Hastings Technology Metals Ltd
Onslow Rare Earth Plant
Fauna Assessment

Spotted Monitor (*Varanus panoptes*) in the Alternative B (Lot 500) area. Photo: M. Bamford

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Executive Summary

Bamford Consulting Ecologists (BCE) was commissioned by Hastings Technology Metals Ltd (Hastings) to conduct a Basic (*sensu* EPA 2020) fauna assessment (desktop review and site inspection) of the Onslow Rare Earths Plant, located within the Ashburton North Strategic Industrial Area (ANSIA) near Onslow. The purposes of this report are to provide information on the fauna values of the project area, an overview of the ecological function of the site within the local and regional context, and to provide discussion on the interaction of proposed 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).

Description of project area

Considerations for the Onslow Rare Earths Plant comprises four land parcels that, together, make up the project area (totalling 289.2 ha): The preferred Onslow Rare Earths Plant site (c. 100.3 ha; within Lot 252) and three alternative locations (ranging between 44.5 and 98.7 ha).

The project area is located in the Cape Range (CAR01) subregion of the Carnarvon bioregion, and it falls across the Dune and Onslow Land systems of Payne (2004). The project area sits within the Ashburton North Strategic Industrial Area (ANSIA). There are no known Ramsar Sites, Important Wetlands, Threatened Ecological Communities, Bush Forever Sites, Key Biodiversity Areas or Environmentally Sensitive Areas within the project area.

Key fauna values

Vegetation and Substrate Associations (VSAs) that provide habitat for fauna. Four major Vegetation and Substrate Associations were identified in the project area: Undulating dunes (VSA 1), Sandy loam

flats (VSA 2), Claypans (VSA 3) and Outcropping limestone (VSA 4). The proposed Onslow Rare Earths Plant site supported three VSAs: VSA 1, VSA 2 and VSA 3.

Fauna assemblage. The desktop study identified 303 vertebrate fauna species as potentially occurring in the project area (7 frogs, 89 reptiles, 166 birds and 41 mammals). The presence of at least 20 species (four reptiles, 15 birds and one mammal) was confirmed during the 2020 site inspection. The fauna assemblage is moderately intact but with a suite of mammal species locally extinct. The assemblage is not particularly rich because the landscape provides a limited range of habitats, and includes a large proportion of visitors among the birds which may only be present during wet periods. The assemblage is distinctive in that it includes several reptile species that are restricted to sandy soils of the Great Onslow to Exmouth Gulf region.

Species of conservation significance. Three broad levels of conservation significance are used in this report:

- Conservation Significance 1 (CS1) – species listed under State or Commonwealth Acts.
- Conservation Significance 2 (CS2) – species listed as Priority by DBCA but not listed under State or Commonwealth Acts.
- 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.

Of the 42 species of conservation significance recorded or that may be present in the project area, only three are expected to occur as residents: *Lerista planiventralis maryani* (CS2), Flock Bronzewing (CS3) and Short-tailed Mouse (CS2). Only three conservation significant species are expected as regular visitors: Pilbara Olive Python (CS1), Barn Swallow (CS1) and Brush-tailed Mulgara (CS2). The remaining species are expected to be irregular visitors or vagrants; the majority of these are waterbirds that will visit the claypans when they flood. Waterbirds include migratory species but previous studies suggest only small numbers are likely to be present. No currently listed threatened or priority invertebrate fauna are expected to occur within the project area.

Patterns of biodiversity. VSA1 is likely to be richest in fauna species due to the soil type and structural complexity of vegetation. Areas of VSA1 with the greatest shrub development may be particularly rich. Claypans and chenopod shrublands (VSA 2) may not be rich in species, but can be expected to support a distinct assemblage. There are a few significant species with distinct patterns of distribution, including the lizard *L. planiventralis maryani* probably restricted to sandy soils in the north, and the Short-tailed Mouse restricted to heavy soils of VSA 2. Areas of termite mounds in VSA 2 are likely to support high richness and abundance of reptiles.

Key ecological processes. The ecological processes that currently have major effects upon the fauna assemblage include hydrology, the presence of feral species, fire, and habitat degradation (due to weeds).

Potential impacts upon fauna

Threatening processes reviewed in relation to the proposed development included: habitat loss, habitat fragmentation, degradation due to weed invasion, direct mortality, impacts of feral and overabundant native species, hydrological change, fire and disturbance (dust, noise and light). Potential impacts are considered to be minor because of the small areas involved and the fauna

assemblage being well-represented in the general region. However, while the Onslow Rare Earths Plant on its own represents Minor impacts, in combination with other developments it contributes to a Moderate impact on the regional fauna assemblage due to cumulative habitat loss.

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1 Introduction

Hastings Technology Metals Ltd (Hastings) is looking to develop a hydromet process plant (rare earths) and an evaporation pond (process plant waste liquor and gypsum) in Lot 152 within the Ashburton North Strategic Industrial Area (ANSIA), on the outskirts of Onslow (see Figure 1). While this is the preferred plant location, three alternative sites are being considered: a second site within Lot 152 (Alternative A), a site within the western half of Lot 500 (Alternative B) and a site within Lot 540 (Alternative C), as indicated in Figure 1.

Bamford Consulting Ecologists (BCE) was commissioned by Hastings to conduct a Basic (*sensu* EPA 2020) fauna assessment (desktop review and site inspection) of the Onslow Rare Earths Plant (encompassing those areas described above). This report presents the results of that fauna desktop review and site inspection.

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:

- 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).

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

1. Conduct a literature review and searches of Commonwealth and State fauna databases;
2. Review the list of fauna expected to occur on the site in the light of fauna habitats present, with a focus on investigating the likelihood of significant species being present;
3. Identify significant or fragile fauna habitats within the project area;

4. Identify any ecological processes in the project area upon which fauna may depend;
5. Identify general patterns of biodiversity within or adjacent to the project area, and
6. Identify potential impacts upon fauna and propose recommendations to minimise impacts.

Descriptions and background information on these values and processes can be found in Appendices 1 to 4. Based on this impact assessment process, the objectives of investigations are to: identify fauna values; review impacting processes with respect to these values and the proposed development; and provide recommendations to mitigate these impacts.

1.2 Description of project area and background environmental information

1.2.1 Project area

For spatial terminology (i.e. definitions of project, survey and study areas) see Section 2.1.1 below.

The Onslow Rare Earths Plant is investigating four areas totalling 289.2 ha, as listed in Table 1 and indicated in Figure 1. These areas, combined, make up the 'project area'. The field investigations in this environmental impact assessment were conducted within the project area only and, therefore, the 'survey area' and project area are treated as synonymous from hereon.

Table 1. Project areas.

Location	Approximate Area (Ha)
Preferred (proposed) Onslow Rare Earths Plant site (within Lot 152)	100.3
Alternative location A for the process plant (within Lot 152)	98.7
Alternative location B for the process plant (within Lot 500)	44.5
Alternative location C for the process plant (Lot 540)	45.7

1.2.2 Interim Biogeographic Regionalisation of Australia (IBRA) and landscape characteristics

The Interim Biogeographic Regionalisation of Australia (IBRA) has identified 26 bioregions in Western Australia which are further divided into subregions (DAWE 2020b). 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 2016c). The project area is within the Cape Range (CAR01) subregion of the Carnarvon bioregion, as mapped in Figure 2. This bioregion falls within the Bioregion Group 2 (Eremaean Botanical Province) classification of EPA (2016c) where "native vegetation is largely contiguous but used for commercial grazing".

