were present through the area (1-2% of the project area). However, over 90% of the project area was recently burnt (in the previous one to two years) with no leaf litter present on the ground.



Plate 1. VSA 1: Heathland on lateritic breakaways.



Plate 2. VSA 2: Low heath on white-grey sand.



Plate 3. VSA 3: Low heath on yellow sand.



Plate 4: Vegetation at drill pad area; VSA 3 with *Xanthorrhoea*, *Allocasuarina* and low shrubs on sand.

3.1.1 Vegetation Types

Given the recent fire affected vegetation during the site visit, pre-fire vegetation survey findings from Woodman Environmental Consulting Pty Ltd were consulted and are reproduced here. These provided an indication of plant species which would otherwise be present, and allows us to better assess fauna values and, in particular, foraging value of the site for Black-Cockatoos. The vegetation types present in the project area are shown in Figure 5 and are listed in Table 8. The locations of each VSA are shown in Figure 6; note that these are mapped based on mapping of Vegetation Types by Woodman Environmental and may require ground-truthing to confirm.

Table 8. Vegetation types in project area identified by Woodman Environmental Consulting Pty Ltd

Vegetation Type ID	Vegetation Description	Aligning VSA
7a	Mid mallee woodland to isolated mallees of <i>Eucalyptus conveniens</i> or mid open shrubland of <i>Allocasuarina campestris</i> over low shrubland and sedgeland of mixed species frequently dominated by <i>Ecdeiocolea monostachya</i> and <i>Melaleuca aspalathoides</i> , or occasionally <i>M. tinkeri</i> , <i>Hakea auriculata</i> or <i>Hakea lissocarpa</i> , on gravelly grey or brown clay loams or sands, usually with laterite on or near the surface, on slopes and crests	VSA 2
7b	Mid mallee woodland to isolated mallees of <i>Eucalyptus conveniens</i> or mid open shrubland of <i>Allocasuarina campestris</i> over low shrubland and sedgeland of mixed species dominated by <i>Banksia carlinoides</i> , <i>Ecdeiocolea monostachya</i> , <i>Hakea incrassata</i> , <i>Hibbertia hypericoides</i> and <i>Melaleuca aspalathoides</i> on gravelly grey or brown clay loams or sands, usually with laterite on or near the surface, on slopes and crests	VSA 2
8	Mid mallee woodland to isolated mallees of <i>Eucalyptus conveniens</i> over mid shrubland to open shrubland dominated by <i>Allocasuarina campestris</i> over low shrubland and sedgeland of mixed species dominated by <i>Ecdeiocolea monostachya</i> , <i>Hakea auriculata</i> , <i>Melaleuca radula</i> , <i>M. aspalathoides</i> and <i>Banksia fraseri</i> var. <i>fraseri</i> on gravelly grey or brown clay loams usually over massive laterite on breakaway tops, ridges and lateritic rises	VSA 1
10	Mid sparse to open shrubland of mixed species including <i>Calothamnus quadrifidus</i> subsp. <i>angustifolius</i> , <i>Grevillea biformis</i> subsp. <i>biformis</i> and <i>Banksia attenuata</i> over low shrubland and sedgeland of mixed species dominated by <i>Ecdeiocolea monostachya</i> , <i>Melaleuca leuropoma</i> , <i>Daviesia divaricata</i> subsp. <i>divaricata</i> ms, <i>Mesomelaena pseudostygia</i> and <i>Banksia shuttleworthiana</i> on yellow-brown or occasionally grey sand on slopes and valley floors	VSA 3
11	Mid sparse to open shrubland of <i>Allocasuarina campestris</i> and <i>Grevillea biformis</i> subsp. <i>biformis</i> over low shrubland and sedgeland dominated by <i>Hakea circumalata</i> , <i>Lepidobolus preissianus</i> subsp. <i>preissianus</i> , <i>Mesomelaena pseudostygia</i> and <i>M. stygia</i> subsp. <i>deflexa</i> (P3) on yellow or yellow-brown sand or sandy loam on mid to upper slopes	VSA 3
13a	Low open woodland of <i>Eucalyptus todtiana</i> over mid to low shrubland of mixed species dominated by <i>Allocasuarina humilis</i> , <i>Banksia scabrella</i> (P4), <i>Calothamnus sanguineus</i> , <i>Eremaea beaufortoides</i> var. <i>microphylla</i> , <i>Melaleuca</i> aff. <i>leuropoma</i> and <i>Hibbertia hypericoides</i> over low shrubland and sedgeland of mixed species including <i>Banksia dallanneyi</i> subsp. <i>media</i> , <i>Conostylis canteriana</i> ,	VSA 2

Vegetation Type ID	Vegetation Description	Aligning VSA
	<i>Mesomelaena pseudostygia</i> and <i>Caustis dioica</i> on grey or brown sand on lower and mid slopes	
13b	Low open woodland of <i>Eucalyptus todtiana</i> over mid to low shrubland of mixed species dominated by <i>Allocasuarina humilis</i> , <i>Calothamnus sanguineus</i> , <i>Hakea trifurcata</i> , <i>Hibbertia hypericoides</i> and <i>Melaleuca leuropoma</i> over low shrubland and rushland of mixed species including <i>Banksia dallanneyi</i> subsp. <i>media</i> , <i>Conostylis aculeata</i> subsp. <i>breviflora</i> and <i>Conostylis canteriata</i> on grey, brown or yellow sand on flats, in depressions and on slopes	VSA 3
14	Low open shrubland dominated by <i>Calothamnus quadrifidus</i> subsp. <i>angustifolius</i> , <i>Banksia carlinoides</i> , <i>Hakea lissocarpha</i> and <i>Verticordia densiflora</i> over low open shrubland, sedgeland and forbland dominated by <i>Dampiera teres</i> (broad-leaf variant), <i>Jacksonia angulata</i> , <i>Harperia lateriflora</i> , <i>Opercularia vaginata</i> and <i>Melaleuca trichophylla</i> on grey- brown sands, sandy loams and clay loams in minor drainage lines and on flats	VSA 2

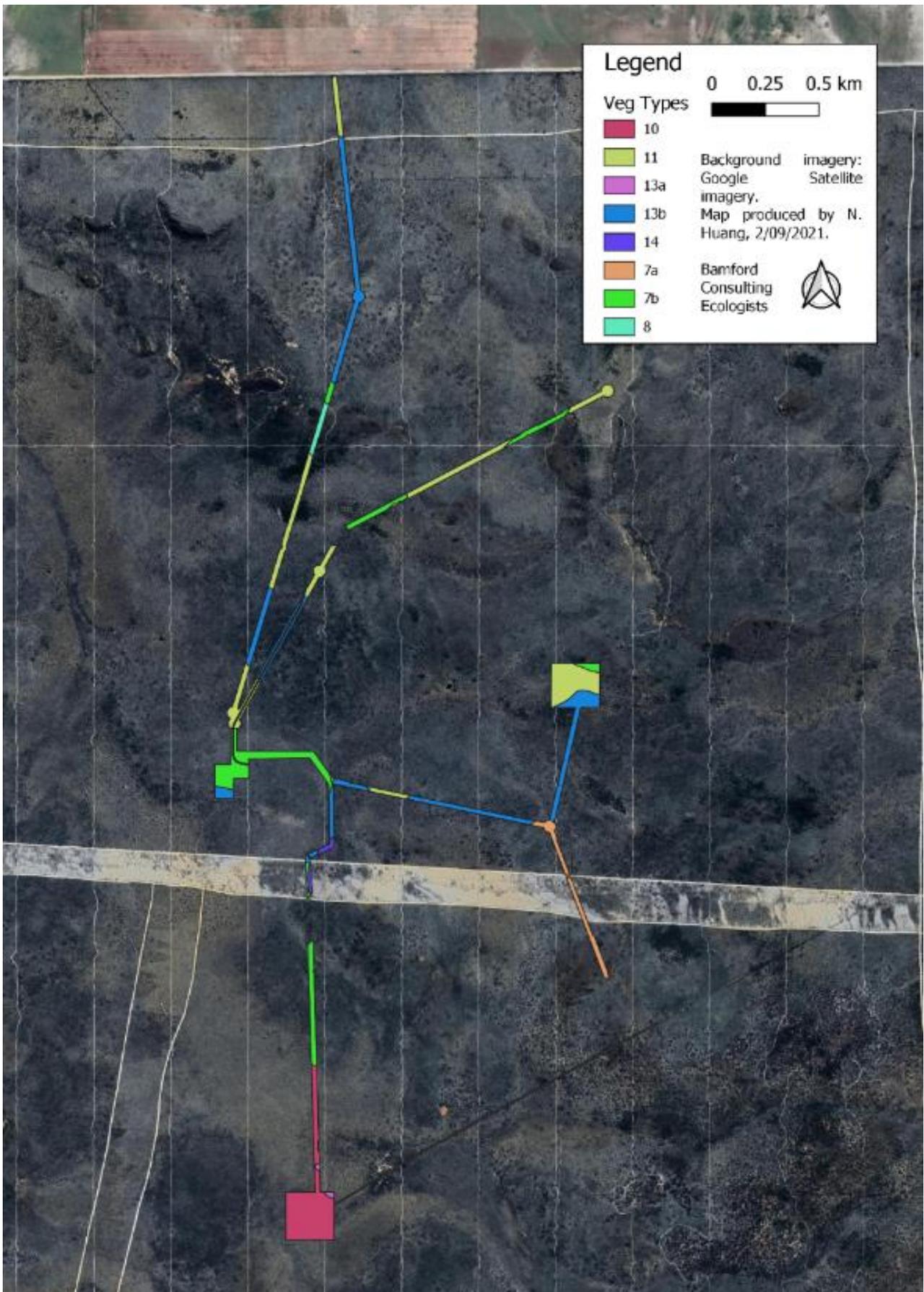


Figure 5. Vegetation Types identified in the project area by Woodman Environmental. See Table 8 for Veg Type ID descriptions.

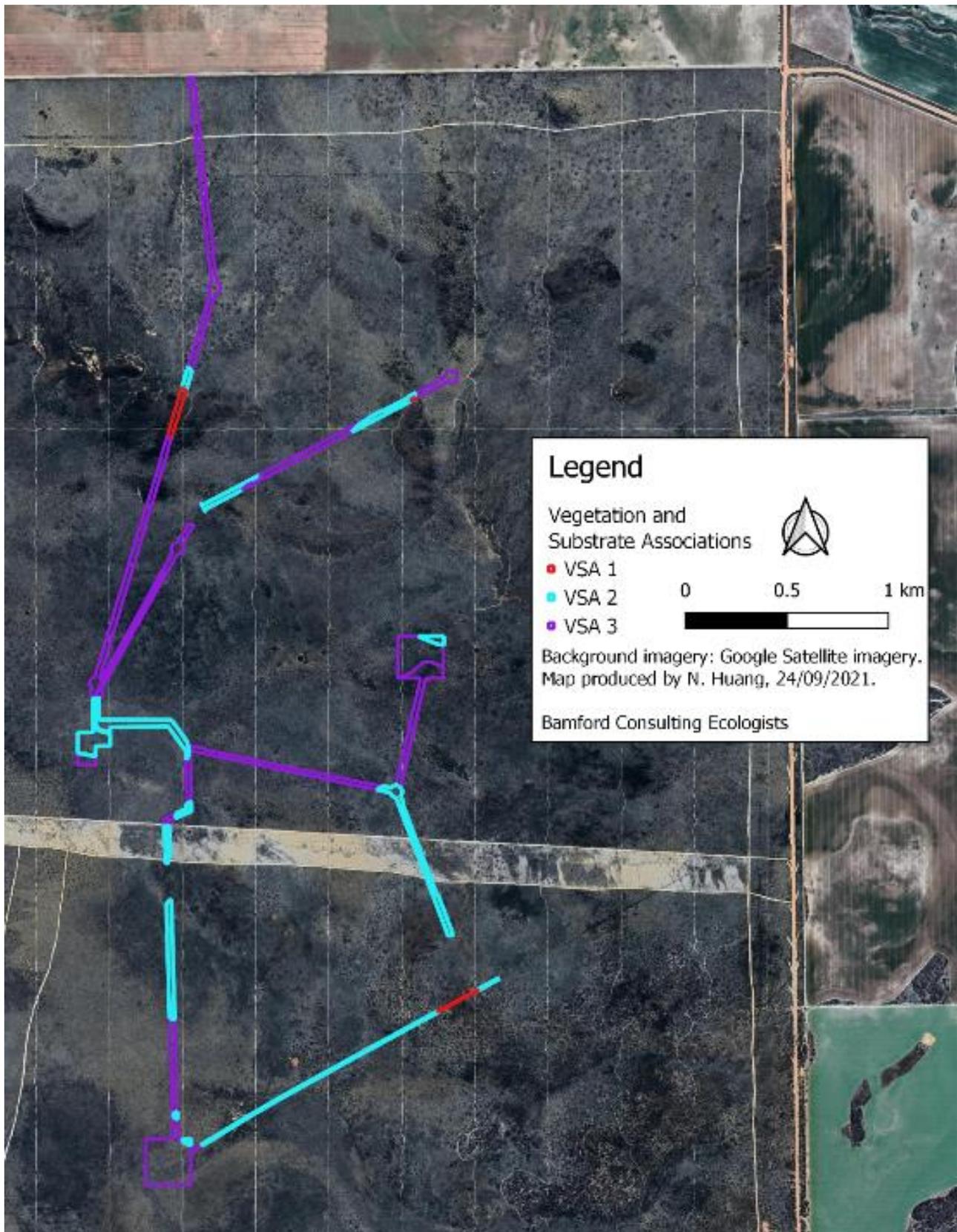


Figure 6. Vegetation and Substrate Associations (VSAs) in project area based on alignment with Vegetation Types of Woodman Environmental.

3.2 Fauna

3.2.1 Overview of vertebrate fauna assemblage

The desktop study identified 202 vertebrate fauna species as potentially occurring in the project area (see Table 9 and Appendix 6): ten frogs, 48 reptiles, 120 birds and 24 mammals (15 native and nine feral mammal species). The assemblage includes eleven vertebrate species of conservation significance, discussed in Section 3.2.3. It is expected that at least twelve mammals, and possibly an additional mammal, one bird and one reptile, have become locally extinct. Extinct species are also discussed in Section 3.2.2 while conservation significant invertebrates are discussed in Section 3.2.5. Species returned from databases but which are considered not to be present are listed in Appendix 8.

Table 9. Composition of expected vertebrate fauna assemblage of the project area.

The number of introduced species is shown in parentheses. Expected species does not include species considered locally extinct.

Taxon	Expected Species*	Number of species in each status category				
		Resident	Migrant or regular visitor	Irregular visitor	Vagrant	Locally extinct
Frogs	10	10	0	0	0	0
Reptiles	48	48	0	0	0	1?
Birds	120 (3)	38	43	29	10	1?
Mammals	24 (9)	13	7	3	1	12+1?
Total	202 (12)	109	50	32	11	12 to 15

*Number of species expected excludes locally extinct species.

Key features of the fauna assemblage expected in the project area are:

- **Uniqueness:** The assemblage in the project area is considered typical of the region with a high level of endemism as is associated with the Geraldton Sandplains.
- **Completeness:** The assemblage is incomplete due to the historical loss of native vegetation when it was converted to farmland and the consequent loss of habitats. The introduction of feral predators has also contributed to species loss. Loss of mammal species is notable.
- **Richness:** The reptile, amphibian and bird assemblages are rich, but the mammal assemblage is depauperate which is typical in the region.

As a fauna value, the most important features of the project area's fauna assemblage are that it is rich with a high level of endemism associated with the Geraldton sandplains. It is also important because the assemblage occurs in a region with a high level of habitat loss.

Frogs

The ten frog species consist of several burrowing frogs which rely on seasonal flooding for breeding and have been recorded near the project area by previous BCE surveys (e.g. Bancroft and Bamford 2021). Such burrowing species are likely to breed in seasonal wetlands around the project area but disperse widely

through upland vegetation for the rest of the year. Two of the frog species (Slender Tree Frog and Motorbike Frog) do not burrow and are often confined to permanent or near-permanent wetlands. They have been recorded by BCE at Ejaro Spring (c. 20 km northwest of the project area). Several individuals of the False Western Froglet *Crinia pseudinsignifera* were recorded calling from the inundated gravel pit at the base of a lateritic breakaway.

Reptiles

All of the 48 reptile species expected are considered to be residents in the project area. The Lesueur Sandplains IBRA subregion and more broadly the mid-west coast of Western Australia is recognised for its high reptile richness and large numbers of species that are at their distributional limits (Maryan 2005). Previous BCE surveys in the general area have recorded up to 39 reptile species in one sampling area (Metcalf and Bamford 2008). Due to the sandy substrate, presence of rocky areas and geographic location of the project area, the expected assemblage is a mix of sand specialists, fossorial species and rocky species along with widespread, generalist species.