The Carnarvon bioregion and Cape Range subregion are described by Kendrick and Mau (2003) and a summary of their work follows here. The Carnarvon bioregion is composed of quaternary alluvial, aeolian and marine sediments overlying Cretaceous strata. A mosaic of saline alluvial plains with samphire and saltbush low shrublands, Bowgada low woodland on sandy ridges and plains,

Snakewood scrub on clay flats, and tree to shrub steppe over hummock grasslands on and between red sand dune fields. Limestone strata with *Acacia stuartii* or *A. bivenosa* shrubland outcrop in the north, where extensive tidal flats in sheltered embayments support mangal.

Within the Cape Range (CAR01) subregion, Cape Range and Giralia dunefields form the northern part of Carnarvon Basin and support rugged tertiary limestone ranges and extensive areas of red aeolian dunefield, Quaternary coastal beach dunes and mud flats. Acacia shrublands over *Triodia* occur on limestone (*Acacia stuartii* or *A. bivenosa*) and red dunefields, *Triodia* hummock grasslands are associated with sparse Eucalyptus trees and shrubs on the Cape Range. Extensive hummock grasslands (*Triodia*) occur on the Cape Range and eastern dune-fields. Tidal mudflats of sheltered embayments of Exmouth Gulf support extensive mangroves. Beach dunes support *Spinifex* communities. An extensive mosaic of saline alluvial plains with samphire and saltbush low shrublands occur along the eastern hinterland of Exmouth Gulf. Islands of the Muiron, Barrow, Lowendal and Montebello groups are limestone-based.

1.2.3 Land systems

Payne (2004) identified 102 land systems for the Pilbara region, with the project area located across two of these:

- Dune Land System – Dune fields supporting soft spinifex grasslands; and
- Onslow Land System – Undulating sandplains, dunes and level clay plains supporting soft spinifex grasslands and minor tussock grasslands.

Both of these systems fall within Payne's (2004) broader 'Land Type' category number 19 (Coastal plains, dunes, mudflats and beaches with tussock grasslands, soft spinifex grasslands and halophytic shrublands). Land systems in the vicinity of the project area are mapped in Figure 3.

1.2.4 Land use and tenure

The dominant land uses within the Cape Range (CAR01) subregion are grazing – native pastures, conservation, mining leases, and urban (Kendrick and Mau 2003). The project area lies in the north-eastern and largely undeveloped sector of the subregion. At the local scale, the project area sits within the Ashburton North Strategic Industrial Area (ANSIA).

1.2.5 Recognised sensitive sites

There are no known Ramsar Sites (DBCA 2020d), Important Wetlands (DBCA 2020b), Threatened Ecological Communities (DBCA 2020e, f), Bush Forever Sites (Dell and Banyard 2000), Key Biodiversity Areas (KBA 2020) or Environmentally Sensitive Areas (DWER 2020a, b) within the project area.

1.2.6 Climate information

For the Eremaean Botanical Province, temperatures increase along a northward latitudinal gradient and rainfall is summer-dominated in the north and more evenly spread across the year in the south (EPA 2020). Episodic summer thunderstorms and rain-bearing depressions are key bioclimatic activators and hence drive vertebrate activity (EPA 2020).

For the Cape Range (CAR01) subregion, climate is arid, or semi-desert to sub-tropical, with variable summer and winter rainfall (Kendrick and Mau 2003). Cyclonic activity can be significant, and cyclonic systems may affect the coast and hinterland annually (Kendrick and Mau 2003).

Climate averages (temperate, rainfall, sunshine) for the project area, as provided by BOM (2020), are presented in Table 2.

Table 2. Climate averages for the project area.

Data from BOM (2020) for:
Site name = ONSLOW AIRPORT
Site number = 005017

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years	
Temperature															
Mean maximum temperature (°C)	36.4	36.4	36.2	34.0	29.4	26.1	25.5	27.4	30.2	33.0	34.4	36.0	32.1	55	1940 2020
Mean minimum temperature (°C)	24.5	25.0	24.3	21.5	17.4	14.4	13.1	13.6	15.5	18.0	20.1	22.4	19.2	54	1943 2020
Rainfall															
Mean rainfall (mm)	37.7	58.9	70.7	11.1	47.2	46.0	19.5	8.2	1.3	0.8	2.7	3.3	308.4	54	1940 2020
Decile 5 (median) rainfall (mm)	11.5	12.9	21.6	2.7	21.8	34.6	9.4	1.8	0.2	0.0	0.0	0.0	277.5	52	1940 2020
Mean number of days of rain ≥ 1 mm	2.3	2.8	2.2	1.0	2.5	2.4	1.5	0.9	0.3	0.1	0.3	0.4	16.7	51	1940 2020
Other daily elements															
Mean daily sunshine (hours)															
Mean number of clear days	15.8	11.2	16.4	14.6	15.1	17.1	19.5	22.1	23.7	24.8	22.4	20.9	223.6	35	1940 1975
Mean number of cloudy days	5.2	6.7	5.3	5.8	7.9	5.9	4.9	3.3	1.7	1.3	1.5	2.4	51.9	35	1940 1975

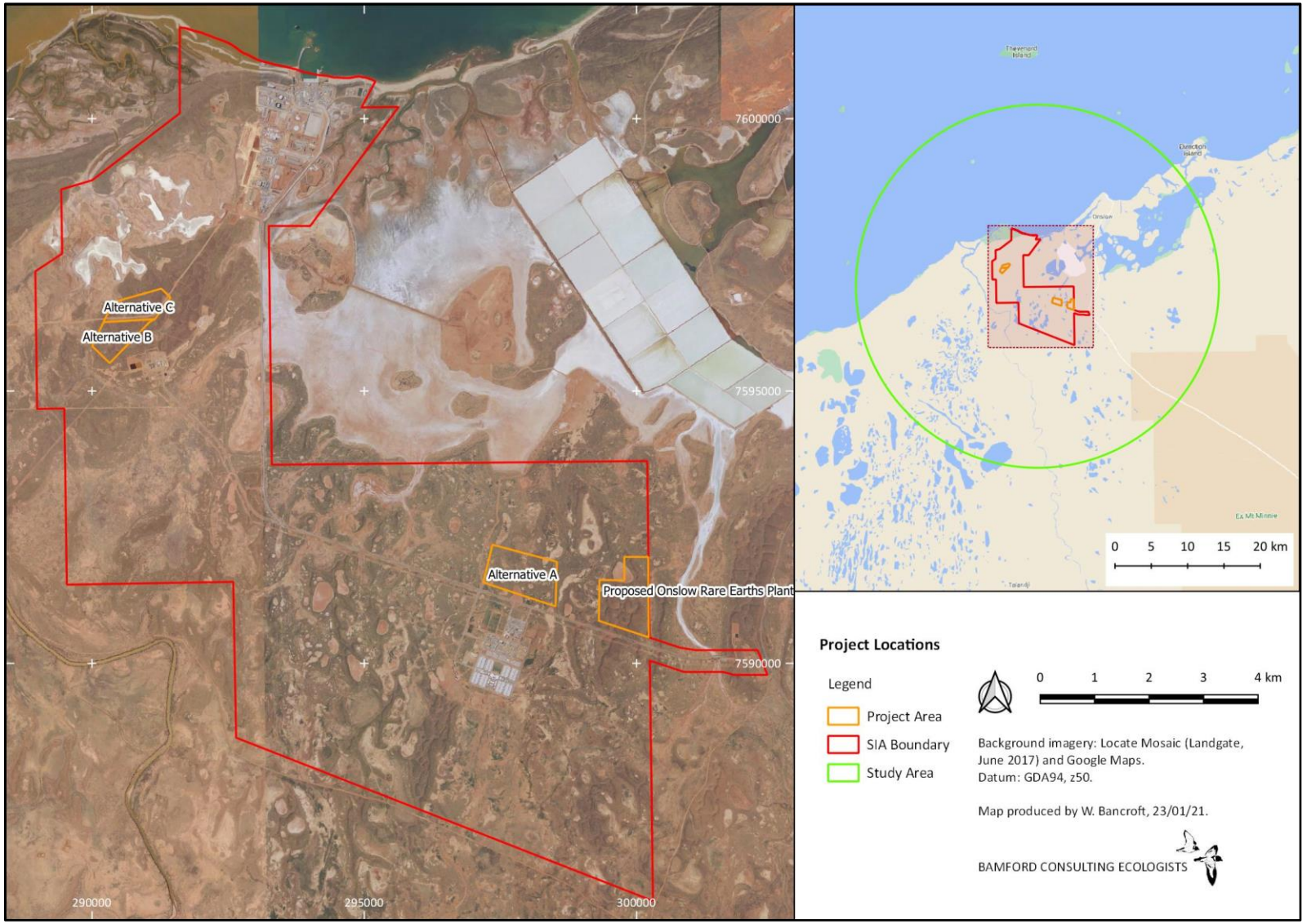

Figure 1. Location of the Onslow Rare Earths Plant site and alternative areas (A-C).

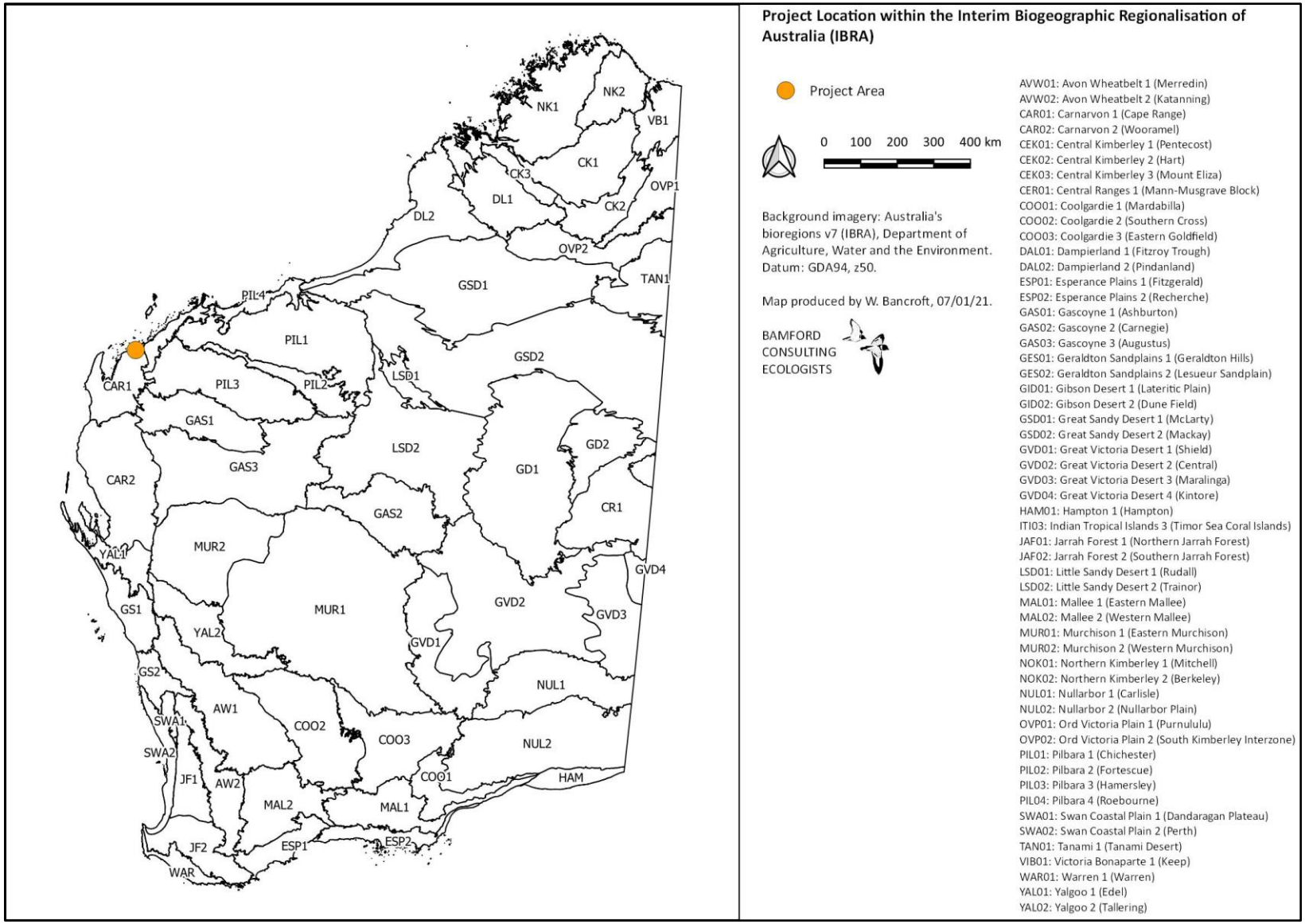

Figure 2. Project location within the Interim Biogeographic Regionalisation of Australia (IBRA).