Birds

The bird assemblage of 120 species includes 38 classed as residents, 43 as regular visitors or migrants, and 39 considered to be irregular visitors or vagrants. Three introduced species are expected. One species, the Western Ground Parrot, is probably locally extinct but there are occasional reports that it persists in the area; this species is discussed further below. There is likely to be a high seasonal abundance of nectivorous birds present in the project area when vegetation is in flower. The project area is subject to incursions of arid zone bird species in some years. For example, in a 30-year study between Cataby and Badgingarra, the Black Honeyeater was absent most years, but approximately one year in ten it was among the most abundant of nectarivores (M. Bamford unpubl. data). Similarly, the White-fronted Honeyeater, Pied Honeyeater, Red-backed Kingfisher, Masked Woodswallow and Budgerigar have each been recorded on fewer than five occasions in the 30-year study north of Cataby. The project area is also expected to be rich in resident birds utilising the dense low heath throughout the project area, in particular those that prefer to keep low in the vegetation strata such as the White-browed Scrubwren, White-breasted Robin and Splendid Fairy-wren.

Mammals

The mammal assemblage is depauperate, with 37 species known generally from the area, but possibly 12 of these being locally extinct due to predation by introduced predators, habitat destruction and changing fire regimes. Extinct species are discussed in section 3.2.2. The extant native mammal assemblage includes 13 residents, seven regular visitors, three irregular visitors and one vagrant. There may also be up to nine introduced mammal species. Four Dunnart species may occur in the area, including the Grey-bellied Dunnart which is at the northern edge of its range, and the White-tailed Dunnart (confirmed by Metcalf and Bamford 2008) which also has a limited range along the west-coast extending from Kalbarri to Mooliabeenee (near Gingin). The Fat-tailed Dunnart is a widespread generalist species. The 'Little Dunnart' (confirmed by Metcalf and Bamford 2008) is a currently unrecognised taxon similar to *Sminthopsis dolichura* (but with a shorter tail being same length as head and body rather than noticeably longer) and known from the site sampled by Metcalf and Bamford (2008) <10km west of the current project area, north of Cataby, Mooliabeenee and just north of Muchea (M. Bamford unpubl. records). Specimens have been lodged with the WA Museum (1984 from Mooliabeenee and 2018 from near Cataby) and have been DNA tested. They are virtually identical to *S. dolichura* on DNA but morphologically distinct based on tail length, and the museum noted that DNA tests are not conclusive (K. Travouillon, pers. comm.). Apparently there are no immediate plans to review the taxonomy of *Sminthopsis* but BCE considers it important that the 'Little Dunnart' should be recognised as a

distinct taxon even while undescribed. The project area may be an important foraging habitat for bats, although it lacks major roosting sites such as caves (but caves are located in Beekeepers NR).

3.2.2 Vertebrate fauna of conservation significance

Twelve of the 13 significant mammal species expected are considered likely to be extinct in the general area; these are not included in species counts but are listed in the expected species list in Appendix 6. Excluding potentially locally extinct species, there is a total of eleven conservation significant species expected to occur in the project area (Appendix 5, Table 10 and Table 11). There are four birds under legislation (CS1), three species listed as priority (CS2), and four species listed as CS3 (locally significant). Conservation significant species (and in some cases groups of species) are discussed further below. Note that a full explanation of the three levels of conservation significance used here is provided in Appendix 1 but, in summary, species classed as CS1 are those listed under legislation (EPBC Act and BC Act), while those classed as CS2 are listed as Priority by the Department of Biodiversity Conservation and Attractions (DBCA), but not listed under legislation. The CS3 class is more subjective, but includes locally significant species that have declined extensively in an area due to natural or human-induced impacts, and species that occur at the edge of their range. This makes their presence in the project area significant as populations on the edge of a species' range are often less abundant and more vulnerable to extinction than populations at the centre of the range (Curnutt *et al.* 1996).

Table 10. Number of conservation significant species expected in the project area.

See Appendix 1 for full explanation of Conservation Significance (CS) levels: CS1 = listed under WA State and/or Commonwealth legislation; CS2 = listed as Priority by DBCA; CS3 = considered locally significant.

CLASS	CONSERVATION SIGNIFICANCE			
	CS1	CS2	CS3	Total
Frogs	0	0	0	0
Reptiles	0	2	0	2
Birds	4	0	4	8
Mammals	0	1	0	1
Total	4	3	4	11

Table 11. Conservation significant vertebrate fauna species expected to occur within the project area.

Species are listed in taxonomic order.

CS1, CS2, CS3 = (summary) levels of conservation significance. See Appendix 1 for full explanation.

EPBC Act listings: C = Critically Endangered, E = Endangered, V = Vulnerable, M = Migratory (see Appendix 2).

WA *Biodiversity Conservation Act 2016* (BC Act) listings: S1 to S7 = Schedules 1 to 7 (see Appendix 2).

DBCA Priority species: P1 to P4 = Priority 1 to 4 (see Appendix 2).

Species Name	Common Name	CS	WA Status	EPBC Status	Status in project area
REPTILES					
<i>Aspidites ramsayi</i>	Woma	CS2	P1		Locally extinct?
<i>Morelia spilota imbricata</i>	Carpet Python	CS3			Resident
<i>Neelaps calonotos</i>	Western Black-striped Snake	CS2	P3		Resident
BIRDS					
<i>Leipoa ocellata</i>	Malleefowl	CS1	S3	V	Irregular visitor
<i>Apus pacificus</i>	Fork-tailed swift	CS1	S5	M	Regular migrant
<i>Falco peregrinus</i>	Peregrine Falcon	CS1	S7		Irregular visitor
<i>Merops ornatus</i>	Rainbow Bee-eater	CS3			Regular migrant
<i>Calyptorhynchus latirostris</i>	Carnaby's Black-Cockatoo	CS1	S2	E	Regular migrant
<i>Pezoporus flaviventris</i>	Western Ground Parrot	CS1	S1	CR	Locally extinct?
<i>Calamanthus campestris</i>	Rufous Fieldwen	CS3			Resident
<i>Calamanthus cautus</i>	Shy Heathwren	CS3			Irregular visitor
<i>Pomatostomus superciliosus</i>	White-browed Babbler	CS3			Irregular visitor
MAMMALS					
<i>Dasyurus geoffroii</i>	Chuditch	CS1	S3	V	Locally extinct
<i>Parantechinus apicalis</i>	Dibbler	CS1	S2	E	Locally extinct
<i>Macrotis lagotis</i>	Greater Bilby	CS1	S3	V	Locally extinct
<i>Bettongia lesueur</i>	Boodie	CS1	S2	V	Locally extinct
<i>Isoodon fusciventer</i>	Quenda	CS2	P4		Locally extinct
<i>Perameles bougainville</i>	Western Barred Bandicoot	CS1	S3	E	Locally extinct
<i>Trichosurus vulpecula</i>	Brush-tail Possum	CS3			Locally extinct?
<i>Bettongia penicillata</i>	Woylie	CS1	S1	E	Locally extinct
<i>Macropus eugenii</i>	Tammar Wallaby	CS2	P4		Locally extinct
<i>Lagostrophus fasciatus</i>	Banded Hare-Wallaby	CS1	S3	V	Locally extinct
<i>Notamacropus irma</i>	Brush Wallaby	CS2	P4		Resident
<i>Macroderma gigas</i>	Ghost Bat	CS1	S3	V	Locally extinct
<i>Pseudomys fieldi</i>	Shark Bay Mouse, Djoongarri	CS1	S3	V	Locally extinct

Information on the conservation status, distribution and habitat, salient ecology and expected occurrence within the project area is provided for each of these species below.

Conservation Significance 1

Malleefowl

Conservation status:	WA – S3; EPBC – V. Has declined in range due to habitat clearing and fragmentation, and probably impacts of feral predators.
Distribution and habitat:	Semi-arid woodlands and shrublands across southern Australia.
Ecology:	Occurs single or in pairs with an unusual breeding system based upon incubation of eggs in a mound. Terrestrial but can fly strongly, and feeds on a range of plant and animal materials.
Expected occurrence:	Irregular visitor. Occasionally recorded in the general area and the WA Museum has reported breeding (mounds) in the general region, but details are not available. There is no indication that there is a resident, breeding population in the project area, with no evidence of the species found during the site visits to the project area, nor in surrounding areas in previous surveys, nearby despite the tracks and mounds being distinctive and conspicuous. Much of the vegetation may be too low as the Malleefowl usually occurs in woodlands and tall shrublands.

Fork-tailed Swift

Conservation status:	WA – S5; EPBC – M. Considered to be significant because it is migratory and subject to international conservation agreements.
Distribution and habitat:	The swift is a largely aerial species of unpredictable occurrence in Western Australia. There are scattered records from the south coast, widespread in coastal and subcoastal areas between Augusta and Carnarvon, scattered along the coast from south-west Pilbara to the north and east Kimberley region. Sparsely scattered inland records, especially in the Wheatbelt, but more common in the north and north-west Gascoyne Region, north through much of the Pilbara Region, and the south and east Kimberley (Higgins 1999; DAWE 2021). Aerial, usually flying from as low as one metre to in excess of 300 m above the ground.
Ecology:	A diurnal, aerial insectivore, this species often forages along the edge of low pressure systems in flocks of ten to 1000 birds (Higgins 1999; DAWE 2021). Breeds in Siberia (April to July) and spends the non-breeding season (October to mid-April) in Australia. Being aerial, it is effectively independent of terrestrial ecosystems when in Australia.
Expected occurrence:	Regular migrant. Flocks may pass over the project area briefly at intervals of a year or more.

Peregrine Falcon

Conservation status:	WA – S7. Only listed under the WA BC Act.
Distribution and habitat:	More or less cosmopolitan throughout Australia (Menkhorst <i>et al.</i> 2017). This species occurs in a variety of habitats but is usually reliant on cliff faces or tall trees for nesting (Debus 2019).

- Ecology:** A highly adept aerial predator that predominantly forages on birds, although will also occasionally take invertebrates, fish, reptiles and mammals (Debus 2019). Mostly diurnal or crepuscular.
- Expected occurrence:** Irregular visitor. The project area may be part of the foraging range of a pair. It is unlikely to breed in the project area due to the lack of suitable nesting sites such as cliff faces, large tree hollows and large nests of other birds, although there are large trees around drainage systems to the east and south, and shallow rivers in the broader region.

Carnaby's Black-Cockatoo

- Conservation status:** WA – S2; EPBC – E. Of significance because of population decline due largely to clearing of breeding habitat in the Wheatbelt and foraging habitat in the non-breeding range near the coast.
- Distribution and habitat:** Endemic to the South-West, roughly south of a line Kalbarri to west of Esperance, but the range has contracted from the Wheatbelt in the last 50 years. Breeds in eucalypt woodlands but forages in eucalypt woodlands and proteaceous woodlands and heaths.
- Ecology:** A granivore that also feeds on insect larvae, the species is migratory with inland breeding habitat (c. July to December) and more coastal non-breeding habitat, but movements are incomplete and some birds are beginning to breed in the former non-breeding range near the coast. The project area is in a region where the breeding and non-breeding ranges overlap and foraging occurs. Often forms large flocks in the non-breeding season and roosts in traditional locations; usually locally large trees close to water. Proteaceous woodlands and heaths are important during the breeding and non-breeding seasons.
- Expected occurrence:** Regular migrant. Likely visits the project area and surrounds to forage. An assessment of foraging habitat is provided below (section 3.2.3).

Conservation Significance 2

Black-striped Snake

- Conservation status:** WA – P3. The Black-striped Snake has a naturally limited distribution and a large part of its range lies within areas affected by agricultural and/or urban development.
- Distribution and habitat:** Confined to the coastal plain between Mandurah and Dongara; sandy soils of heaths and woodlands. Bush *et al.* (2007) suggest that the Dongara population is isolated as at the time there was only a single record from that area, but the Metcalf and Bamford (2008) record of the species from the Tronox Lease suggests it is more widespread in the north of its range. It was in kwongan shrubland on sand like much of that in the current project area. There are suitable environments between Cooljarloo ((about 20km south of Arrowsmith and where the species has been recorded by BCE) and the Dongara/Arrowsmith region, but it has not been detected around Eneabba despite extensive fauna surveys in that region.

Ecology:	A fossorial species that probably feeds on small lizards. Often found by hand-searching through loose, sandy soil.
Expected occurrence:	Resident. Expected to occur throughout low heath on sands (VSAs 2 and 3) throughout the majority of the project area.

Brush Wallaby

Conservation status:	WA – P4. The Brush Wallaby is widespread in the South-West but has declined due to habitat loss (clearing for agriculture and urban development) and may also be affected by Fox predation.
Distribution and habitat:	Endemic to the South-West more or less south of line from Geraldton to Esperance, although it has disappeared from much of the Wheatbelt due to clearing. Occurs in a wide range of vegetation types from Eucalypt Woodland to Banksia Woodland, Shrublands and Kwongan. The Brush Wallaby is encountered consistently in Kwongan heath and low woodlands from Cataby to Dongara (M. Bamford pers. obs.).
Ecology:	Based on detailed radio-tracking study in Banksia Woodland in Whiteman Park (Bamford and Bamford 1999): a largely solitary species that browses on shrubs and bushes; rarely on grass. Rarely drinks free-standing water and rarely ventures from dense vegetation. Individuals occupy home ranges of up to c. 10ha; larger in males than females and those of females overlap.
Expected occurrence:	Resident and presumably widespread in the project area.

Conservation Significance 3

South-West Carpet Python

Conservation status:	Previously considered Priority 4 but has since been delisted. The sub-species has declined due to land-clearing and predation by feral species. It is considered CS3 as these threatening processes remain, and where Fox control is implemented the pythons becomes noticeably more abundant (M. Bamford pers obs.).
Distribution and habitat:	Occurs across southern WA from near Shark Bay to the southern edge of the Nullarbor Plain; in a wide range of environments from forest to woodlands and coastal shrublands. Often in areas with rocks or logs that provide shelter.
Ecology:	A usually nocturnal predator of vertebrates and in particular mammals.
Expected occurrence:	Resident. While a difficult species to detect, it is seen regularly in Woodlands and Kwongan between Cataby and Badgingarra (Brand Highway) and along Indian Ocean Drive north of Jurien (M. Bamford pers. obs.). It probably occurs in all VSAs in the project area.

Rainbow Bee-eater

Conservation status:	This species was recently removed from the Migratory list of the EPBC Act and Schedule 5 of the WA Act. Despite this, it is a migrant in the South-West. Part of its conservation interest is related to its selection of breeding sites, as it is likely to breed along the edges of clearings and tracks, and thus may place itself at risk of mortality. It has been recorded regularly across the region and in nearby areas.
Distribution and habitat:	Occurs across mainland Australia and parts of Indonesia; a summer-breeding migrant in the south. In the South-West it arrives in October and departs in January/February. Favours fairly open vegetation types including parkland clearing and constructs nesting burrows in sandy to sandy-loam soils, often in the open.
Ecology:	An aerial insectivore that forages by 'sallying' from a perch. Eats a wide range of insects and not just bees. Often seen in loose flocks on migration and may breed in loose colonies or singly. Tends to be faithful to breeding sites but will also move if a site gets too overgrown or is destroyed. Will also colonise new areas and has been known to nest in piles of earth on construction sites.
Expected occurrence:	Regular migrant. Can be expected to arrive in October and depart in February. Will breed where there are areas of suitable sparse vegetation on sand. The species may be particularly abundant during migration periods as birds pass through.

Rufous Fieldwren, Shy Heathwren and White-browed Babbler

Conservation status:	Formerly listed as Priority (thus CS2) due to massive declines as a result of habitat loss across the Wheatbelt. Considered of local conservation significance as these declines have happened and are probably ongoing in some cases as remnant vegetation degrades, and the project area is on the edge of the Wheatbelt.
Distribution and habitat:	These three species occur broadly across southern Australia and in the South-West are found in semi-arid heaths and woodlands, hence their susceptibility to clearing in the Wheatbelt. The Rufous Fieldwren occurs in very low heath (such as low heath present across the majority of the project area) and will also move into areas following fire and during minesite rehabilitation, moving out as the vegetation gets dense and tall (M. Bamford pers obs.). The Shy Heathwren favours denser, taller vegetation, while the White-browed Babbler usually occurs in tall and moderately open shrubland with scattered thickets.
Ecology:	Insectivores that forage over the ground and low vegetation; the babbler will also search under loose bark. Mostly sedentary but will move if the environment changes, such as the Fieldwren moving as vegetation structure alters with time since fire or rehabilitation.
Expected occurrence:	The Rufous Fieldwren is expected as resident due to the presence of its preferred habitat of low heath across the project area. The Shy Heathwren and Babbler are expected as irregular visitors as most of the vegetation may be too low and dense for them, although records from databases suggest resident birds nearby.