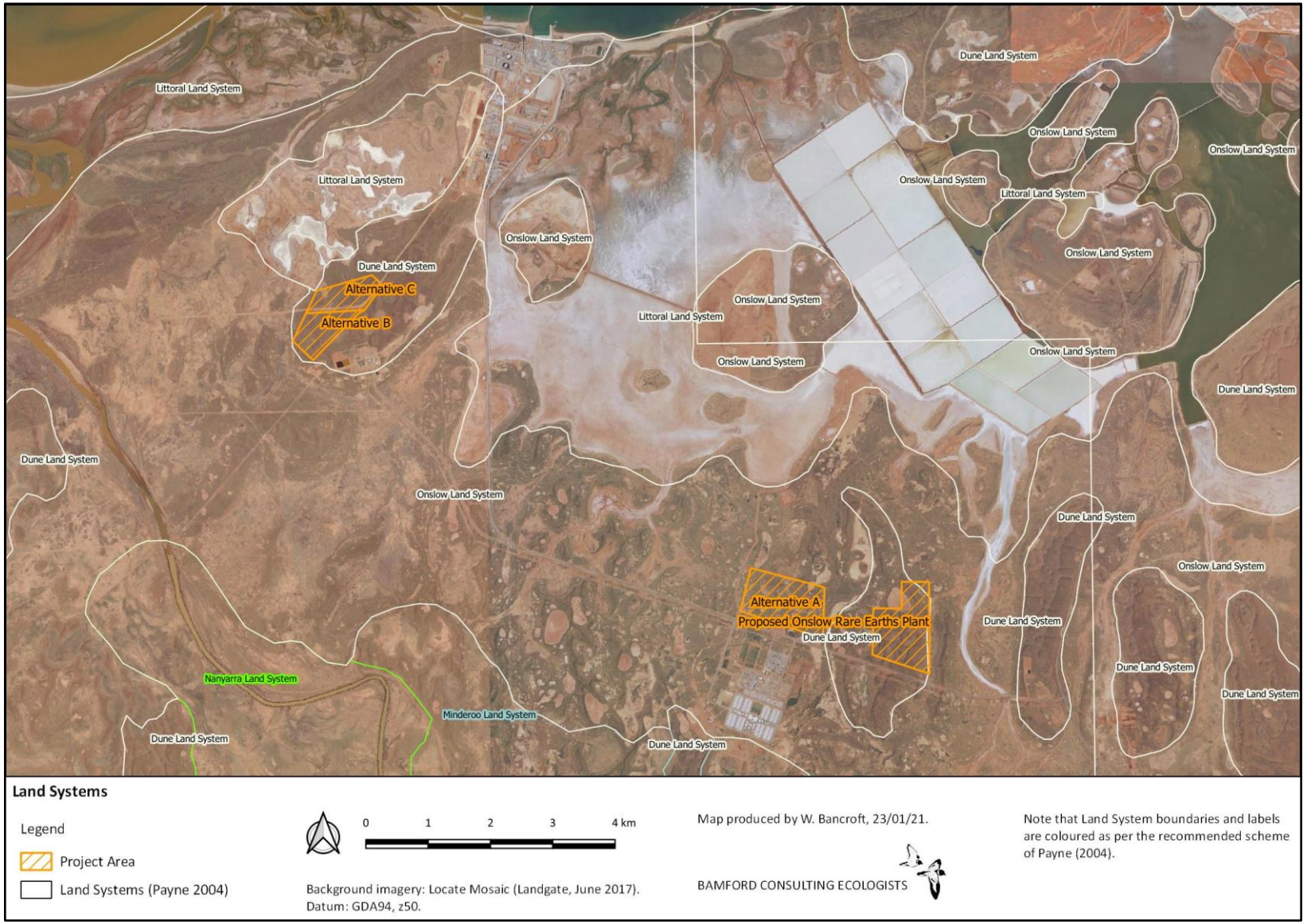

Figure 3. Land systems (Payne 2004) in the vicinity of the Onslow Rare Earths Plant.

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, b, 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.

Guidance for field investigations methods is provided by the EPA (2016c, 2020) and by Bamford *et al.* (2013).

A 'basic' level survey (desktop review, fauna habitat identification and a site inspection) is considered appropriate for the Onslow Rare Earths Plant. This is based upon the level of existing knowledge (which is extensive; see Section 2.3 below), the extent, distribution and significance of habitats (widespread) and the significance of species likely to be present (generally a limited assemblage of significant species).

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.

2.1.1 Spatial terminology

A range of terms are used through the report to refer to the spatial environment around the proposed project, and these are defined below:

- Development footprint – the expected extent of land clearing and/or development. Usually a subset of the *project area* but in some cases this will be equivalent to *project area* (where the entire *project area* is proposed to be developed).
- Project area – the outermost boundary within which the proposed project will be located (the maximum envelope in which development could occur). This will usually be a lease area or land over which the proponent has some tenure.
- Survey area – the outermost boundary of the environmental impact assessment (including the area to which the results of the desktop analysis are directed and/or the area within which field investigations are conducted). While the minimum *survey area* boundary is equivalent to *project area*, often this boundary will exceed that of the *project area* where reference, contextual or regional information is sourced (including field investigations outside of the *project area*; i.e. outside the land over which the proponent has tenure). Note that while the

term '*survey area*' is used throughout the guidance provided by EPA (2020), it does not appear to be explicitly defined and, therefore, the above definition has been developed with interpretation of both the guidance and BCE report structure.

- Study area – the outermost boundary of the desktop assessment that is almost always a specified buffer distance (see Section 2.3.1 below) around the *project area*, or the *project area* centroid. This is generally the area from which databases are sourced.

Where available, these spatial boundaries are mapped in Figure 1.

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.

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 of expected species

2.3.1 Sources of information

As per the recommendations of EPA (2020), information on the fauna assemblage of the project area was drawn from a range of sources including databases (as listed in Table 3) and reports from other fauna surveys in the region (as listed in Table 4). Information from these 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 5.

Table 3. Databases searched for the desktop review; accessed November and December 2020.

Database	Type of records held in database	Area searched
BCE Database	Fauna recorded by BCE in the vicinity of ANSIA.	25 km buffer around the centroid of the project areas (296317E, 7592930N; or 21.756° S, 115.030° E).

Database	Type of records held in database	Area searched
Atlas of Living Australia (ALA 2020)	Fauna records from Australian museums and conservation/research bodies, including records from BirdLife Australia's Atlas (Birdata) Database.	25 km buffer around the centroid of the project areas (296317E, 7592930N; or 21.756° S, 115.030° E).
NatureMap (DBCA 2020c)	Records from the Western Australian Museum (WAM) and Department of Biodiversity, Conservation and Attractions (DBCA) databases, including historical data and Threatened and Priority species in WA.	25 km buffer around the centroid of the project areas (296317E, 7592930N; or 21.756° S, 115.030° E).
EPBC Protected Matters Search Tool (DAWE 2020j)	Records on MNES protected under the EPBC Act.	25 km buffer around the centroid of the project areas (296317E, 7592930N; or 21.756° S, 115.030° E).
Index of Biodiversity Surveys for Assessment (IBSA) (DWER 2020c)	Flora and fauna data contained in EIA biodiversity survey reports.	25 km buffer around the centroid of the project areas (296317E, 7592930N; or 21.756° S, 115.030° E).

Table 4. Literature sources for the desktop review.

Author	Title
Bancroft and Bamford (2005a)	Assessment of the Terrestrial Fauna of the Proposed BHP Billiton Onslow LNG Plant.
Bancroft and Bamford (2005b)	Repeat survey for terrestrial fauna at the proposed site of the BHP Billiton Onslow LNG Plant, Onslow, September 2005.
Smith *et al*. (2009)	Fauna Assessment: BHP Billiton Petroleum Pty Ltd Macedon Gas Development. Terrestrial Plant Site and Linear Infrastructure Corridor.
Bamford *et al*. (2009)	Survey for Migratory Waterbirds in the Wheatstone LNG Project Area, November 2008 and March 2009.
Biota (2010b)	Wheatstone Project Terrestrial Fauna Survey.
Biota (2010a)	Wheatstone Project Flora and Fauna Assessment Addendum.
Biota (2010c)	Wheatstone Project Claypan Ephemeral Fauna Survey
Biota (2010d)	Wheatstone Project Subterranean Fauna Assessment
ENV (2012b)	Ashburton North Strategic Industrial Area Fauna Assessment.
ENV (2012a)	Ashburton North Strategic Industrial Area Biological Desktop Review.
Biota (2013)	Desktop Review of the Proposed Onslow Micro-Siting Survey Area.
Ninox (2014)	A Level 1 Vertebrate Fauna Assessment of the Proposed Ashburton North Gas Pipeline.
RPS (2015a)	Environmental Assessment Report: Ashburton North Strategic Industrial Area Improvement Scheme.
RPS (2015b)	Terrestrial Fauna Review: Ashburton North Strategic Industrial Area.
Thompson and Thompson (2020)	A comparison of an environmental impact assessment (EIA) vertebrate fauna survey with a post-approval fauna salvage program: consequences of not adhering to EIA survey guidelines, a Western Australian example.

Table 5. Sources of information used for general patterns of fauna distribution.

Taxa	Sources
Fish	Morgan *et al.* (1998), Allen *et al.* (2003), Morgan *et al.* (2014), DoF (2020).
Frogs	Tyler and Doughty (2009), Anstis (2017).
Reptiles	Storr *et al*. (1983, 1990, 1999, 2002), Bush and Maryan (2011), Wilson and Swan (2017).
Birds	Johnstone and Storr (1998, 2005), Menkhorst *et al*. (2017).
Mammals	Van Dyck and Strahan (2008), Churchill (2009), Menkhorst and Knight (2011).

2.3.2 Previous fauna surveys

There has been an extensive number of previous comprehensive fauna investigations undertaken in the region over more than a decade. A list of the fauna surveys used in the literature review here is presented in Table 4. Appendix 5 summarises the survey approaches and methods used in key investigations within a radius of about 10 km of the current project area. In the last 15 years there have been five site inspections including targeted searching for significant species, four major trapping surveys (detailed surveys), one intensive searching program for fauna salvage prior to clearing and two targeted waterbird surveys, including an aerial survey. Previous studies included two projects investigating invertebrates in the general Onslow industrial area.

2.3.3 Nomenclature and taxonomy

As per the recommendations of the EPA (2020), the nomenclature and taxonomic order presented in this report are generally based on the Western Australian Museum's (WAM) Checklist of the Fauna of Western Australia 2019. The authorities used for each vertebrate group were: fish (Morgan *et al.* 2014), frogs (Doughty *et al.* 2019a), reptiles (Doughty *et al.* 2019b), birds (BirdLife Australia 2019; Gill and Donsker 2020), and mammals (Travouillon 2019). 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 (e.g. the BirdLife Australia working list of names for Australian Birds, and the International Ornithological Congress' 'World Bird List'). English common names of species, where available, are used throughout the text; Latin names are presented with corresponding English names in tables in the appendices. The use of subspecies is limited to situations where there is an important (and relevant) geographically distinct population, or where the taxonomic distinction has direct relevance to the conservation status or listing of a taxon.

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 (the study area, see Figure 1) 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 investigations

2.4.1 Overview

A site inspection was conducted to familiarise the consultants with the project area. This involved looking around as much of the project area as possible; including walking through areas that did not have direct vehicle access. 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;
- continuous recording of bird species encountered; and
- opportunistic fauna observations.

2.4.2 Dates

The project area was visited on the 30th of September and 1st of October 2020.

2.5 Personnel

Personnel involved in the field investigations and report preparation (including desktop review) are listed in Table 6.

Table 6. Personnel involved in the field investigations and report preparation.

Personnel	EIA Experience	Field Investigations	Report Preparation
Dr Mike Bamford *BSc (Biol.), Hons (Biol.), PhD (Biol.)*	40 years	+	+
Dr Wes Bancroft *BSc (Zool./Microbiol.), Hons (Zool.), PhD (Zool.)*	23 years		+

2.6 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 7. No limitations were identified.

The lack of detailed survey (i.e. intensive sampling of the fauna assemblage) is not considered a limitation as this assemblage is well-understood in the area due to multiple previous field investigations. 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. 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 7. Survey limitations as outlined by EPA (2020).

EPA Survey Limitations	BCE Comment
Availability of data and information	Abundant information from databases and previous studies (see Section 2.3.1). 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 also Table 6 for further details. 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. Some information on threatened invertebrates was available from databases. Not a limitation.
Timing, weather and season	Timing is not of great importance for Basic level field investigations in this region. Not a limitation.
Disturbance that may have affected results	None. Not a limitation.
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.

2.7 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 (2012) (see Appendix 4). 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 on the basis of 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 investigations 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 2.

2.7.1 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 8). 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 (2016c) 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 8), 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 8. 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.

2.8 Mapping

Low resolution maps have been provided within the body this report. Higher resolution maps and GIS files can be supplied if required. As per the recommendation of EPA (2020), maps use the GDA94 datum and are projected into the appropriate Map Grid of Australia (MGA94) zone.

3 Fauna values

3.1 Vegetation and substrate associations (VSAs) ['Habitat assessment ']

Vegetation and substrate associations within the project area are a complex mosaic, largely reflecting soil types. Four major vegetation and substrate associations (VSAs) were identified in the project area:

VSA 1. Undulating dunes. Undulating sandy dunes with scattered shrubs (*Acacia* and *Hakea*) over spinifex on sand and sandy loam in valleys. The most extensive VSA, being very well-developed (large dunes) in the proposed Hydromet plant site (Lot 152). This corresponds largely with the Dune Land System (Figure 3). See Plate 1.

VSA 2. Sandy loam flats. Sandy loam flats tending towards clay with some chenopod shrubs, and a few areas with termite mounds. Termite mounds are aggregated in one part of the Alternative B (Lot 500) area but otherwise very few. This corresponds largely with the Onslow Land System (Figure 3). See Plate 2.

VSA 3. Claypans. Claypans; mostly bare ground of clayey loam subject to inundation. Some areas also have chenopod shrubs. Most extensive in Alternative A (Lot 152) area. These claypans lie within the Onslow Land System and within the Littoral Land System (Figure 3). See Plate 3.

VSA 4. Outcropping limestone. Locations where underlying limestone is exposed at the surface, and the vegetation is low spinifex with scattered, low shrubs. These areas are generally small, and only occurred in the Alternative B (Lot 500) and Alternative C (Lot 540) areas. They account for, at most, a few hectares and are not recognised as a distinct land system, falling within the Dune Land System. See Plate 4.

The extent of the VSAs in the project area is mapped in Figure 4.

The proposed Onslow Rare Earths Plant site supported three VSAs: sandy loam flats (VSA 2) along the eastern and western boundaries, an extensive area of undulating dunes (VSA 1) with well-developed dunes, centrally, and some smaller claypan areas (VSA 3) along the northern, western and eastern boundaries (within VSA 2). There were additional claypans (VSA 3) surrounding the site, and a drainage line just to the east of the site (but outside of the site boundary).

The Alternative A (Lot 152) area was more complex but was predominantly VSA 1 with VSA 3 interspersed throughout. Some valleys had loam-clay soil and supported low woodland of Mesquite (*Prosopis* sp.) or similar, notably in north and alongside the road. Some of the VSA 3 claypans were bare and some were vegetated with chenopod shrubs.

The Alternative B (Lot 500) and Alternative C (Lot 540) areas are adjacent. They comprised mostly VSA 1 and VSA 2, with some small patches of VSA 4. Claypans (VSA 3) lie just to the north and west of these areas.

Plate 1. VSA 1: Undulating dunes.

Plate 2. VSA 2: Sandy loam flats with termite mounds (Alternative C).

Plate 3. VSA 3: Claypans.

Plate 4. VSA 4: Outcropping limestone (Alternative B).