Locally extinct species

Thirteen mammal species that formally occurred in the area, some probably well into the 20th Century, are now considered locally extinct (Appendix 6). All but one species are mostly of high conservation significance and in some cases are now represented only by island sub-species, with the mainland subspecies that would have been present in the project area being extinct. Their local extinction is likely due to a combination of factors including habitat degradation, changed fire regime and feral predators.

One reptile species (Woma) is likely locally extinct in the project area, and has declined across much of its range, probably due to clearing and predation by feral predators. It was not returned from databases for the region of the project area, but there are records from Kwongan heath on sand at Badgingarra, Watheroo (1989) and Marchagee (1986; B. Maryan pers. comm.). It was almost certainly a former resident in the project area and while probably locally extinct, there is a slight chance it persists in the area. If present at very low densities, the species would be almost undetectable.

One bird species (Western Ground Parrot) is likely locally extinct. The Western Ground Parrot is of very high significance and has suffered a catastrophic decline in range and abundance with the only confirmed population numbering just over 100 birds in the Cape Arid region east of Esperance. The decline in range is due to a combination of factors, but broad-scale fire (as opposed to patchy fires that provide a range of fire-age vegetation) and feral predators (possibly feral Cats in particular) are of key concern. It was formerly widespread in near-coastal shrublands of the south-west, including in the Kwongan heaths north of Perth, and thus a species which may occur throughout the low heaths of the project area. There are no recent confirmed records north of Perth. However, there are accounts of the Western Ground Parrot persisting in this region, including a fairly reliable sighting in 1992 of an adult male and an immature bird. In 2008 and 2012 targeted Ground Parrot surveys were undertaken in the areas west of the project area in the former Tronox leases to the east and Beekeepers NR to the west and south (Bamford 2008, Bamford 2012). The surveys involved several people listening for calls of the Parrot during the times before sunrise and after sunset, when the species is most vocal. In 2012, one and two note calls were heard from two individuals that were likely to be from the Western Ground Parrot. However, given the full song was not heard, the species could not be confirmed. Whilst not confirmed, it is a possibility that the species does persist in the area. Both 1992 and 2012 records were in areas of Kwongan shrubland.

3.2.3 *Black-Cockatoos*

One Black-Cockatoo species of conservation significance has been confirmed in the general area, Carnaby's Black-Cockatoo. The other two significant black-cockatoos in the South-West, Baudin's and the Forest Red-tailed, do not occur on the northern Swan Coastal Plain. Red-tailed Black-Cockatoo in the general region of the project are a different and widespread sub-species (*Calyptorhynchus naso escondidus*). Carnaby's Black-Cockatoo may forage on proteaceous and myrtaceous vegetation in the project area and roost in large trees near water courses.

Foraging habitat

Banksias, hakeas, eucalypt trees, acacias and Woody Pears (*Xylomelum*) provide foraging habitat for Carnaby's Black-Cockatoos, and low hakeas and banksias in particular are widespread throughout the project area. Large flocks have occasionally been recorded in the general area, foraging in Kwongan heath and banksia low woodland, including about 500 birds just north of Yandanogo Nature Reserve (April 2015;

Bamford *et al.* 2015) and flocks of over 300 individuals in the vicinity of the Arrowsmith River just west of Brand Highway (Bamford and Chuk 2015-2017).

Assessing the vegetation composition score component for the foraging assessment during the site visit was restricted by the limited post-fire groundcover vegetation. However, Coffey (2013) reported that the entire project area contained Black-Cockatoo foraging habitat with foraging plant species present. In addition, the Vegetation Types reported by Woodman Environmental include Black-Cockatoo foraging plant species across the project area (e.g. *Hakea sp. and Banksia sp.*; see Section 3.1.1). As suitable foraging plant species were present throughout the project area, the project area was given a vegetation composition score of 4. The site context score for the project area was a score of 2 as the site comprises between 5-10% of the similar vegetation within a 15 km radius circle. A score of 0 was given for the species density score as there were no Carnaby's Black-Cockatoos seen during the site visit and there was no evidence of foraging in the project area. This may be an effect of the fire and actual food resources will increase as the vegetation regenerates. Therefore, a total foraging score of **6 out of 10** is given to the project area, indicating it provides moderate foraging value for Black-Cockatoos.

Breeding habitat

The project area is unlikely to support breeding by Carnaby's Black-Cockatoos due to a lack of suitable nesting sites (no large trees of sufficient size to provide nesting hollows). There are no large trees in the project area. A small band of Wandoo were recorded outside the project area, although none had hollows large enough for Black-Cockatoos. The nearest known breeding by Carnaby's Black-Cockatoo is at Coomallo Creek, about 100km south of the Arrowsmith area (Saunders and Dawson 2017).

Roosting habitat

No roosting habitat was identified within the project area but a small band of Wandoo outside the project area may provide roosting habitat for Black-Cockatoos. Five confirmed Carnaby's Black-Cockatoo roosts have been recorded within 30 km of the project area by the Great Cocky Count and BCE in previous surveys; these are shown in Figure 7. There are two roosts approximately 17 km to the east-south-east of the project area, two roosts 20 km to the west-north-west, and one roost 25 km to the southwest of the project area (Figure 7). Details of the two roosts recorded by BCE are:

1. Roost comprising >500 birds located in large trees around wetland in Yandanogo Nature Reserve; visited April 2015.
2. Roost comprising >300 birds located along the Arrowsmith River; visited June 2016.

There are no tall trees within the project area so the site itself is not expected to provide Black-Cockatoo roosting habitat. However, as described above roosts have been recorded within 30 km of and surrounding the project area, so the site is considered likely to be utilised by roosting individuals as they enter and leave the roost sites to forage.

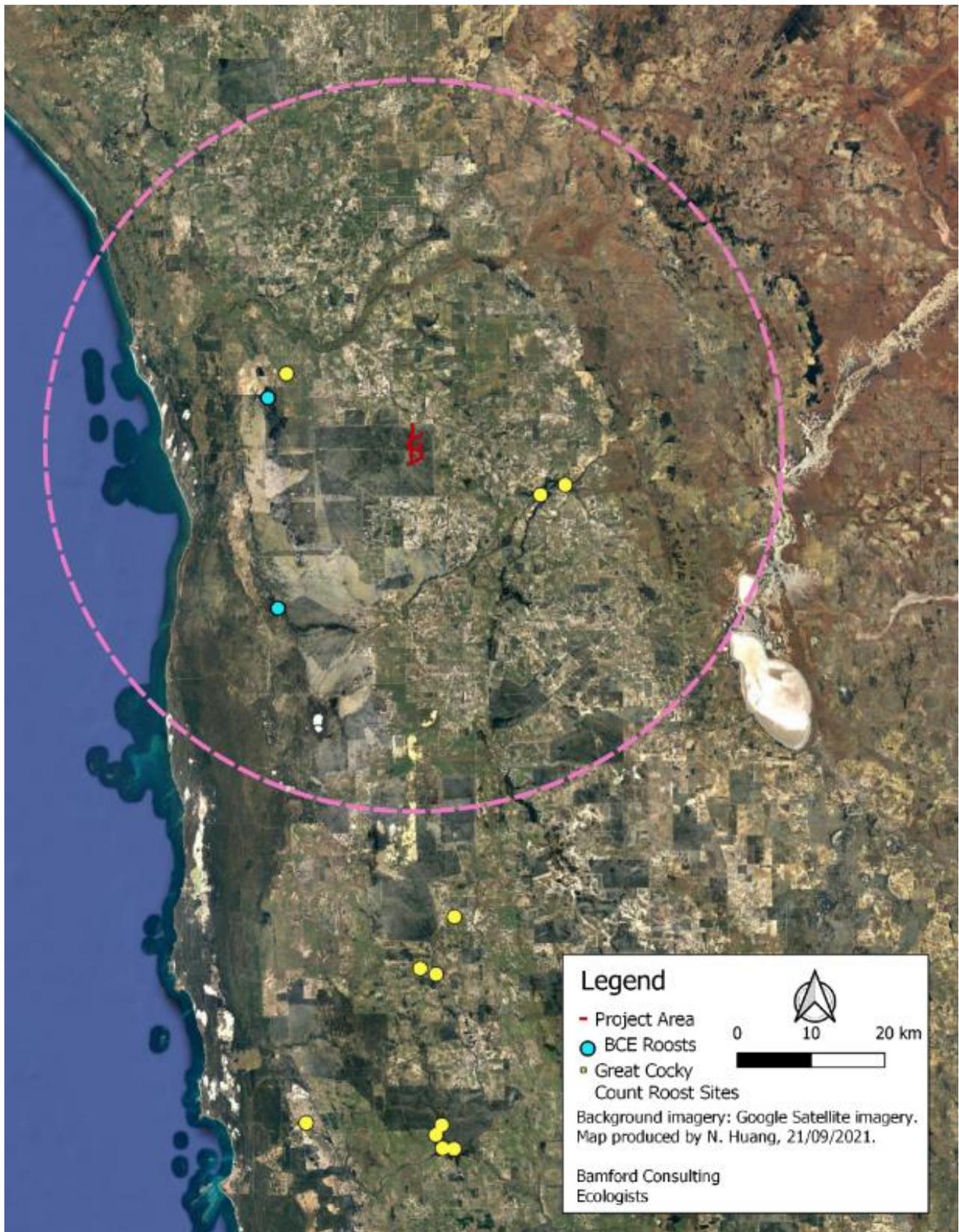


Figure 7. Black-Cockatoo roost sites recorded by BCE in previous surveys and as part of the Great Cocky Count (data retrieved from SLIP website, September 2021). Pink dotted line shows 50 km radius around project area.

3.2.4 Introduced species

Twelve introduced vertebrate species could occur in the project area, comprising three bird and nine mammal species. The species of greatest interest are the Red Fox and Cat, due to the threat they pose to mammals and ground-nesting birds which can lead to local extinctions. A recent study investigated the presence and frequency of feral animals along exploration tracks approximately 20 km west of the project area (Bamford & Chuk, 2017). Motion sensitive cameras were used for monitoring and Fox, Goat, Rabbit and Cat were recorded regularly, while the House Mouse and Black Rat were infrequent and Dog was noted through footprints. Also of interest were the findings that some feral mammals (Cat, Goat and Red Fox) appear to favour disturbed habitats and were seen more frequently on cleared tracks compared with undisturbed vegetation. It would be expected that the project area would have a similar assemblage of feral animals, and the usage of tracks by these species has implications for the current project and its interactions with native fauna.

3.2.5 Invertebrate Fauna

Based on the desktop assessment and field records, at least seven invertebrate species of conservation significance are expected to occur in the project area (Table 12 and Appendix 6). The project area sits within DBCA's Midwest management region (DBCA 2021). DBCA (2021) listed 18 threatened or priority invertebrate fauna in this region, as outlined in Table 12. Eight of these species are not expected to occur within the project area and the reasons for exclusion are presented within the same table (E.g. wholly or locally extinct, absence of suitable habitat in the survey area, distance from known populations). To help ascertain the status of the remaining ten species, all location records from WAM (2021), BCE surveys and Bennelongia (2021) were compiled and mapped in relation to the project area. A map of records of these threatened and priority invertebrate species is provided in Figure 8.

The desktop assessment returned no records of threatened invertebrate fauna within the project area nor within 10 km radius of the project area. There are records of six threatened fauna species within a 50 km radius of the project area (Figure 8). These include a millipede *Antichiropus Eneabba 1*, a land snail *Bothriembryon perobesus*, a native bee *Hylaeus globuliferus*, two trapdoor spiders *Idiosoma arenaceum* and *Idiosoma kwongan*, and the cricket *Phasmodes jeeba*. There is a record of an additional species, the cricket *Hemisaga vepreculae*, just three metres beyond the 50 km boundary (and therefore effectively within the 50km radius).

Some of the expected species are considered likely to be resident in the project area, probably in VSA 1 or adjacent areas. It should be noted that the ecology and distribution of short-range endemic invertebrates is often poorly understood or documented, and the project area occurs in a region that is relatively remote and likely to be poorly-surveyed for these groups. Thus there may be undetected SRE species present, with the most suitable environments being the low lateritic breakaways present throughout the project area (VSA 1). Extensive surveys would be required to document these species, which may well be undescribed, and therefore on a precautionary basis this VSA should be recognised as important for conservation significant invertebrates and impact risk assessed accordingly.

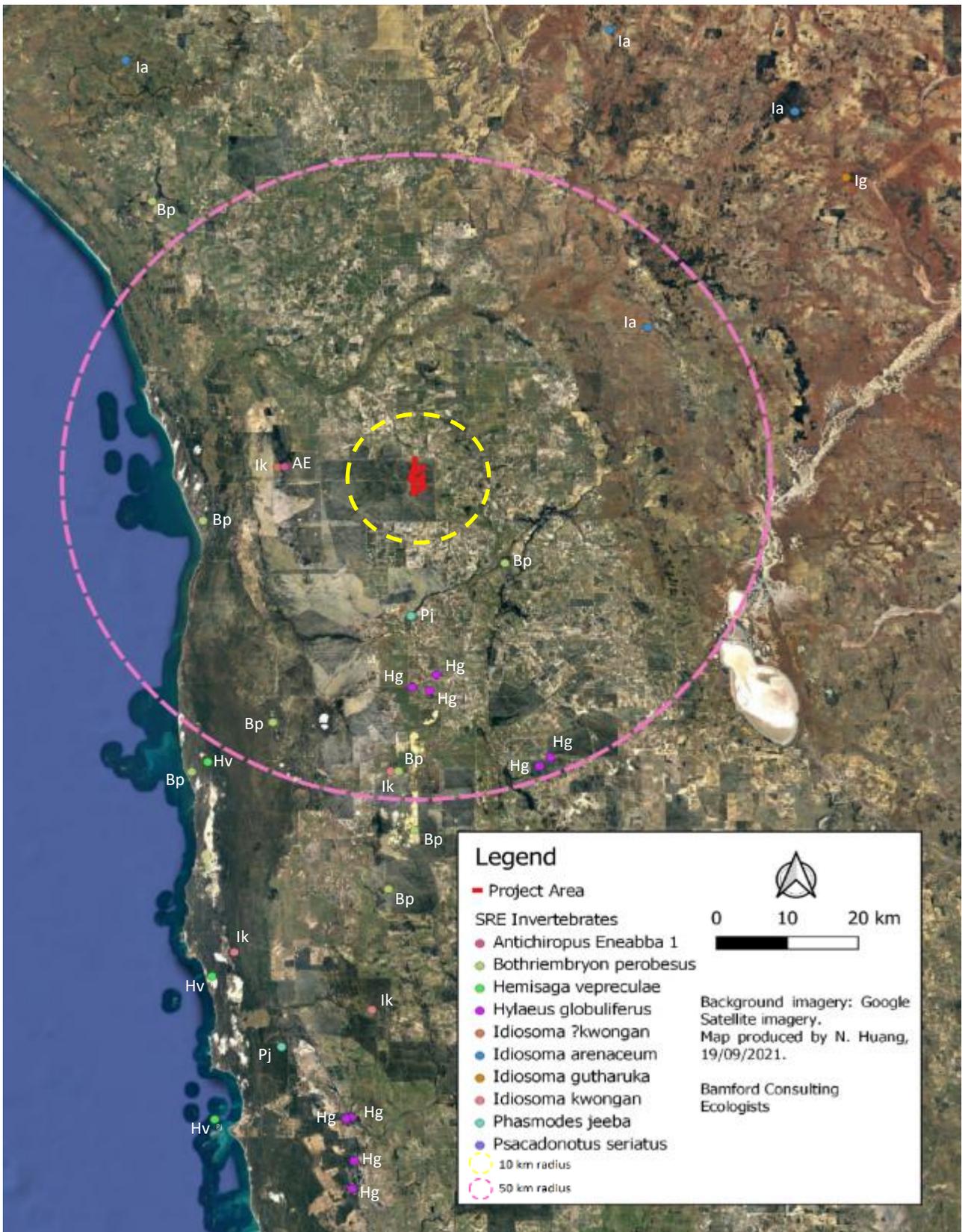


Figure 8. Short-range endemic invertebrates previously recorded within 10km and 50km radius of project area; data from WAM and Bennelongia (2021).

Table 12. Conservation significant invertebrate fauna species expected to occur in the Midwest region (as per DBCA 2021) and project area, including conservation status and likely residency status in the project area.