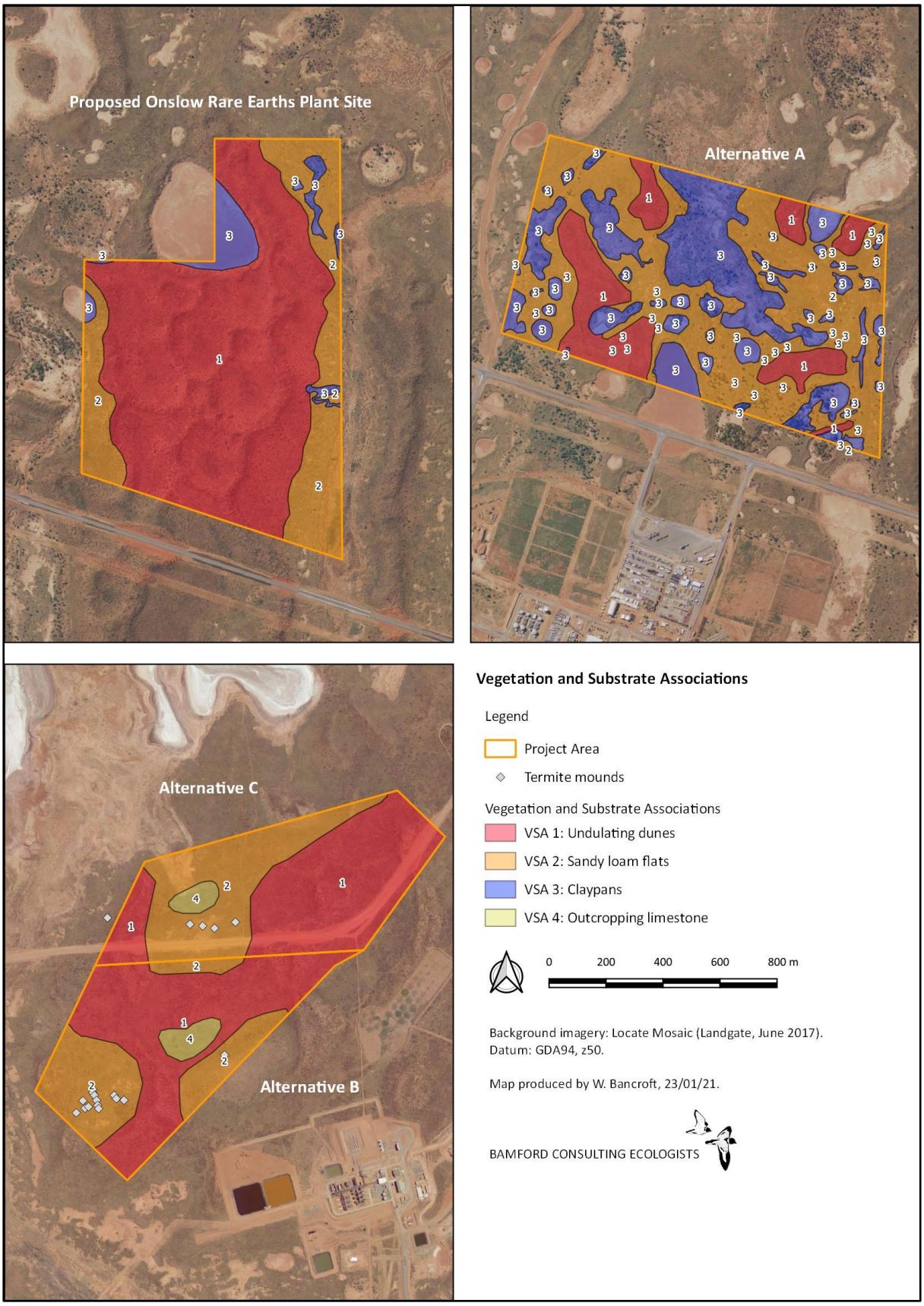

Figure 4. The distribution of VSAs in the project area.

3.1.1 Adequacy of previous sampling in each VSA

The distribution of VSAs in the Onslow area is simple and relates closely to Land Systems (Figure 3). Previous surveys were conducted across these Land Systems and were largely within 15km of the current project area. Actual sampling sites of previous studies were mostly within what are now developed areas north of Alternative C and south of Alternative A (see Figure 5), but there were some reference (unimpacted) sites nearby. Some sampling took place in the current project area, with evidence of old pitfall traps found in Alternative A.

Appendix 5 provides details on previous field investigations in the area, including sampling effort. Total sampling effort using primary trapping techniques was:

- Bancroft and Bamford (2005a & b) and Bancroft *et al.* (2007): 970 pitfall nights, 750 funnel trap nights and 665 Elliott trap nights;
- Biota (2010a & b): 950 pitfall nights, 150 funnel trap nights and 500 Elliott trap nights.
- Both studies also carried out systematic bird censussing with about 150 bird census events in the Bancroft and Bamford work.

Approximately half the sampling effort took place in the VSAs represented in the current project area. In addition, Thompson and Thompson (2020) undertook intensive searching for reptiles and small mammals prior to clearing in the areas north of Alternative C and south of Alternative A; they removed about 28,500 animals of 83 species, largely from VSAs 1 and 2.

3.1.2 Regional development

The landscape in which the project area is located is extensive along the near-coast of the Onslow region but has been partly developed for industry and for the nearby salt evaporation ponds. Figure 5 illustrates the existing extent of development in a 15 km buffer around the project area. Existing developments (c. 2419 ha) impact c. 3.98% of the total land area within this buffer (c. 60,721 ha). The proposed Onslow Rare Earths Plant site has a total area of c. 100 ha (see Table 1) and, therefore, would, at most, contribute 0.17% to the land clearing within the region, taking the total developments in the region to c. 4.15% of the land area. It should be noted that the development footprint (see Section 2.1.1) within the project area will likely be less than this figure.

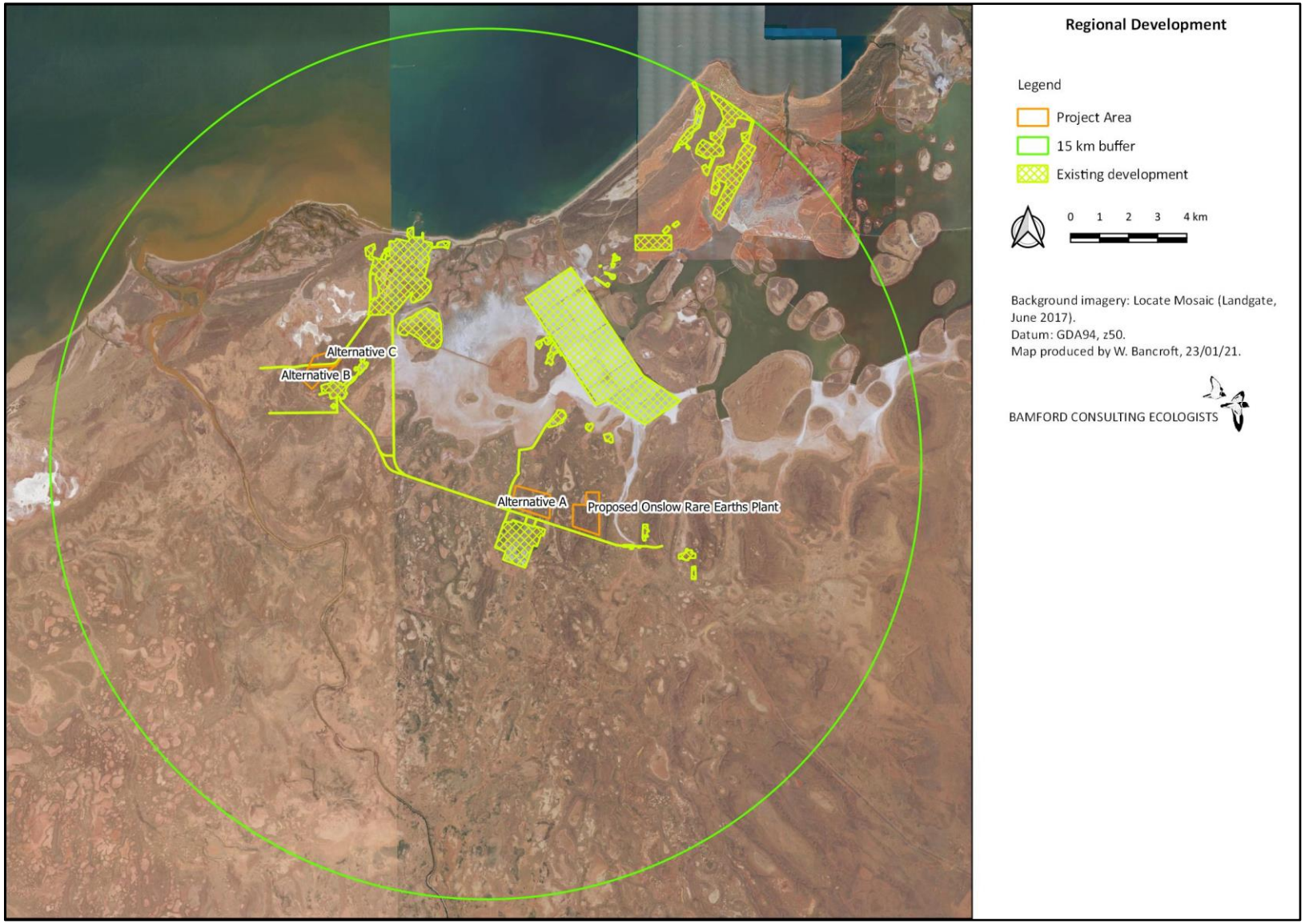

Figure 5. Estimated existing development within the region (15 km).