See Appendix 3 for descriptions of conservation significance levels.

EPBC Act listed species: V = Vulnerable, E = Endangered, Cr = Critically Endangered, M = Migratory.

WC Act listed species: S1 - S4 = Schedule 1 - 4, DEC Priority Species: P1 - P5 = Priority 1 - 5.

Species immediately considered as unlikely to occur in the project area are listed in grey font.

Other exclusions (plain black text) followed spatial analysis of current records.

Expected species are highlighted.

* indicates species not listed by DBCA (2021) but are known from the region (BCE database) and likely to be a SRE.

Species		Conservation Status	Expected Status in Project Area
<i>Aganippe castellum</i>	Tree-Stem Trapdoor Spider	CS2 (P4)	Absent. Project area more than 200 km outside of species known range.
<i>Austrosaga spinifer</i>	Spiny Katydid (Swan Coastal Plain)	CS2 (P2)	Absent. No records within 50 km of the project area.
<i>Bothriembryon perobesus</i>	A bothriembryontid land snail (Moore River)	CS2 (P1)	Uncertain. Records within 50 km of survey area.
<i>Bothriembryon whitleyi</i>	Whitley's Bothriembryontid Land Snail (Geraldton)	Extinct	Absent. Extinct.
<i>Branchinella denticulata</i>	A fairy shrimp (Carnarvon to Kalgoorlie)	CS2 (P3)	Absent. No suitable wetland habitat.
<i>Branchinella simplex</i>	A fairy shrimp (inland WA)	CS2 (P1)	Absent. No suitable wetland habitat.
<i>Branchinella wellardi</i>	A fairy shrimp (Carnarvon and Murchison)	CS2 (P3)	Absent. No suitable wetland habitat.
<i>Daphnia jollyi</i>	A water flea (inland south west)	CS2 (P1)	Absent. No suitable wetland habitat.
<i>Hemisaga vepreculae</i>	Thorny Bush Katydid (Moora)	CS2 (P2)	Uncertain. No records within 50 km of survey area, although one record just 3 km beyond 50 km boundary.
<i>Hylaeus globuliferus</i>	Woollybush Bee	CS2 (P3)	Uncertain. Records within 50 km of survey area.
<i>Idiosoma arenaceum</i> *	Trapdoor Spider	CS3	Uncertain. Records within 50 km of survey area.
<i>Idiosoma dandaragan</i>	Dandaragan Plateau Shield-Backed Trapdoor Spider	CS2 (P2)	Absent. No records within 50 km of the project area.
<i>Idiosoma gutharuka</i>	Gutha Pintharuka Shield-Backed Trapdoor Spider	CS2 (P1)	Absent. No records within 50 km of the project area.
<i>Idiosoma kwongan</i> *	Kwongan Heath Shield-Backed Trapdoor Spider	CS2 (P1)	Resident. Records within 50 km of survey area.
<i>Neopasiphae simplicior</i>	A short-tongued bee	CS1 (E, S3)	Absent. No records within 50 km of the project area.
<i>Phasmodes jeeba</i>	Springtime Corroboree Stick Katydid (Eneabba)	CS2 (P3)	Uncertain. Records within 50 km of survey area.
<i>Psacadonotus seriatus</i>	A fan-winged katydid (Champion Bay)	CS2 (P1)	Absent. No records within 50 km of the project area.
<i>Synemon gratiosa</i>	Graceful Sunmoth	CS2 (P4)	Absent. No records within 50 km of the project area.
<i>Teyl</i> sp. (BY Main 1953/2683, 1984/13)	Minnivale Trapdoor Spider	CS1 (S1)	Absent. Survey area more than 100 km outside of species known range.

Species	Conservation Status	Expected Status in Project Area
<i>Throscodectes xederoides</i> Mogumber Bush Cricket, Northern Throsco	CS2 (P3)	Absent. Survey area more than 100 km outside of species known range.
* <i>Antichiropus</i> Eneabba 1 A millipede	CS3	Resident. Records within 50 km of survey area.

Collected specimens

Two specimens of millipedes were collected at 336874E, 6747060N (Figure 9). These were identified by the WA Museum as male *Antichiropus* 'DIP076 houstoni'. This species has been recorded nearby at Cooljarloo, Arrowsmith River and Eneabba. Three specimens of slater were collected at 338752E, 6747927N (Figure 9). These were identified as *Buddelundia callosa*, comprising one male and two females. This is a common and widespread species. Invertebrates are defined as short-range endemic (SRE) if they have a natural distribution of <10,000 km² (Harvey 2002). Based on this definition, the millipede and slater species collected are not SRE invertebrates. Trapdoor Spiders were also collected during the site visit and these are discussed below.

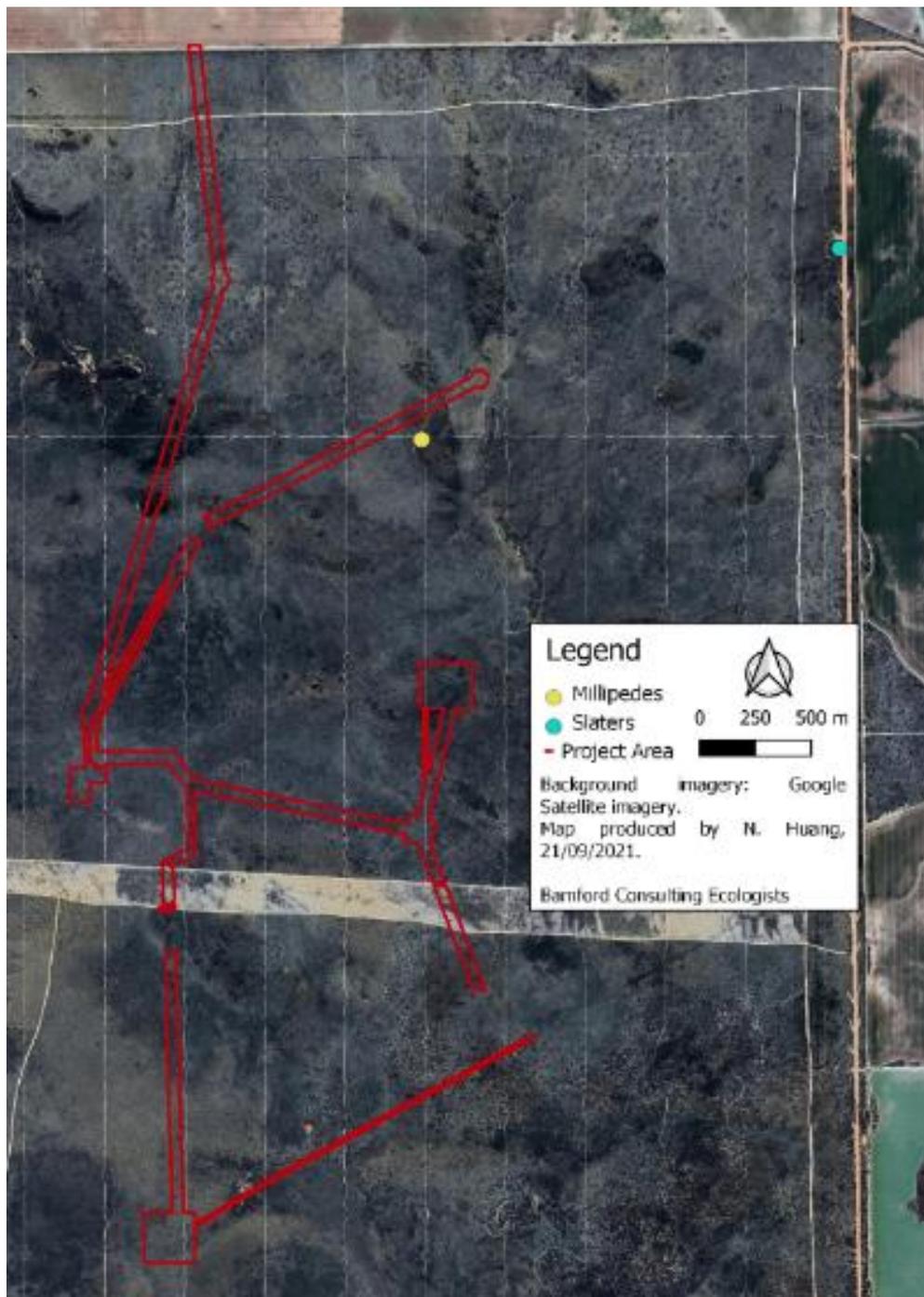


Figure 9. Locations where millipedes and slaters were collected.

Trapdoor Spiders

Five Trapdoor Spider burrows were recorded during the site visit (Table 13), and these were all found within a narrow band of unburnt *Allocasuarina campestris* (Figure 10 and Figure 11). The locations of the spider burrows in relation to the project area are shown in Figure 12. Specimens of spiders were identified as *Idiosoma sp.*. Given this genus is detected through the distinctive leaf litter construction around its burrow (Figure 10), the lack of leaf litter in over 90% of the project due to recent fire meant these species were not able to be detected elsewhere, even if they were present. When examining Vegetation Types previously identified by Woodman Environmental, vegetation which contained *Allocasuarina sp.* comprised approximately 82% of the entire project area, so it is possible the Trapdoor Spider may occur throughout the majority, if not entirety, of the project area. There are two *Idiosoma sp.* expected to occur in the project area: one is CS3 and one is listed as Priority 1 (CS2) (see Table 12). The Kwongan Heath Shield-backed Trapdoor Spider *Idiosoma kwongan* (a priority 1 species) has been recorded within 50 km of the project area, approximately 18 km to the west and 43 km to the south of the project area (Figure 8). The record to the west was recorded in 2020 by BCE and is unconfirmed. It is possible the individuals recorded within the project area were this species but they may also be *I. aranaceum*.

Table 13. Trapdoor Spider burrows recorded during site visit.

Date	No.	Easting	Northing	Details of Trapdoor Spider burrow
23/06/2021	TDS1	337390.4	6743978.061	15mm burrow in yellow sand. Unburnt <i>Allocasuarina</i> thicket. Shieldback spider seen with milliscope. Spider collected.
23/06/2021	TDS2	337383.2	6743977.625	12mm burrow in yellow sand. Unburnt <i>Allocasuarina</i> thicket. Shieldback spider seen with milliscope.
23/06/2021	TDS3	337382.4	6743973.401	8mm burrow in yellow sand. Unburnt <i>Allocasuarina</i> thicket. Shieldback spider seen with milliscope.
23/06/2021	TDS4	337408.3	6743971.89	6mm burrow in yellow sand. Unburnt <i>Allocasuarina</i> thicket. Pale Shieldback seen with milliscope, very small. 12cm down burrow.
23/06/2021	TDS5	337404.1	6743975.265	25mm burrow 30cm down to spider seen with milliscope. Yellow sand, unburnt <i>Allocasuarina</i> thicket.



Figure 10. Trapdoor Spider burrow entrance and lid constructed with leaf litter; this burrow was recorded within project area



Figure 11. A Trapdoor Spider *Idiosoma* sp. which was excavated from its burrow

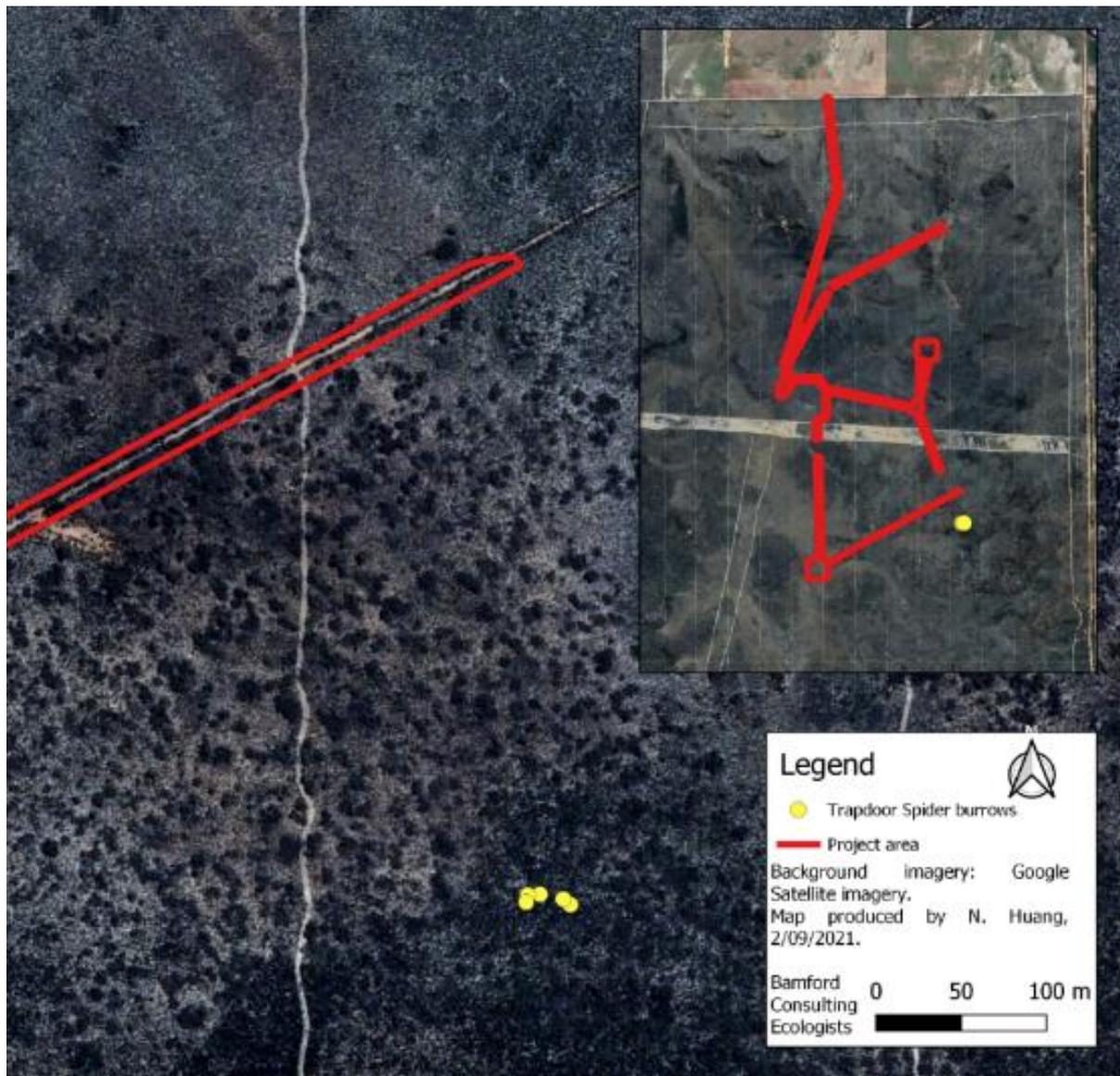


Figure 12. Locations of Trapdoor Spider *Idiosoma sp.* burrows within unburnt area

3.3 Patterns of biodiversity

Investigating patterns of biodiversity can be complex and are often beyond the scope even of Detailed or Targeted investigations, and is also more relevant to impact assessment when addressing projects of at least moderate size, rather than the very small area involved with this project. However, based upon the different landscapes in the project area, the previous studies that have taken place in the vicinity and the field investigations conducted in 2021, some likely patterns of biodiversity are:

- Entire project area likely to support high diversity of bird and reptile species, including the conservation significant Carnaby's Black-Cockatoo and Trapdoor Spiders; and
- Lateritic breakaways (VSA 1) may support SRE invertebrates due to the VSA being small in extent and distinctive; this VSA may also support other fauna associated with rocky breakaways.

3.4 Ecological processes

The nature of the landscape and the fauna assemblage indicate some of the ecological processes that may be important for ecosystem function in the project area (see Appendices 4 and 5 for descriptions and other ecological processes). Ecological processes which may be important in the project area are discussed below.

Fire. Native vegetation throughout the project area is subject to fire and while appropriate fire regimes can benefit biodiversity, inappropriate regimes can lead to a loss of biodiversity. There is probably no current managed fire regime and recent fires have probably been too often and too extensive. The majority of the project area was burnt in the last 1-2 years which resulted in few fauna records in the present survey. However, most fauna species are remarkably resilient in the face of fires and altered fire regimes and return to post-fire areas over time (Bamford 1986, 1992, 1995; Bamford and Roberts 2003).

Feral species and interactions with over-abundant native species. Feral species occur throughout Western Australia and are a major component of the current mammal fauna of the project area and region. They have contributed to local extinctions and may be affecting populations of extant species.

Connectivity and landscape permeability. The project area occurs in an area which has historically and recently experienced a high level of habitat loss and fragmentation. It is located within a large area of remnant bushland so the development may lead to further fragmentation.

3.5 Summary of Fauna Values

The desktop study identified 200 vertebrate fauna species as potentially occurring in the project area (ten frogs, 48 reptiles, 120 birds and 23 mammals (14 native and nine feral)), with a further 15 species considered to be locally extinct. The presence of two vertebrate species (two birds) and three invertebrate species (including a conservation significant Trapdoor Spider) was confirmed during the 2021 site visit. This extremely low number of fauna records is likely due to the project area being recently burnt and to the availability of unburnt vegetation nearby.

Fauna assemblage.

Moderately rich but incomplete with some species locally extinct, mostly critical weight range mammals. The reptile assemblage in particular is rich and distinctive due to the biogeography of the region. There is a high proportion of non-resident birds, including many which are nectivorous and exploit seasonal abundance of nectar and pollen from the species-rich flora. Overall, the vertebrate fauna assemblage is likely to be well represented and typical of the Lesueur Sandplains subregion. The invertebrate fauna assemblage is more likely to include some species with restricted distributions (SREs) associated with particular landscape features in the lateritic breakaways.

Species of conservation significance.

A total of seven invertebrate and eleven vertebrate species of conservation significance are expected to occur in the project area. The vertebrates comprise four CS1, three CS2 and four CS3 species from two reptiles, eight birds and one mammal. Twelve conservation significant mammal species may be locally extinct and are not included in species counts. Carnaby's Black-Cockatoo is important as it is

likely to be a regular foraging visitor to the project area. There are roosting records for the species nearby, but the nearest confirmed breeding site is c. 100km to the south. Vegetation within the project area represents foraging habitat of at least moderate value for the species. The Western Ground Parrot may be locally extinct but because of its very high conservation significance (with the only known wild population estimated as c. 100 birds; A. Burbidge pers. comm.) and previous records within close proximity of the project area, the slight possibility of the species being extant in the general area is important. While significant invertebrates are poorly-documented, landscape interpretation suggest that VSA 1 may support SRE species and the entire project area may support the priority Trapdoor Spider.

Vegetation and Substrate Associations (VSAs).

The project area encompasses three VSAs, all of which are intact. The most distinct of these are the lateritic breakaways of VSA 1. The most extensive across the project area are low heath on white-grey sand (VSA 2) and low heath on yellow sand (VSA 3), which are expected to support conservation significant species and a high diversity of birds and reptiles. All three VSAs are well-represented in the region.

Patterns of biodiversity.

Within the project area all VSAs are intact and likely to support a high level of species richness. VSAs 2 and 3 (low heath) are by far the most extensive and likely to support a high reptile and bird richness. VSA 1 may support some SREs and species associated with rocky areas due to the VSA being small in extent and distinctive.

Key ecological processes.

The main processes which may affect the fauna assemblage are likely to be the fire regime, the presence of feral species, and habitat loss/fragmentation.

4 Discussion - Impact Assessment

Threatening processes have to be considered in the context of fauna values and the nature of the proposed action and are examined below. Context is also important, as the project area is in a largely undisturbed landscape. Impact categories are defined in Table 7. Impact categories are assigned on the assumption of some management.

Based on the desktop review and site inspection, the proposed development can be assessed against a standard suite of threatening processes. Impacts are generally minor, largely because of the small area of the development. Of the threatening processes discussed below, potential impacts on the lateritic breakaways which may support SRE species are of greatest concern.

Loss of habitat affecting population survival.

Negligible to Minor

The project area lies within a large remnant of native vegetation but with extensive cleared areas immediately to the east. The development footprint is small so proportional habitat loss is low, but loss of some parts of lateritic breakaways (limited in extent in the project area) will result in the loss of habitat for some SRE species. However, this is expected to be a negligible to minor impact given the small size of the disturbance footprint.

Loss of habitat leading to population fragmentation.

Negligible to Minor

The project area lies in a large remnant of native vegetation which is continuous to the west, but to the east lies cleared agricultural land. The development footprint is narrow and linear and is unlikely to fragment habitat for fauna as long as the linear clearing does not become wider due to vegetation degradation, as can result if vehicles leave tracks or through weed invasion along tracks.

Increased mortality.

Negligible to Minor

The main source of mortality is likely to be roadkill through collision with vehicles. When common species are affected it is more of an animal welfare issue than a conservation issue.

Species interactions, including predation and competition.

Minor

Feral species are present in the project area, and increased development almost always attracts more feral species to the area. Species of concern would be Feral Cats and Foxes. Feral Cats could be inadvertently (or even deliberately) encouraged through the provision of food and shelter; they are a known predator of reptiles and small mammals. Foxes may also increase due to human activity. Both Foxes and Cats will use cleared lines to access otherwise intact areas of native vegetation, so this has potential to increase predation pressure on native fauna. Avoiding an increase in predator activity would require some management of waste and possibly education and signage.

Fire.

Minor (with management)

Increased human activity brings with it an increase in the risk of fire. The majority of the project area has been recently burnt so the risk of fire in the short-term is low due to the low fuel load. However, additional fire events which occur too soon or are severe can affect vegetation recovery and should be avoided. Tracks increase the risk of fire but also provide the potential for fire management.

Disturbance: dust, light, noise, and vibration.

Minor (with management)

These effects would be very localised and can be minimised through directing light away from surrounding vegetated areas and minimising disturbance at all times.

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6 Appendices

6.1 Appendix 1. Explanation of fauna values.

Fauna values are the features of a site and its fauna that contribute to biodiversity, and it is these values that are potentially at threat from a development proposal. Fauna values can be examined under the five headings outlined below. It must be stressed that these values are interdependent and should not be considered equal, but contribute to an understanding of the biodiversity of a site. Understanding fauna values provides opportunities to predict and therefore mitigate impacts.

Assemblage characteristics

Uniqueness. This refers to the combination of species present at a site. For example, a site may support an unusual assemblage that has elements from adjacent biogeographic zones, it may have species present or absent that might be otherwise expected, or it may have an assemblage that is typical of a very large region. For the purposes of impact assessment, an unusual assemblage has greater value for biodiversity than a typical assemblage.

Completeness. An assemblage may be complete (i.e. has all the species that would have been present at the time of European settlement), or it may have lost species due to a variety of factors. Note that a complete assemblage, such as on an island, may have fewer species than an incomplete assemblage (such as in a species-rich but degraded site on the mainland).

Richness. This is a measure of the number of species at a site. At a simple level, a species rich site is more valuable than a species poor site, but value is also determined, for example, by the sorts of species present.

Vegetation and substrate associations (VSAs)

VSAs combine broad vegetation types, the soils or other substrate with which they are associated, and the landform. In the context of fauna assessment, VSAs are the environments that provide habitats for fauna. The term habitat is widely used in this context, but by definition an animal's habitat is the environment that it utilises (Calver *et al.* 2009), not the environment as a whole. Habitat is a function of the animal and its ecology, rather than being a function of the environment. For example, a species may occur in eucalypt canopy or in leaf-litter on sand, and that habitat may be found in only one or in several VSAs. VSAs are not the same as vegetation types since these may not incorporate soil and landform, and recognise floristics to a degree that VSAs do not. Vegetation types may also not recognise minor but often significant (for fauna) structural differences in the environment. VSAs also do not necessarily correspond with soil types, but may reflect some of these elements.

Because VSAs provide the habitat for fauna, they are important in determining assemblage characteristics. For the purposes of impact assessment, VSAs can also provide a surrogate for detailed information on the fauna assemblage. For example, rare, relictual or restricted VSAs should automatically be considered a significant fauna value. Impacts may be significant if the VSA is rare, a large proportion of the VSA is affected and/or the VSA supports significant fauna. The disturbance of even small amounts of habitat in a localised area can have significant impacts to fauna if rare or unusual habitats are disturbed.

VSA assessment was made with reference to the key attributes provided by (EPA 2020):

- soil type and characteristics
- extent and type of ground surfaces and landforms
- height, cover and dominant flora within each vegetation stratum
- presence of specific flora or vegetation of known importance to fauna
- evidence of fire history including, where possible, estimates of time since fire
- evidence and degree of other disturbance or threats, e.g. feral species
- presence of microhabitats and significant habitat features, such as coarse woody debris, rocky
- outcrops, tree hollows, water sources and caves
- evidence of potential to support significant fauna
- function of the habitat as a fauna refuge or part of an ecological linkage.

Patterns of biodiversity across the landscape

This fauna value relates to how the assemblage is organised across the landscape. Generally, the fauna assemblage is not distributed evenly across the landscape or even within one VSA. There may be zones of high biodiversity such as particular environments or ecotones (transitions between VSAs). There may also be zones of low biodiversity. Impacts may be significant if a wide range of species is affected even if most of those species are not significant per se.

Species of conservation significance

Species of conservation significance are of special importance in impact assessment. The conservation status of fauna species in Australia is assessed under Commonwealth and State Acts such as the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Western Australian Biodiversity Conservation Act 2016* (BC Act). In addition, the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA) recognises priority levels, while local populations of some species may be significant even if the species as a whole has no formal recognition. Therefore, three broad levels of conservation significance can be recognised and are used for the purposes of this report, and are outlined below. A full description of the conservation significance categories, schedules and priority levels mentioned below is provided in Appendix 2.

Conservation Significance (CS) 1: Species listed under State or Commonwealth Acts.

Species listed under the EPBC Act are assigned to categories recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN 2012), or are listed as migratory. Migratory species are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA), the Republic of South Korea Australia Migratory Bird Agreement (ROKAMBA), and/or the Convention on the Conservation of Migratory Species of Wild Animals (CMS; also referred to as the Bonn Convention). The *Wildlife Conservation Act 1950* uses a series of seven Schedules to classify conservation status that largely reflect the IUCN categories (IUCN 2012).

Conservation Significance (CS) 2: Species listed as Priority by DBCA but not listed under State or Commonwealth Acts.

In Western Australia, DBCA has produced a supplementary list of Priority Fauna, being species that are not considered threatened under the *Wildlife Conservation Act 1950* but for which DBCA feels there is cause for concern.

Conservation Significance (CS) 3: Species not listed under Acts or in publications, but considered of at least local significance because of their pattern of distribution.

This level of significance has no legislative or published recognition and is based on interpretation of distribution information, but is used here as it may have links to preserving biodiversity at the genetic level (EPA 2002). If a population is isolated but a subset of a widespread (common) species, then it may not be recognised as threatened, but may have unique genetic characteristics. Conservation significance is applied to allow for the preservation of genetic richness at a population level, and not just at a species level. Species on the edge of their range, or that are sensitive to impacts such as habitat fragmentation, may also be classed as CS3, as may colonies of waterbirds. The Western Australian Department of Environmental Protection, now DBCA, used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of the Perth Bushplan (DEP 2000).

Marine-listed species

Some conservation significant species may also be listed as 'Marine' under the EPBC Act. This listing protects these species in 'Commonwealth areas' which include "marine areas beyond the coastal waters of each State and the Northern Territory, and includes all of Australia's Exclusive Economic Zone (EEZ)" (Geoscience Australia 2020). The EEZ extends to 200 nautical miles (approximately 350 kilometres) from the coast (Geoscience Australia 2020). This may mean that the 'Marine' listing does not apply to the project/survey area (depending on its location). Therefore, when a species is otherwise protected (under the EPBC Act or BC Act) or priority-listed (by the DBCA) then the Marine listing is also noted but it does not have site-specific relevance. In cases where a species is solely Marine-listed (for a list see DAWE 2020g) and a project/survey area is not within a Commonwealth area then it is treated like all other fauna.

Invertebrates

Invertebrate species considered to be short range endemics (SREs) also fall within the CS3 category, as they have no legislative or published recognition and their significance is based on interpretation of distribution information. Harvey (2002) notes that the majority of species that have been classified as short-range endemics have common life history characteristics such as poor powers of dispersal or confinement to discontinuous habitats. Several groups, therefore, have particularly high instances of short-range endemic species: Gastropoda (snails and slugs), Oligochaeta (earthworms), Onychophora (velvet worms), Araneae (mygalomorph spiders), Pseudoscorpionida (pseudoscorpions), Schizomida (schizomids), Diplopoda (millipedes), Phreatoicidea (phreatoicidean crustaceans), and Decapoda (freshwater crayfish). The poor understanding of the taxonomy of many of the short-range endemic species hinders their conservation (Harvey 2002).

Introduced species

In addition to these conservation levels, species that have been introduced (INT) are indicated throughout the report. Introduced species may be important to the native fauna assemblage through effects by predation and/or competition.

Ecological processes upon which the fauna depend

These are the processes that affect and maintain fauna populations in an area and as such are very complex; for example, populations are maintained through the dynamic of mortality, survival and recruitment being more or less in balance, and these are affected by a myriad of factors. The dynamics of fauna populations in a project may be affected by processes such as fire regime, landscape patterns (such as fragmentation and/or linkage), the presence of feral species and hydrology. Impacts may be significant if processes are altered such that fauna populations are adversely affected, resulting in declines and even localised loss of species. Threatening processes as outlined in Appendix 3 are effectively the ecological processes that can be altered to result in impacts upon fauna.

6.2 Appendix 2. Categories used in the assessment of conservation status.

IUCN (International Union for the Conservation of Nature) categories, as outlined by IUCN (2012), and as used for the *Environment Protection and Biodiversity Conservation Act 1999* and the *Western Australian Biodiversity Conservation Act 2016*.

Extinct	Taxa not definitely located in the wild during the past 50 years.
Extinct in the Wild (Ex)	Taxa known to survive only in captivity.
Critically Endangered (CR)	Taxa facing an extremely high risk of extinction in the wild in the immediate future.
Endangered (E)	Taxa facing a very high risk of extinction in the wild in the near future.
Vulnerable (V)	Taxa facing a high risk of extinction in the wild in the medium-term future.
Near Threatened	Taxa that risk becoming Vulnerable in the wild.
Conservation Dependent	Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classed as Vulnerable or more severely threatened.
Data Deficient (Insufficiently Known)	Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.
Least Concern.	Taxa that are not Threatened.

Schedules used in the *WA Biodiversity Conservation Act 2016*

Schedule 1 (S1)	Critically Endangered fauna.
Schedule 2 (S2)	Endangered fauna
Schedule 3 (S3)	Vulnerable Migratory species listed under international treaties.
Schedule 4 (S4)	Presumed extinct fauna
Schedule 5 (S5)	Migratory birds under international agreement
Schedule 6 (S6)	Conservation dependant fauna
Schedule 7 (S7)	Other specially protected fauna

WA DBCA Priority species (species not listed under the *WA Biodiversity Conservation Act 2016*, but for which there is some concern).

Priority 1 (P1)	Taxa with few, poorly known populations on threatened lands.
Priority 2 (P2)	Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.
Priority 3 (P3)	Taxa with several, poorly known populations, some on conservation lands.
Priority 4 (P4)	Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change.
Priority 5 (P5)	Taxa in need of monitoring. Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years (IUCN Conservation Dependent).

6.3 Appendix 3. Scoring system for the assessment of foraging value of vegetation for black-cockatoos.

Introduction

Application of the Offset Assessment Guide (offsets guide) developed by the federal environment department for assessing black-cockatoo foraging habitat requires the calculation of a score out of 10. The following system has been developed by Bamford Consulting to provide an objective scoring system that is practical and can be used by trained field zoologists with experience in the environments frequented by the species.

Calculating the total score (out of 10) requires the following steps:

- A Determining a score out of six for the vegetation composition, condition and structure; plus
- B Determining a score out of three for the context of the site; plus
- C Determining a score out of one for species density.
- D Determining the total score out of 10, which may require moderation for context and species density with respect to the vegetation composition.

Calculation of scores and the moderation process are described in detail below.