3.2 Fauna assemblage

3.2.1 Overview of vertebrate fauna assemblage

The desktop study identified 303 vertebrate fauna species as potentially occurring in the project area: 7 frogs, 89 reptiles, 166 birds and 41 mammals. These species are listed in Appendix 6. The presence of at least 20 species (four reptiles, 15 birds and one mammal) was confirmed during the 2020 site inspection (as presented in Appendix 7, but also indicated in Appendix 6).

One hundred and nineteen species (two frogs, 40 reptiles, 60 birds and 17 mammals) that were returned by the database searches and/or literature review have been omitted from the expected species list because of habitat or range limitations, or because they are considered to be locally extinct in the project area. The locally extinct species are three mammals. These species are listed in Appendix 8.

The composition of the vertebrate fauna is summarised in Table 9.

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

The number of non-native mammals is shown in parentheses.

Taxon	Expected Species	Recorded Species	Number of species in each status category				
			Resident	Migrant or regular visitor	Irregular visitor	Vagrant	Locally extinct
Frogs	7	0	5	1	1		
Reptiles	89	4	86		3		
Birds	166	15	79	11	65	11	
Mammals	41 (9)	1 (1)	36 (9)	2	1	2	3
Total	303	20	206	14	70	13	3

There is limited information on invertebrate fauna in the area; this fauna is discussed in Section 3.2.3.

3.2.2 Expected vertebrate fauna

The seven frog species include five that are considered to be residents and are likely to breed in seasonal freshwater pools (including freshwater claypans), one species (*Litoria rubella*) that is likely to be a regular visitor to the site when suitable conditions prevail, and one (*Cyclorana occidentalis*) that may occur irregularly and/or in very low numbers (Thompson and Thompson 2020). *L. rubella* usually occurs in large trees along water courses but will disperse in rainy periods.

The 89 reptile species are all considered to be residents with the exception of Gilbert's Dragon, Rock Ctenotus and Pilbara Olive Python which may occur as irregular visitors. These latter two species generally prefer rocky substrates that are not present within the project area, but they are likely to be

present in the broader region and may pass through the project area on occasion. The Pilbara Olive Python is of conservation significance and is discussed further below. Gilbert's Dragon is usually associated with water courses but may disperse more broadly on occasion.

The bird assemblage of 166 species includes 51 wetland-dependent species that are only likely to occur as irregular visitors when suitable conditions (i.e. flooding of clayplans) prevail within the project area. Seventy-nine of the bird species are considered to be resident in the project area, with a further 11 that are regular visitors and 11 vagrant species. Nearly half the bird assemblage is therefore not resident, which reflects the seasonal nature of wetlands (claypans) in the area. For example, many of the regular and irregular visitors are waterbirds.

Most of the 41 mammal species are considered to be residents (36) with nine of these introduced species. Two mammal species (Northern Quoll and Orange Leaf-nosed Bat) are considered visitors because they generally prefer rocky substrates that are not present within the project area but they may pass through, or forage above, the project area. Across a seven year period, Thompson and Thompson (2020) recorded a very low density of Northern Quoll in the region ("At least two (and possibly three) *D. hallucatus* were in the project area…"). The two fruit-bat species are likely to be vagrants. Three mammals are considered to be locally extinct (see Appendix 8). The disappearance of these species (Greater Bilby, Spectacled Hare-Wallaby and Tunney's Rat) is most likely due to a combination of feral predators and altered fire regimes.

The key features of the fauna assemblage expected in the project area are:

- **Uniqueness:** The fauna assemblage is probably widespread across similar soils and vegetation in the western Pilbara. It is unusual in the inclusion of several reptile species restricted to sandy soils in the Onslow to Exmouth Gulf region, and in the paucity of rock-haunting species more typical of the Pilbara.
- **Completeness:** The assemblage is likely to be substantially complete but lacks at least three mammal species which are all thought to be locally extinct.
- **Richness:** The assemblage is only moderately rich as the project area has a limited range of VSAs to provide habitat for fauna. For example, it lacks major watercourses and rocky landscapes.

As a fauna value, the most important feature of the project area's assemblage is the presence of a suite of reptile species restricted to the broader Onslow to Exmouth Gulf region.

3.2.3 Invertebrate fauna of conservation significance

The project area sits within DBCA's Pilbara management region (DBCA 2020a). DBCA (2019) listed 49 threatened or priority invertebrate fauna in this region, as outlined in Appendix 9. At least 47 of these species can be immediately ruled out from occurring within the project area and the reasons for exclusion are presented in Appendix 9 (e.g. wholly or locally extinct, absence of suitable habitat in the project area, distance from known populations). To help ascertain the status of the remaining two species, all location records from ALA (2020) and WAM (2021h) were compiled, collated and mapped in relation to the project area. A map of these DBCA-listed threatened and priority species is provided in Figure 6.

There are no records of threatened invertebrate fauna within the project area, nor within the regional (15 km) buffer. Indeed, only two threatened invertebrate species were considered to possibly occur in the vicinity of the project area: the dragonfly *Antipodogomphus hodgkini* (Pilbara Dragon) and the damselfly *Nososticta pilbara* (Pilbara Threadtail). Watson (1974) and Theischinger and Hawking (2012) list both of these species as occurring within the north-west of Western Australia (NWA) region that does include the project area but finer examination of available records (Figure 6) shows that the nearest Pilbara Dragon and Pilbara Threadtail populations are know from c. 130 km and c. 190 km away from the project area, respectively. In addition, both species occur in rivers, streams, and riverine pools (Theischinger and Hawking 2012) that are not present within the project area. It is uncertain as to whether seasonally flooded claypan areas (e.g. VSA 4) would support these species but given that their larvae inhabit the stony beds of flowing water (Theischinger and Hawking 2012) it seems highly unlikely. Given the above range and habitat considerations, neither of these species is expected to occur in the project area and, thus, they have not been included as expected conservation significant species.

It should be noted that the ecology and distribution of short-range endemic invertebrates is often poorly understood or documented, but in addition to the review of databases (above) two invertebrate studies have been undertaken in the Onslow region as part of assessments for industrial developments (Biota c & d). These address aquatic invertebrates of claypans (zooplankton and macro-invertebrates) and subterranean fauna; methods are summarised in Appendix 5.

The claypan invertebrate sampling yielded 141 taxa and it was concluded that all could be expected to be widespread, reflecting the nature of ephemeral claypans that are interconnected over large areas during flood events. The majority of taxa were described and had been previously collected, with the conclusion that they were 'widespread in the bioregion and beyond' (Biota 2010c). Four were undescribed but were still considered likely to be widespread. This included two taxa, an undescribed clam shrimp and an undescribed worm, collected only from one site which was an artificial wetland formed by flooded of a roadside excavation. Biota (2010c) concluded that it was 'unlikely that these records represent natural locally endemic distributions'.

The troglofauna (subterranean fauna found above the water table) sampling yielded 14,398 invertebrate specimens of eight orders, but all were surface or soil invertebrates expected to be widespread and therefore not of significance. No troglofaunal were collected. It was concluded that

the surface and sub-surface geology of fine sediments, combined with a high water table, provided little habitat for troglofauna.

The stygofauna sampling yield two species: the copepod *Phyllopodopsyllus thiebaudii* and the oligochaete worm Enchytraeideae sp. 1. The copepod was collected from one near-coastal bore but is considered to be widespread, with records including Barrow Island. The oligochaete worm was collected from two boreholes and Biota (2010d) concluded that given its small size and the ecology of similar stygal oligochaetes, it was very unlikely to have a restricted distribution. Thus neither species was concluded to be of conservation significance.