A. Vegetation composition, condition and structure scoring

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	Baudin's Black-Cockatoo	Forest Red-tailed Black-Cockatoo
0	<p>No foraging value. No Proteaceae, eucalypts or other potential sources of food. Examples:</p> <ul style="list-style-type: none"> • Water bodies (e.g. salt lakes, dams, rivers); • Bare ground; • Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits). 	<p>No foraging value. No eucalypts or other potential sources of food. Examples:</p> <ul style="list-style-type: none"> • Water bodies (e.g. dams, rivers); • Bare ground; • Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits). 	<p>No foraging value. No eucalypts or other potential sources of food. Examples:</p> <ul style="list-style-type: none"> • Water bodies (e.g. dams, rivers); • Bare ground; • Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits).
1	<p>Negligible to low foraging value. Examples:</p> <ul style="list-style-type: none"> • Scattered specimens of known food plants but projected foliage cover of these is < 2%. This could include urban areas with scattered foraging trees; • Paddocks that are partly vegetated with melons or other known food-source weeds (e.g. <i>Erodium</i> spp.) that represent a short-term and/or seasonal food source; • Blue Gum plantations (foraging by Carnaby's Black-Cockatoos has been reported but appears to be unusual). 	<p>Negligible to low foraging value. Scattered specimens of known food plants but projected foliage cover of these < 1%. This could include urban areas with scattered foraging trees.</p>	<p>Negligible to low foraging value. Scattered specimens of known food plants but projected foliage cover of these < 1%. Could include urban areas with scattered foraging trees.</p>

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	Baudin's Black-Cockatoo	Forest Red-tailed Black-Cockatoo
2	<p>Low foraging value. Examples:</p> <ul style="list-style-type: none"> • Shrubland in which species of foraging value, such as shrubby banksias, have < 10% projected foliage cover; • Woodland with tree banksias 2-5% projected foliage cover; • Open eucalypt woodland/mallee of small-fruited species; • Paddocks that are densely vegetated with melons or other known food-source weeds (e.g. <i>Erodium</i> spp.) that represent a short-term and/or seasonal food source. 	<p>Low foraging value. Examples:</p> <ul style="list-style-type: none"> • Woodland with scattered specimens of known food plants (e.g. Marri and Jarrah) 1-5% projected foliage cover; • Urban areas with scattered foraging trees. 	<p>Low foraging value. Examples:</p> <ul style="list-style-type: none"> • Woodland with scattered specimens of known food plants (e.g. Marri, Jarrah or Sheoak) 1-5% projected foliage cover; • Urban areas with scattered food plants such as Cape Lilac, <i>Eucalyptus caesia</i> and <i>E. erythrocorys</i>.

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	Baudin's Black-Cockatoo	Forest Red-tailed Black-Cockatoo
3	<p>Low to Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> • Shrubland in which species of foraging value, such as shrubby banksias, have 10-20% projected foliage cover; • Woodland with tree banksias 5-20% projected foliage cover; • Eucalypt Woodland/Mallee of small-fruited species; • Eucalypt Woodland with Marri < 10% projected foliage cover. 	<p>Low to Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> • Eucalypt Woodland with known food plants (especially Marri) 5-20% projected foliage cover; • Parkland-cleared Eucalypt Woodland/Forest with known food plants 10-40% projected foliage cover (poor long-term viability without management); • Younger areas of (managed) revegetation with known food plants 10-40% projected foliage cover (establishing food sources with good long-term viability). 	<p>Low to Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> • Eucalypt Woodland with known food plants (especially Marri and Jarrah) 5-20% projected foliage cover; • Parkland-cleared Eucalypt Woodland/Forest with known food plants 10-40% projected foliage cover (poor long-term viability without management); • Younger areas of (managed) revegetation with known food plants 10-40% projected foliage cover (establishing food sources with good long-term viability).

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	Baudin's Black-Cockatoo	Forest Red-tailed Black-Cockatoo
4	<p>Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> • Woodland/forest with tree banksias 20-40% projected foliage cover; • Eucalypt Woodland/Forest with Marri 20-40% projected foliage cover. 	<p>Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> • Marri-Jarrah Woodland/Forest with 20-40% projected foliage cover; • Marri-Jarrah Forest with 40-60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths. • Eucalypt Woodland/Forest with diverse, healthy understorey and known food trees (especially Marri) 10-20% projected foliage cover. • Orchards with highly desirable food sources (e.g. apples, pears, some stone fruits). 	<p>Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> • Marri-Jarrah Woodland/Forest with 20-40% projected foliage cover; • Marri-Jarrah Forest with 40-60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Sheoak Forest with 40-60% projected foliage cover.
5	<p>Moderate to High foraging value. Examples:</p> <ul style="list-style-type: none"> • Banksia Forest with 40-60% projected foliage cover; • Banksia Forest with > 60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Pine plantations with trees more than 10 years old. 	<p>Moderate to High foraging value. Examples:</p> <ul style="list-style-type: none"> • Marri-Jarrah Forest with 40-60% projected foliage cover; • Marri-Jarrah Forest with > 60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths. 	<p>Moderate to High foraging value. Examples:</p> <ul style="list-style-type: none"> • Marri-Jarrah Forest with 40-60% projected foliage cover; • Marri-Jarrah Forest with > 60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths. • Sheoak Forest with > 60% projected foliage cover.

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	Baudin's Black-Cockatoo	Forest Red-tailed Black-Cockatoo
6	<p>High foraging value. Example:</p> <ul style="list-style-type: none"> Banksia Forest with > 60% projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term). 	<p>High foraging value. Example:</p> <ul style="list-style-type: none"> Marri-Jarrah Forest with > 60% projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term). 	<p>High foraging value. Example:</p> <ul style="list-style-type: none"> Marri-Jarrah Forest with > 60% projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term).

Vegetation structural class terminology follows Keighery ([1994](#)).

B. Site context.

The maximum score is given in situations where foraging habitat is supporting breeding birds. It can also be given in fragmented landscapes where there is little foraging habitat remaining and thus what is left has a high contextual value. The site context score is species-specific as it depends upon factors such as the vegetation type and extent, and the presence of breeding birds, and the following table, developed by Bamford consulting in conjunction with DEE, provides a *guide* to the assignment of site context scores (note that 'local area' is defined as within a 15 km radius of the centre point of the study site):

Site Context Score	Percentage of the existing native vegetation within the 'local' area that the study site represents.	
	'Local' breeding known/likely	'Local' breeding unlikely
3	> 5%	> 10%
2	1 - 5%	5 - 10%
1	0.1 - 1%	0.1 - 5%
0	< 0.1%	< 0.1%

C. Species density.

Assignment of the species density score (0 or 1) is based upon the black-cockatoo species being either abundant or not abundant, and is species specific. A score of 1 is used where the species is seen or reported regularly and/or there is abundant foraging evidence. Regularly is when the species is seen at intervals of every few days or weeks for at least several months of the year. A score of 0 is used when the species is recorded or reported very infrequently and there is little or no foraging evidence.

D. Moderation of scores for the calculation of a value out of 10.

The foraging value score provides a numerical value that reflects the significance of vegetation as foraging habitat for Black-Cockatoos, and this numerical value is designed to provide the information needed by the Federal Department of the Environment and Energy (DEE) to assess impact significance and offset requirements. The foraging value of the vegetation depends upon the type, density and condition of trees and shrubs in an area, and can be influenced by the context such as the availability of foraging habitat nearby. The BCE scoring system for value of foraging habitat has three components as detailed above. These three components are drawn from the DEE offsets guide but the scoring approach was developed by Bamford Consulting Ecologists.

- A A score out of six for the vegetation composition, condition and structure; plus
- B A score out of three for the context of the site; plus
- C A score out of one for species density.

Foraging value can thus be assigned a score out of six, based upon site vegetation characteristics, or a score out of 10 if context and species density are considered. Assigning a score out of 10 represents step D and may require moderation rather than simple addition.

The score out of six for vegetation characteristics and value can be compared across a site, while a score out of 10 is the overall foraging value and is used for the purposes of aiding offset calculations. The calculation out of 10 requires the vegetation characteristics (out of 6) to be combined with the scores given for context and species density. It is considered that the context and density scores are not independent of vegetation characteristics; otherwise habitat of absolutely no value for black-cockatoo foraging (such as concrete or a wetland) could get a foraging score out of 10 as high as 4 if it occurred in an area where the species breed (context score of 3) and are abundant (species density score of 1). Similarly, vegetation of negligible or low characteristics which could not support black-cockatoos could be assigned a score as high as 6 out of 10. In that case, the score of 6 would be more a reflection of nearby vegetation of high characteristics than of the foraging value of the negligible to low scoring vegetation. The Black-Cockatoos would only be present because of vegetation of high characteristics, so applying the context and species density scores to vegetation of low characteristics would not give a true reflection of their foraging value.

For this reason, the context and species density scores need to be moderated for the vegetation characteristic score to prevent vegetation of little or no foraging value receiving an excessive score out of 10. A simple approach is to assign a context and species density score of zero to vegetation with a characteristic score of low (2), negligible (1) or none (0), on the basis that birds will not use such areas unless they are adjacent to at least low-moderate quality foraging habitat (≥ 3). The approach to calculating a score out of 10 can be summarised as follows:

vegetation composition, condition and structure score	context score	Species density score
3-6 (low/moderate to high value)	Assessed as per B above	Assessed as per C above
0-2 (no to low value)	0	0

6.4 Appendix 4. Explanation of threatening processes.

Potential impacts of proposed developments upon fauna values can be related to threatening processes. This is recognised in the literature and under the EPBC Act, in which threatening processes are listed (see Appendix). Processes that may impact fauna values are discussed below. Rather than being independent of one another, processes are complex and often interrelated. They are the mechanisms by which fauna can be affected by development. Impacts may be significant if large numbers of species or large proportions of populations are affected.

Note that the terms direct and indirect impacts are used by the DoE (2013), DSEWPac (2013b) and EPA (2016a), but there is some inconsistency in how these are defined. The federal guidance does not define direct impact but has a very broad definition of indirect, and makes the statement (DoE 2013) *‘Consideration should be given to all adverse impacts that could reasonably be predicted to follow from the action, whether these impacts are within the control of the person proposing to take the action or not. Indirect impacts will be relevant where they are sufficiently close to the proposed action to be said to be a consequence of the action, and they can reasonably be imputed to be within the contemplation of the person proposing to take the action.’* Indirect impacts therefore can even include what the DoE (2013) calls facilitated impacts, which are the result of third party actions triggered by the primary action. In contrast, the EPA (2016a) defines direct impacts to *‘include the removal, fragmentation or modification of habitat, and mortality or displacement of individuals or populations.’* This document then lists as indirect impacts what in many cases are the consequences of the removal, fragmentation or modification of habitat. For example, *‘disruption of the dispersal of individuals required to colonise new areas inhibiting maintenance of genetic diversity between populations’* is a consequence of habitat fragmentation. Impacts of light, noise and even roadkill are defined as indirect but they are clearly the result of the action and in control of the person taking the action. Roadkill is as direct a form of mortality as can be observed, but it is considered as an indirect impact in the context of a development presumably because it is not directly linked to land clearing. The EPA (2016a) makes a strong distinction between removal of vegetation (direct impact) and the consequences of such clearing and other aspects of a development (indirect impacts). It is not obvious how this distinction between direct and indirect impacts is helpful in the EIA process, as the key aim is to ensure that all impacts that result from a project are addressed in this assessment process. Interestingly, Gleeson and Gleeson (2012), in a major review of impacts of development on wildlife, do not use the terms direct or indirect. In the following outlines of threatening processes that can cause impacts, the emphasis is upon interpreting how a threatening process will cause an impact. For example, loss of habitat (threatening process) can lead to population decline and to population fragmentation, which are two distinct impacts, with population decline considered a direct impact and fragmentation an indirect impact by the EPA (2016a).

Loss of habitat affecting population survival

Clearing for a development can lead to habitat loss for a species with a consequent decline in population size. This may be significant if the smaller population has reduced viability. Conservation significant species or species that already occur at low densities may be particularly sensitive to habitat loss affecting population survival.

Loss of habitat leading to population fragmentation

Loss of habitat can affect population movements by limiting movement of individuals throughout the landscape as a result of fragmentation (Soule *et al.* 2004; Gleeson and Gleeson 2012). Obstructions associated with the development, such as roads, pipes and drainage channels, may also affect movement of small, terrestrial species. Fragmented populations may not be sustainable and may be sensitive to effects such as reduced gene flow.

Degradation of habitat due to weed invasion leading to population decline

Weed invasion, such as through introduction by human boots or vehicle tyres, can occur as a result of development and if this alters habitat quality, can lead to effects similar to habitat loss.

Increased mortality

Increased mortality can occur during project operations; for example from roadkill, animals striking infrastructure and entrapment in trenches. Roadkill as a cause of population decline has been documented for several medium-sized mammals in eastern Australia (Dufty 1989; Jones 2000). Increased mortality due to roadkill is often more prevalent in habitats that have been fragmented (Scheick and Jones 1999; Clevenger and Waltho 2000; Jackson and Griffin 2000).

Increased mortality of common species during development is unavoidable and may not be significant for a population. However, the cumulative impacts of increased mortality of conservation significant species or species that already occur at low densities may have a significant impact on the population.

Species interactions, including predation and competition

Changes in species interactions often occur with development. Introduced species, including the feral Cat, Red Fox and Rabbit may have adverse impacts upon native species and development can alter their abundance. In particular, some mammal species are very sensitive to introduced predators and the decline of many mammals in Australia has been linked to predation by the Red Fox, and to a lesser extent the feral Cat (Burbidge and McKenzie 1989). Introduced grazing species, such as the Rabbit, Goat, Camel and domestic livestock, can also degrade habitats and deplete vegetation that may be a food source for other species.

Changes in the abundance of some native species at the expense of others, due to the provision of fresh watering points, can also be a concern. Harrington (2002) found the presence of artificial fresh waterpoints in the semi-arid mallee rangelands to influence the abundance and distribution of certain bird species. Common, water-dependent birds were found to out-compete some less common, water-independent species. Similarly, Read *et al.* (2015) found a decline in some bird species but an increase in others in the vicinity of active mines and concluded this was due to the mine attracting large and aggressive species that displaced other species. Over-abundant native herbivores, such as kangaroos, can also adversely affect less abundant native species through competition and displacement.

Hydroecology

Interruptions of hydroecological processes can have major effects because they underpin primary production in ecosystems and there are specific, generally rare habitats that are hydrology-dependent. Fauna may be impacted by potential changes to groundwater level and chemistry and

altered flow regime. These changes may alter vegetation across large areas and may lead to habitat degradation or loss. Impacts upon fauna can be widespread and major.

Changes to flow regime across the landscape may alter vegetation and may lead to habitat degradation or loss, affecting fauna. For example, Mulga has a shallow root system and relies on surface sheet flow during flood events. If surface sheet flow is impeded, Mulga can die (Kofoed 1998), which may impact on a range of fauna associated with this vegetation type.

Fire

The role of fire in the Australian environment and its importance to vertebrate fauna has been widely acknowledged (Gill *et al.* 1981; Fox 1982; Letnic *et al.* 2004). It is also one of the factors that has contributed to the decline and local extinction of some mammal and bird species (Burbidge and McKenzie 1989). Fire is a natural feature of the environment but frequent, extensive fires may adversely impact some fauna, particularly mammals and short-range endemic species. Changes in fire regime, whether to more frequent or less frequent fires, may be significant to some fauna. Impacts of severe fire may be devastating to species already occurring at low densities or to species requiring long unburnt habitats to survive. In terms of conservation management, it is not fire *per se* but the fire regime that is important, with evidence that infrequent, extensive and intense fires adversely affect biodiversity, whereas frequent fires that cover small areas and are variable in both season and intensity can enhance biodiversity. Fire management may be considered the responsibility of managers of large tracts of land, including managers of mining tenements.

Dust, light, noise and vibration

Impacts of dust, light, noise and vibration upon fauna are difficult to predict. Some studies have demonstrated the impact of artificial night lighting on fauna, with lighting affecting fauna behaviour more than noise (Rich and Longcore 2006). Effects can include impacts on predator-prey interactions, changes to mating and nesting behaviour, and increased competition and predation within and between invertebrates, frogs, birds and mammals.

The death of very large numbers of insects has been observed around some remote mine sites and attracts other fauna, notably native and introduced predators (M. Bamford pers. obs). The abundance of some insects can decline due to mortality around lights, although this has previously been recorded in fragmented landscapes where populations are already under stress (Rich and Longcore 2006). Artificial night lighting may also lead to disorientation of migratory birds. Aquatic habitats and open habitats such as grasslands and dunes may be vulnerable to light spill.

6.5 Appendix 5. Ecological and threatening processes identified under legislation and in the literature.

Ecological processes are processes that maintain ecosystems and biodiversity. They are important for the assessment of impacts of development proposals, because ecological processes make ecosystems sensitive to change. The issue of ecological processes, impacts and conservation of biodiversity has an extensive literature. Following are examples of the sorts of ecological processes that need to be considered.

Ecological processes relevant to the conservation of biodiversity in Australia (Soule *et al.* 2004):

- Critical species interactions (highly interactive species);
- Long distance biological movement;
- Disturbance at local and regional scales;
- Global climate change;
- Hydroecology;
- Coastal zone fluxes;
- Spatially-dependent evolutionary processes (range expansion and gene flow); and
- Geographic and temporal variation of plant productivity across Australia.

Threatening processes (EPBC Act)

Under the EPBC Act, a key threatening process is an ecological interaction that threatens or may threaten the survival, abundance or evolutionary development of a threatened species or ecological community. There are currently 21 key threatening processes listed by the federal Department of the Environment (DAWE 2021):

- Competition and land degradation by rabbits.
- Competition and land degradation by unmanaged goats.
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*).
- Incidental catch (bycatch) of Sea Turtle during coastal otter-trawling operations within Australian waters north of 28 degrees South.
- Incidental catch (or bycatch) of seabirds during oceanic longline fishing operations.
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis.
- Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris.
- Invasion of northern Australia by Gamba Grass and other introduced grasses.
- Land clearance.
- Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants.
- Loss of biodiversity and ecosystem integrity following invasion by the Yellow Crazy Ant (*Anoplolepis gracilipes*) on Christmas Island, Indian Ocean.
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases.
- Novel biota and their impact on biodiversity.
- Predation by European red fox.
- Predation by exotic rats on Australian offshore islands of less than 1000 km² (100,000 ha).
- Predation by feral cats.
- Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs.
- Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species.
- The biological effects, including lethal toxic ingestion, caused by Cane Toads (*Bufo marinus*).
- The reduction in the biodiversity of Australian native fauna and flora due to the red imported fire ant, *Solenopsis invicta* (fire ant).

General processes that threaten biodiversity across Australia (The National Land and Water Resources Audit):

- Vegetation clearing;
- Increasing fragmentation, loss of remnants and lack of recruitment;
- Firewood collection;
- Grazing pressure;
- Feral animals;
- Exotic weeds;
- Changed fire regimes;
- Pathogens;
- Changed hydrology—dryland salinity and salt water intrusion;
- Changed hydrology— such as altered flow regimes affecting riparian vegetation; and
- Pollution.

In addition to the above processes, the federal Department of Agriculture, Water and the Environment (DAWE) produced Significant Impact Guidelines that provide criteria for the assessment of the significance of impacts. These criteria provide a framework for the assessment of significant impacts. The criteria are listed below.

- Will the proposed action lead to a long-term decrease in the size of a population?
- Will the proposed action reduce the area of occupancy of the species?
- Will the proposed action fragment an existing population?
- Will the proposed action adversely affect habitat critical to the survival of a species?
- Will the proposed action disrupt the breeding cycle of a population?
- Will the proposed action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?
- Will the proposed action result in introducing invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat?
- Will the proposed action introduce disease that may cause the species to decline?
- Will the proposed action interfere with the recovery of the species?

6.6 Appendix 6. Fauna expected to occur in the project area.

These lists are derived from the results of database and literature searches and from previous field surveys conducted in the local area. Species for which no source is cited are included on the basis of the literature and interpretation of the environment. Sources of information are:

- ALA = Atlas of Living Australia, searched July 2021;
- NM = Naturemap Database, searched July 2021;
- EPBC = EPBC Protected Matters, searched July 2021;
- BA = Birdlife Australia's Birdata database, searched July 2021;
- BCE = BCE surveys undertaken previously in the general area (BCE database records 1981 to 2018, including Harris *et al.* (2008), Metcalf and Bamford (2008), Bamford (2009), Bamford (2012), Everard and Bamford (2014), Bamford *et al.* (2015), Bamford and Chuk 2015-2017). Note that BCE records from the Arrowsmith North project area (surveys for Tronox (Metcalf and Bamford 2008) and acquired during surveys in 2018/19 are indicated in **bold**. These species (in bold) have thus been recorded on the project area).
- Site visits = species observed during the two site visits to the project area (September 2021). Species seen in the actual project area in bold; other seen nearby (within c. 5km) not in bold.

Conservation significance (CS) codes are:

- CS1, CS2, CS3 = (summary) levels of conservation significance. See Appendix 3 for full explanation.
- EPBC Act listings: Cr = Critically Endangered, E = Endangered, V = Vulnerable, Mig = Migratory (see Appendix 3).
- Biodiversity Conservation Act listings: for all CS1 species S1 to 7 = Schedules 1 to 7 respectively, (see Appendix 3).
- DBCA Priority species: P1 to P4 = Priority 1 to 4 (see Appendix 3).

Int = introduced species. LEx = locally extinct. Ex = species is extinct.

INVERTEBRATES	CS	ALA	N	EPBC	BCE	Site visit	Expected status in project area
GASTROPODA							
A bothriembryontid land snail (Moore River) <i>Bothriembryon perobesus</i>	P1						Uncertain
ARACHNIDA							
Trapdoor Spider <i>Idiosoma arenaceum</i>	CS3						Uncertain
Kwongan Heath Shield-Backed Trapdoor Spider <i>Idiosoma kwongan</i>	P1						Resident
Trapdoor Spider <i>Idiosoma sp.</i>	P1				X	X	Resident
DIPLOPODA							
Millipede <i>Antichiropus 'DIP076 houstoni'</i>					X	X	Resident

Millipede	<i>Antichiropus Eneabba 1</i>	CS3				X		Resident
MALACOSTRACA								
Slater	<i>Buddelundia callosa</i>						X	Resident
INSECTA								
Thorny Bush Katydid (Moora)	<i>Hemisaga vepreculae</i>	P2						Uncertain
Springtime Corroboree Stick Katydid	<i>Phasmodes jeeba</i>	P3		X				Uncertain
Woollybush Bee	<i>Hylaeus globuliferus</i>	P3						Uncertain
Total Number of Species Expected:	9	7					3	

Note: The invertebrate tables only lists conservation significant species and species which were recorded during surveys.

FROGS	CS	ALA	N	EPBC	BCE	Site visit	Expected status in project area
HYLIDAE							
Slender Tree Frog	<i>Litoria adelaidensis</i>	X			X		Resident
Motorbike Frog	<i>Litoria moorei</i>	X			X		Resident
LIMNODYNASTIDAE							
Western Spotted Frog	<i>Heleioporus albopunctatus</i>				X		Resident
Moaning Frog	<i>Heleioporus eyrei</i>	X	X		X		Resident
Sand Frog	<i>Heleioporus psammophilus</i>				X		Resident
Banjo Frog	<i>Limnodynastes dorsalis</i>				X		Resident
Humming Frog	<i>Neobatrachus pelobatoides</i>	X	X		X		Resident
MYOBATRACHIDAE							
False Western Froglet	<i>Crinia pseudinsignifera</i>				X	X	Resident
Turtle Frog	<i>Myobatrachus gouldii</i>	X	X		X		Resident
Gunther's Toadlet	<i>Pseudophryne guentheri</i>	X	X		X		Resident
Number of Species Expected:	10	0					

REPTILES	CS	ALA	N	EPBC	BCE	Site visit	Expected status in project area
AGAMIDAE							
Western Heath Dragon		X	X		X		Resident
Spotted Military Dragon		X	X		X		Resident
Thorny Devil		X			X		Resident
Dwarf Bearded Dragon		X	X		X		Resident
DIPLODACTYLIDAE							
South-Western Clawless Gecko					X		Resident
Western Stone Gecko					X		Resident
Spotted Sandplain Gecko		X			X		Resident
White-spotted Ground Gecko					X		Resident
South-western Spiny-tailed Gecko		X	X		X		Resident
GEKKONIDAE							
Tree Dtella		X	X		X		Resident
PYGOPODIDAE							
Sedgeland's Worm-Lizard					X		Resident
Javelin Legless Lizard					X		Resident
Fraser's Delma					X		Resident
Side-barred Delma		X			X		Resident
Burton's Snake-Lizard		X	X		X		Resident
Keeled Legless-Lizard							Resident
Common Scaly-foot		X	X		X		Resident
SCINCIDAE							
Buchanan's Snake-eyed Skink		X	X		X		Resident
West-coast Ctenotus			X		X		Resident
Odd-striped Ctenotus					X		Resident
Leopard Ctenotus		X	X		X		Resident
					X		Resident

REPTILES		CS	ALA	N	EPBC	BCE	Site visit	Expected status in project area
	<i>Lerista christinae</i>					X		Resident
Elegant Slider	<i>Lerista elegans</i>		X	X		X		Resident
Dotted-Line Robust Slider	<i>Lerista lineopunctulata</i>		X	X				Resident
Blunt-Tailed West-Coast Slider	<i>Lerista praepedita</i>		X	X		X		Resident
Southern Sand-skink	<i>Liopholis multiscutata</i>			X		X		Resident
Common Dwarf Skink	<i>Menetia greyii</i>		X	X		X		Resident
West Coast Morethia Skink	<i>Morethia lineocellata</i>							Resident
Shrubland Morethia Skink	<i>Morethia obscura</i>					X		Resident
Western Blue-tongue	<i>Tiliqua occipitalis</i>		X	X		X		Resident
Bobtail	<i>Tiliqua rugosa</i>		X	X		X		Resident
VARANIDAE								
Gould's Goanna	<i>Varanus gouldii</i>		X	X		X		Resident
Black-Headed Monitor	<i>Varanus tristis</i>					X		Resident
TYPHLOPIDAE								
Southern Blind Snake	<i>Anilius australis</i>		X					Resident
Beaked Blind Snake	<i>Anilius waitii</i>							Resident
PYTHONIDAE								
Children's (Stimson's) Python	<i>Antaresia childreni</i>							Resident
Woma	<i>Aspidites ramsayi</i>	P1						Locally extinct?
Carpet Python	<i>Morelia spilota imbricata</i>	CS3						Resident
ELAPIDAE								
Narrow-banded Shovel-nosed Snake	<i>Brachyuropis fasciolata</i>							Resident
Southern Shovel-nosed Snake	<i>Barchyuropis semifasciata</i>							Resident
Yellow-Faced Whip Snake	<i>Demansia psammophis</i>					X		Resident
Bardick	<i>Echiopsis curta</i>		X	X		X		Resident
Black-naped Snake	<i>Neelaps bimaculata</i>							Resident

REPTILES		CS	ALA	N	EPBC	BCE	Site visit	Expected status in project area
Black-striped Snake	<i>Neelaps calonotos</i>	P2		X		X		Resident
Gould's Hooded Snake	<i>Parasuta gouldii</i>					X		Resident
King Brown (Mulga) Snake	<i>Pseudechis australis</i>					X		Resident
Western Brown Snake	<i>Pseudonaja mengdeni</i>		X	X		X		Resident
Jan's Banded Snake	<i>Simoselaps bertholdi</i>					X		Resident
Number of Species Expected:	48	2						

BIRDS		CS	ALA	N	EPBC	BA	BCE	Site visit	Expected status in project area
CASUARIIDAE									
Emu	<i>Dromaius novaehollandiae</i>		X	X		X	X		Resident
MEGAPODIDAE									
Malleefowl	<i>Leipoa ocellata</i>	V S3		X	X				Irregular visitor
PHASIANIDAE									
Stubble Quail	<i>Coturnix pectoralis</i>						X		Resident
TURNICIDAE									
Painted Button-quail	<i>Turnix varius</i>						X		Resident
Little Button-quail	<i>Turnix velox</i>						X		Irregular visitor
COLUMBIDAE									
Rock Pigeon	<i>Columba livia</i>	Int.	X		X		X		Vagrant
Crested Pigeon	<i>Ocyphaps lophotes</i>		X	X		X	X		Resident
Common Bronzewing	<i>Phaps chalcoptera</i>		X	X		X	X		Resident
Brush Bronzewing	<i>Phaps elegans</i>			X		X	X		Resident
Laughing Dove	<i>Streptopelia senegalensis</i>	Int.	X		X	X	X		Regular visitor
CUCULIDAE									
Fan-tailed Cuckoo	<i>Cacomantis flabelliformis</i>		X	X		X	X		Regular migrant
Pallid Cuckoo	<i>Cacomantis pallidus</i>		X	X		X	X		Regular migrant

BIRDS		CS	ALA	N	EPBC	BA	BCE	Site visit	Expected status in project area
Horsfield's Bronze-Cuckoo	<i>Chrysococcyx basalis</i>		X	X		X	X		Regular migrant
Shining Bronze-Cuckoo	<i>Chrysococcyx lucidus</i>		X			X	X		Regular migrant
Black-eared Cuckoo	<i>Chalcites osculans</i>				X	X			Vagrant
APODIDAE									
Fork-tailed Swift	<i>Apus pacificus</i>	M S5	X	X	X	X			Regular migrant
RALLIDAE									
Buff-banded Rail	<i>Gallirallus philippensis</i>						?		Irregular visitor
Black-tailed Native-hen	<i>Tribonyx ventralis</i>		X	X		X			Irregular visitor
CHARADRIIDAE									
Black-fronted Dotterel	<i>Euseyornis melanops</i>					X	X		Irregular visitor
Banded Lapwing	<i>Vanellus tricolor</i>		X	X		X	X		Irregular visitor
OTIDIDAE									
Australian Bustard	<i>Ardeotis australis</i>		X	X					Irregular visitor
ACCIPTRIDAE									
Brown Goshawk	<i>Accipiter fasciatus</i>		X	X		X	X		Regular visitor
Collared Sparrowhawk	<i>Accipiter cirrocephalus</i>		X	X		X	X		Resident
Wedge-tailed Eagle	<i>Aquila audax</i>		X	X		X	X		Regular visitor
Swamp Harrier	<i>Circus approximans</i>								Irregular visitor
Spotted Harrier	<i>Circus assimilis</i>		X				X		Regular visitor
Black-shouldered Kite	<i>Elanus axillaris</i>		X	X		X	X		Regular visitor
Whistling Kite	<i>Haliastur sphenurus</i>		X			X	X		Regular visitor
Little Eagle	<i>Hieraetus morphnoides</i>		X	X		X	X		Regular visitor
Square-tailed Kite	<i>Lophoictinia isura</i>						X		Irregular visitor
Black Kite	<i>Milvus migrans</i>						X		Vagrant
FALCONIDAE									
Brown Falcon	<i>Falco berigora</i>			X		X	X		Resident
Nankeen Kestrel	<i>Falco cenchroides</i>		X	X		X	X		Regular visitor

BIRDS	CS	ALA	N	EPBC	BA	BCE	Site visit	Expected status in project area
Australian Hobby <i>Falco longipennis</i>			X		X	X		Regular visitor
Peregrine Falcon <i>Falco peregrinus</i>	S7	X	X		X	X		Irregular visitor
STRIGIDAE								
Southern Boobook <i>Ninox novaeseelandiae</i>		X			X			Resident
TYTONIDAE								
Barn Owl <i>Tyto alba</i>						X		Regular visitor
PODARGIDAE								
Tawny Frogmouth <i>Podargus strigoides</i>		X	X	X		X		Resident
CAPRIMULGIDAE								
Spotted Nightjar <i>Eurostopodus argus</i>						X		Regular visitor
AEGOTHELIDAE								
Australian Owlet-nightjar <i>Aegotheles cristatus</i>				X				Irregular visitor
MEROPIDAE								
Rainbow Bee-eater <i>Merops ornatus</i>	CS3	X	X	X	X	X		Regular migrant
ALCEDINIDAE								
Laughing Kookaburra <i>Dacelo novaeguineae</i>	Int.	X	X		X	X		Irregular visitor
Red-backed Kingfisher <i>Todiramphus pyrrhopygius</i>						X		Irregular visitor
Sacred Kingfisher <i>Todiramphus sanctus</i>		X	X		X	X		Regular migrant
CACATUIDAE								
Western Corella <i>Cacatua pastinator</i>						X		Regular visitor
Little Corella <i>Cacatua sanguinea</i>		X	X		X			Irregular visitor
Carnaby's Black-Cockatoo <i>Calyptorhynchus latirostris</i>	E S2	X	X	X	X	X		Regular migrant
Red-tailed Black-Cockatoo (inland subspecies) <i>Calyptorhynchus banksii escondidus</i>			X					Irregular visitor
Galah <i>Eolophus roseicapillus</i>		X	X		X	X	X	Regular visitor
Cockatiel <i>Nymphicus hollandicus</i>		X				X		Vagrant
PSITTACIDAE								
Australian Ringneck <i>Barnardius zonarius</i>		X	X		X	X	X	Resident

BIRDS	CS	ALA	N	EPBC	BA	BCE	Site visit	Expected status in project area
Regent Parrot <i>Polytelis anthopeplus</i>		X						Vagrant
Budgerigar <i>Melopsittacus undulatus</i>		X	X		X	X		Vagrant
Western Ground Parrot <i>Pezoporus flaviventris</i>	Cr S1							Locally extinct?
Elegant Parrot <i>Neophema elegans</i>		X	X		X	X		Regular visitor
Scarlet-chested Parrot <i>Neophema splendida</i>						X		Vagrant
MALURIDAE								
Purple-backed (Variegated) Fairy-wren <i>Malurus assimilis</i>		X				X		Resident
Blue-Breasted Fairy-wren <i>Malurus pulcherrimus</i>		X	X		X	X		Resident
Splendid Fairy-wren <i>Malurus splendens</i>		X	X		X	X		Resident
White-winged Fairy-wren <i>Malurus leucopterus</i>		X	X		X	X		Resident
Southern Emu-wren <i>Stipiturus malachurus</i>						X		Resident
MELIPHAGIDAE								
Spiny-cheeked Honeyeater <i>Acanthagenys rufogularis</i>		X	X		X	X		Regular visitor
Western Spinebill <i>Acanthorhynchus superciliosus</i>		X	X		X			Resident
Western Wattlebird <i>Anthochaera lunulata</i>		X	X		X	X		Regular visitor
Red Wattlebird <i>Anthochaera carunculata</i>		X	X		X	X		Regular visitor
Pied Honeyeater <i>Certhionyx variegatus</i>						X		Irregular visitor
White-fronted Chat <i>Epthianura albifrons</i>		X	X		X	X		Irregular visitor
Crimson Chat <i>Epthianura tricolor</i>		X	X		X	X		Irregular visitor
Tawny-crowned Honeyeater <i>Gliciphila melanops</i>		X	X		X	X		Regular visitor
Singing Honeyeater <i>Lichenostomus virescens</i>		X			X	X		Resident
Brown Honeyeater <i>Lichmera indistincta</i>		X	X		X	X		Resident
Yellow-throated Miner <i>Manorina flavigula</i>		X	X		X	X		Regular visitor
Brown-headed Honeyeater <i>Melithreptus brevirostris</i>		X	X		X	X		Regular visitor
White-cheeked Honeyeater <i>Phylidonyris niger</i>		X	X		X	X		Resident
New Holland Honeyeater <i>Phylidonyris novaehollandiae</i>		X	X		X	X		Irregular visitor

BIRDS	CS	ALA	N	EPBC	BA	BCE	Site visit	Expected status in project area
White-fronted Honeyeater <i>Purnella albifrons</i>		X	X		X	X		Vagrant
Black Honeyeater <i>Sugomel niger</i>		X				X		Irregular visitor
PARDALOTIDAE								
Striated Pardalote <i>Pardalotus striatus</i>		X	X		X	X		Regular visitor
Spotted Pardalote <i>Pardalotus punctatus</i>		X	X		X	X		Irregular visitor
ACANTHIZIDAE								
Inland Thornbill <i>Acanthiza apicalis</i>		X	X		X	X		Resident
Yellow-rumped Thornbill <i>Acanthiza chrysorrhoa</i>		X	X		X	X		Resident
Western Thornbill <i>Acanthiza inornata</i>		X				X		Resident
Rufous Fieldwren <i>Calamanthus campestris</i>	CS3		X			X		Resident
Shy Heathwren <i>Calamanthus cautus</i>	CS3				X	X		Irregular visitor
Western Gerygone <i>Gerygone fusca</i>		X	X		X	X		Regular visitor
White-browed Scrubwren <i>Sericornis frontalis</i>		X	X		X	X		Resident
Weebill <i>Smicronis brevirostris</i>		X	X		X	X		Resident
POMATOSTOMIDAE								
White-browed Babbler <i>Pomatostomus superciliosus</i>	CS3	X	X		X	X		Irregular visitor
CAMPEPHAGIDAE								
Black-faced Cuckoo-shrike <i>Coracina novaehollandiae</i>		X	X		X	X		Regular visitor
White-winged Triller <i>Lalage sueurii</i>		X			X	X		Regular visitor
PACHYCEPHALIDAE								
Grey Shrike-thrush <i>Colluricincla harmonica</i>		X	X		X	X		Resident
Rufous Whistler <i>Pachycephala rufiventris</i>		X	X		X	X		Resident
Western Whistler <i>Pachycephala occidentalis</i>		X			X	X		Irregular visitor
OREOICIDAE								
Crested Bellbird <i>Oreoica gutturalis</i>		X	X		X	X		Resident
ARTAMIDAE								
Black-faced Woodswallow <i>Artamus cinereus</i>		X	X		X	X		Regular visitor

BIRDS	CS	ALA	N	EPBC	BA	BCE	Site visit	Expected status in project area
Dusky Woodswallow <i>Artamus cyanopterus</i>		X	X		X	X		Irregular visitor
Masked Woodswallow <i>Artamus personatus</i>		X				X		Vagrant
Pied Butcherbird <i>Cracticus nigrogularis</i>		X	X		X	X		Resident
Australian Magpie <i>Cracticus tibicen</i>		X	X		X	X		Resident
Grey Butcherbird <i>Cracticus torquatus</i>		X	X		X	X		Resident
Grey Currawong <i>Strepera versicolor</i>		X	X		X	X		Irregular visitor
RHIPIDURIDAE								
Grey Fantail <i>Rhipidura albiscapa</i>		X	X		X	X		Regular visitor
Willie Wagtail <i>Rhipidura leucophrys</i>		X	X		X	X		Resident
CORVIDAE								
Little Crow <i>Corvus bennetti</i>		X	X		X	X		Regular visitor
Australian Raven <i>Corvus coronoides</i>		X	X		X	X		Resident
MONARCHIDAE								
Magpie-Lark <i>Grallina cyanoleuca</i>		X	X		X	X		Regular visitor
Restless Flycatcher <i>Myiagra inquieta</i>			X			X		Vagrant
PETROICIDAE								
Southern Scrub-robin <i>Drymodes brunneopygia</i>		X	X		X	X		Irregular visitor
White-breasted Robin <i>Eopsaltria georgiana</i>		X	X		X	X		Resident
Hooded Robin <i>Melanodryas cucullata</i>		X			X	X		Resident
Red-capped Robin <i>Petroica goodenovii</i>		X	X		X	X		Resident
NECTARINIIDAE								
Mistletoebird <i>Dicaeum hirundinaceum</i>		X	X		X	X		Regular visitor

ESTRILDIDAE								
Zebra Finch <i>Taeniopygia guttata</i>		X				X		Irregular visitor
MOTACILLIDAE								
Australian Pipit <i>Anthus novaeseelandiae</i>		X			X	X		Resident

BIRDS	CS	ALA	N	EPBC	BA	BCE	Site visit	Expected status in project area
MEGALURIDAE								
Brown Songlark <i>Cincloramphus cruralis</i>		X			X	X		Irregular visitor
Rufous Songlark <i>Cincloramphus mathewsi</i>		X			X	X		Regular visitor
HIRUNDINIDAE								
White-backed Swallow <i>Cheramoeca leucosterna</i>		X	X		X	X		Regular visitor
Welcome Swallow <i>Hirundo neoxena</i>		X	X		X	X		Regular visitor
Fairy Martin <i>Petrochelidon ariel</i>		X	X		X	X		Regular visitor
Tree Martin <i>Petrochelidon nigricans</i>		X	X		X	X		Regular visitor
ZOSTEROPIDAE								
Silvereye <i>Zosterops lateralis</i>		X	X		X	X		Regular visitor
Total Number of Species Expected:	120	8						

MAMMALS	CS	ALA	N	EPBC	BCE	Site visit	Expected status in project area
TACHYGLOSSIDAE							
Short-Beaked Echidna <i>Tachyglossus aculeatus</i>					X		Resident
DASYURIDAE							
Chuditch <i>Dasyurus geoffroii</i>	V S3			X			Locally extinct
Dibbler <i>Parantechinus apicalis</i>	E S2			X			Locally extinct
Little Dunnart <i>Sminthopsis aff. dolichura</i>					X		Resident
Fat-tailed Dunnart <i>Sminthopsis crassicaudata</i>							Regular visitor
Grey-bellied Dunnart <i>Sminthopsis fuliginosa</i>							Resident
White-tailed Dunnart <i>Sminthopsis granulipes</i>					X		Resident
THYLACOMYIDAE							
Greater Bilby <i>Macrotis lagotis</i>	V S3						Locally extinct
PERAMELIDAE							
Boodie <i>Bettongia lesueur</i>	V S2						Locally extinct
Quenda <i>Isoodon fusciventer</i>	P4						Locally extinct
Western Barred Bandicoot <i>Perameles bougainville</i>	E S3						Locally extinct

MAMMALS	CS	ALA	N	EPBC	BCE	Site visit	Expected status in project area
TARSIPEDIDAE							
Honey Possum <i>Tarsipes rostratus</i>					X		Resident
PHALANGERIDAE							
Australian Brushtail Possum <i>Trichosurus vulpecula</i>	CS3				X		Locally extinct?
POTOROIDAE							
Woylie <i>Bettongia penicillata</i>	E S1						Locally extinct
MACROPODIDAE							
Tammar Wallaby <i>Macropus eugenii</i>	P4						Locally extinct
Western Grey Kangaroo <i>Macropus fuliginosus</i>		X	X		X		Resident
Banded Hare-Wallaby <i>Lagostrophus fasciatus</i>	V S3						Locally extinct
Brush Wallaby <i>Notamacropus irma</i>	P4		X		X		Resident
MEGADERMATIDAE							
Ghost Bat <i>Macroderma gigas</i>	V S3						Locally extinct
MOLOSSIDAE							
White-striped Freetail-Bat <i>Austronomus australis</i>					X		Regular visitor
VESPERTILIONIDAE							
Gould's Wattled Bat <i>Chalinolobus gouldii</i>					X		Regular visitor
Chocolate Wattled Bat <i>Chalinolobus morio</i>		X	X		X		Regular visitor
Lesser Long-eared Bat <i>Nyctophilus geoffroyi</i>					X		Regular visitor
Southern Forest Bat <i>Vespadelus regulus</i>					X		Regular visitor
MURIDAE							
Noodji <i>Pseudomys albocinereus</i>					X		Resident
Shark Bay Mouse, Djoongarri <i>Pseudomys fieldi</i>	V S3						Locally extinct
Moodit <i>Rattus fuscipes</i>			X		X		Resident
Pale Field Rat <i>Rattus tunneyi</i>							Locally extinct
Number of native species expected (not including locally extinct): 15	1						
INTRODUCED MAMMALS							
Dog, Dingo <i>Canis lupus familiaris</i>	Int.	X		X	X		Irregular visitor
Goat <i>Capra hircus</i>	Int.	X	X	X	X		Regular visitor
Horse <i>Equus caballus</i>	Int.				X		Vagrant

MAMMALS	CS	ALA	N	EPBC	BCE	Site visit	Expected status in project area
Cat <i>Felis catus</i>	Int.	X	X	X	X		Resident
House Mouse <i>Mus musculus</i>	Int.	X	X	X	X		Resident
Rabbit <i>Oryctolagus cuniculus</i>	Int.		X	X	X		Resident
Black Rat <i>Rattus rattus</i>	Int.		X		X		Irregular visitor
Pig <i>Sus scrofa</i>	Int.			X			Irregular visitor
Red Fox <i>Vulpes vulpes</i>	Int.	X	X	X	X		Resident
Number of introduced mammals:	9						

6.7 Appendix 7. Species recorded in the field investigations (September 2021).

Species	2021 Annotations
Trapdoor Spider <i>Idiosoma sp.</i>	Specimens collected
Millipede <i>Antichiropus</i> 'DIP076 houstoni'	Specimens collected
Slater <i>Buddelundia callosa</i>	Specimens collected
Pink and Grey Galah	Recorded visiting hollows in Wandoos outside project area
Australian Ringneck	Recorded visiting hollows in Wandoos outside project area

6.8 Appendix 8. Species returned in database searches but unlikely to occur in the project area

Database searches often return species found nearby but that are unlikely to be present in the project area due to lack of suitable habitat (e.g. marine species) or ecological barriers preventing them from reaching the area (e.g. island species). There are also some errors, out-of-date Latin names, zoo specimens and subtleties of distribution that are not recognised in databases. The species listed below are considered highly unlikely to be found in the project area (although some bird species could occur as very rare vagrants, such as marine species flying overhead).

Species	
ARACHNIDA	
Shield-backed Trapdoor Spider	<i>Idiosoma nigrum</i>
FISH	
Twospot Goby	<i>Eviota bimaculata</i>
Black-throated Threefin	<i>Helcogramma decurrens</i>
Many-spotted Blenny	<i>Laiphognathus multimaculatus</i>
Yellow-striped Leatherjacket	<i>Meuschenia flavolineata</i>
Wavy Grubfish	<i>Parapercis haackei</i>
Miller's Damselfish	<i>Pomacentrus milleri</i>
Yellowfin Dottyback	<i>Pseudochromis wilsoni</i>
Western Red Scorpionfish	<i>Scorpaena sumptuosa</i>
Viviparous Brotula	<i>Zephyrichthys barryi</i>
Green Swordtail	<i>Xiphophorus helleri</i>
Western Minnow	<i>Galaxias occidentalis</i>
Western Pygmy-perch	<i>Edelia (Nannoperca) vittata</i>
Swan River Goby	<i>Pseudogobius olorum</i>
REPTILES	
Flat-shelled Tortoise	<i>Chelodina steindachneri</i>
South-West Long-necked Tortoise	<i>Chelodina oblonga</i>
Central Netted Dragon	<i>Ctenophorus nuchalis</i>
	<i>Lerista planiventralis decora</i>
Goldfields Pebble-mimic Dragon	<i>Tympanocryptis pseudopsephos</i>
Bar-Shouldered Ctenotus	<i>Ctenotus inornatus</i>
Western Spiny-tailed Skink	<i>Egernia stokesii badia</i>
Western Slender Blue-tongue	<i>Cyclodomorphus celatus</i>
BIRDS	
Brown Quail	<i>Coturnix ypsilophora</i>
Black Swan	<i>Cygnus atratus</i>
Australian Shelduck	<i>Tadorna tadornoides</i>
Australasian Shoveler	<i>Anas rhynchotis</i>
Pacific Black Duck	<i>Anas superciliosus</i>
Grey Teal	<i>Anas gracilis</i>
Australian Wood Duck	<i>Chenonetta jubata</i>
Musk Duck	<i>Biziura lobata</i>
Hoary-headed Grebe	<i>Poliiocephalus poliocephalus</i>

Species	
Australasian Grebe	<i>Tachybaptus novaehollandiae</i>
Baudin's Black-Cockatoo	<i>Calyptorhynchus baudinii</i>
Straw-necked Ibis	<i>Threskiornis spinicollis</i>
Gull-billed Tern	<i>Gelochelidon nolitica</i>
Fairy Tern	<i>Sternula nereis</i>
Inland Dotterel	<i>Charadrius australis</i>
Red-capped Plover	<i>Charadrius ruficapillus</i>
Bar-tailed Godwit	<i>Limosa lapponica</i>
Red-necked Stint	<i>Calidris ruficollis</i>
Common Sandpiper	<i>Actitis hypoleucos</i>
Sharp-tailed Sandpiper	<i>Calidris acuminata</i>
Red Knot	<i>Calidris canutus</i>
Curlew Sandpiper	<i>Calidris ferruginea</i>
Pectoral Sandpiper	<i>Calidris melanotos</i>
Eastern Curlew	<i>Numenius madagascariensis</i>
Common Greenshank	<i>Tringa nebularia</i>
Australian Painted-snipe	<i>Rostratula australis</i>
Eurasian Coot	<i>Fulica atra</i>
White-necked Heron	<i>Ardea pacifica</i>
White-faced Heron	<i>Ardea novaehollandiae</i>
Eastern Great Egret	<i>Ardea modesta</i>
Eastern Reef Egret	<i>Egretta sacra</i>
Cattle Egret	<i>Ardea ibis</i>
Little Pied Cormorant	<i>Microcarbo melanoleucos</i>
Black Cormorant	<i>Phalacrocorax carbo</i>
Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>
Pied Cormorant	<i>Phalacrocorax varius</i>
Australasian Darter	<i>Anhinga novaehollandiae</i>
Letter-winged Kite	<i>Elanus scriptus</i>
Eastern Osprey	<i>Pandion cristatus</i>
Osprey	<i>Pandion haliaetus</i>
Black-breasted Buzzard	<i>Hamirostra melanosternon</i>
White-bellied Sea-Eagle	<i>Haliaeetus leucogaster</i>
Grey Wagtail	<i>Motacilla cinerea</i>
Chestnut-rumped Thornbill	<i>Acanthiza uropygialis</i>
Redthroat	<i>Pyrrholaemus brunneus</i>
White-plumed honeyeater	<i>Ptilotula penicillata</i>
Jacky Winter	<i>Microeca fascinans</i>
Western Yellow Robin	<i>Eopsaltria griseogularis</i>
Eurasian Tree Sparrow	<i>Passer montanus</i>
Australian Reed-Warbler	<i>Acrocephalus australis</i>
Red Kangaroo	<i>Osphranter rufus</i>
Rakali or Water-Rat	<i>Hydromys chrysogaster</i>