The database review of significant invertebrate records and the observations from Biota (2010 b & c) are consistent with the general conclusion that the project area lacks the distinctive geological features (such as isolated rocky hills, mesic refugia, and/or fragmented and well-developed subterranean habitat) with which SRE species are often associated. The occasional interconnectedness of wetlands is a major factor in reducing the likelihood of SRE invertebrates being present.

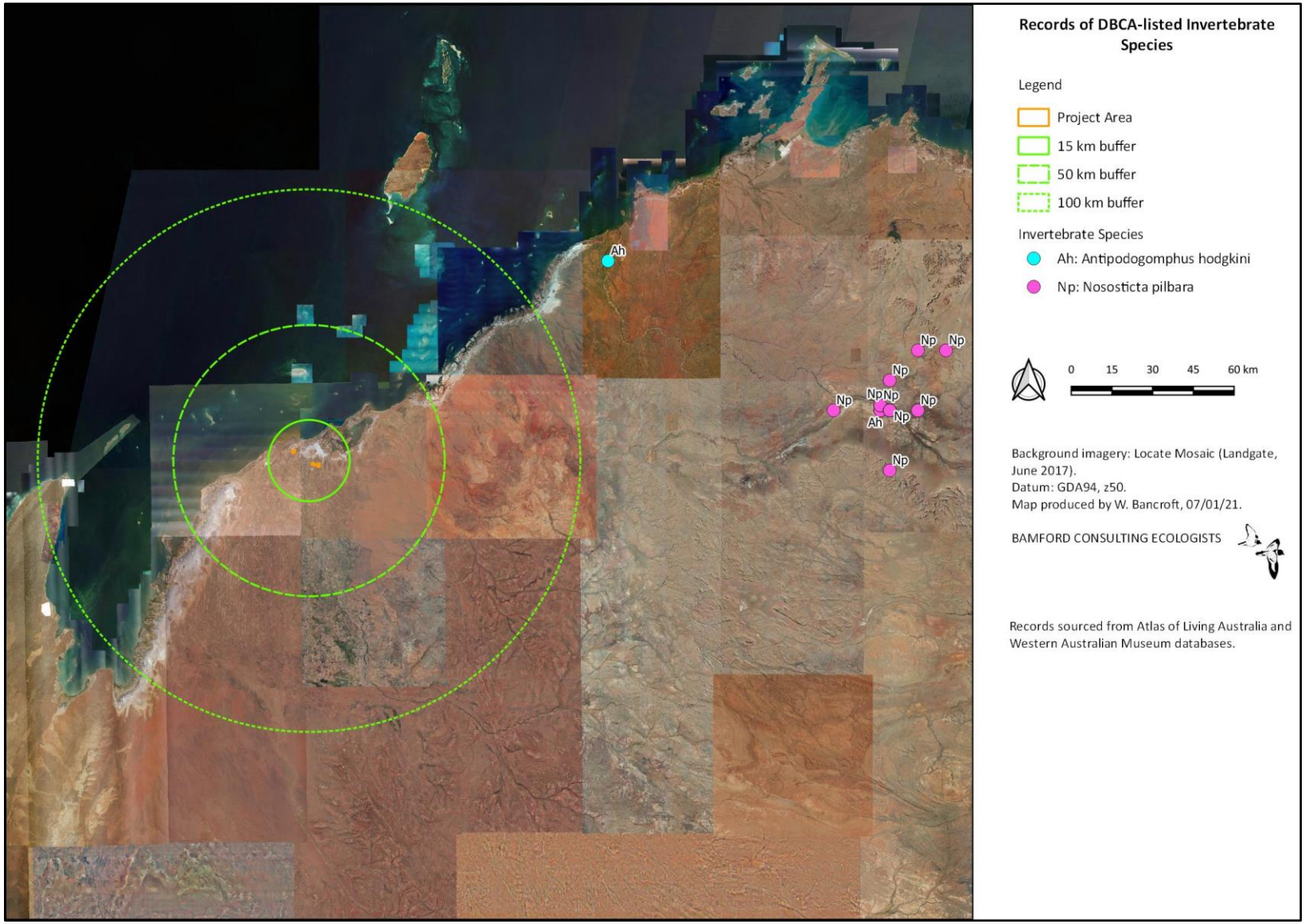

Figure 6. Records of DBCA-listed (threatened or priority) invertebrate species within 100 km of the project area.

3.2.4 Vertebrate fauna of conservation significance

Of the 303 species of vertebrate fauna that are expected to occur in the project area (Section 3.2.1 above), 42 are considered to be of conservation significance (37 CS1, three CS2 and two CS3; see Appendix 1 for descriptions of these CS (conservation significance) levels. A summary of the numbers in each vertebrate class is presented in Table 10. These species of conservation significance are indicated in the complete species list (Appendix 5. Details on methodology of key previous surveys sourced in the current assessment.

Title	Methods used
Assessment of the Terrestrial Fauna of the Proposed BHP Billiton Onslow LNG Plant Repeat survey for terrestrial fauna at the proposed site of the BHP Billiton Onslow LNG Plant, Onslow, September 2005 Fauna surveys of the Proposed Locations of BHP Billiton's Onslow Gas Processing Plant Components, November 2006.	**Level 2 survey (Detailed)** <u>Review of databases and literature</u> <u>Site inspection (27-28th September 2004)</u> • All mainland areas of site visited • Notes made regarding available habitat and opportunistic observations of fa <u>Field survey (9-17th December 2004)</u> • Focused on locations that have been poorly represented in previous studies • For frogs, reptiles, and mammals: o 2 transects with 30 pitfall traps, 15 baited Elliot traps, and 24 funne o 1 transect with 20 pitfall traps, 10 baited Elliot traps and 16 funnel t o Each transect was operated for 5 nights. Total sampling effort = 350 280 funnel-trap nights. • For birds: o birds observed or heard within 50m of each trapping transect were o Targeted bird surveys at Four Mile Creek and Beadon Creek (at leas location, low and hide tide). o Opportunistic sightings recorded • One spotlighting survey (on foot) conducted per transect, from dusk until ~2 • Limitations: no bat surveys, limited hand searching <u>Field survey (5-12th September 2005)</u> • Similar transect locations to Bancroft and Bamford (2005a) o Transect 1 relocated to maximise change of capturing *Leggadina lal* For frogs, reptiles, mammals: o Each transect was operated for 5 nights and comprised 20 pitfall tra 10 funnel traps o Total sampling effort = 300 pitfall-, 300 Elliott- and 150 funnel-trap • For birds: o Birds observed or heard within 50m of each trapping transect were o Targeted bird surveys at Four Mile Creek and Beadon Creek o Opportunistic sightings recorded • For bats: survey at Beadon Creek 9-10th September 2005 o Echolocation calls recorded and analysed using Anabat detector and • One spotlighting survey (on foot) conducted per transect, from dusk until ~2 • Limitations: limited hand searching. Motion-sensitive cameras were not ava survey, but fauna that could have been detected by cameras weer detected <u>Update and review of databases and literature (including previous fauna survey</u> <u>Site inspection</u>

	• To familiarise consultants with the environment and fauna habitats of the a
	
	Field survey (12-19th November 2006)
	• Trapping for frogs, reptiles, and mammals:
	  ○ Pitfall traps, funnel traps and Elliot traps were deployed in various f sites. Traps at each site were operated for 5 nights.
	  ○ Total sampling effort:
	  ▪ Beadon Creek, 85 pitfall-, 85 funnel-, 40 Elliot- trap nights
	  ▪ Camp site: 150 pitfall-, 150 funnel-, 0 Elliot- trap nights
	  ▪ LNG plant site: 85 pitfall-, 85 funnel-, 150 Elliot- trap nights

Fauna Assessment: BHP Billiton Petroleum Pty Ltd Macedon Gas Development. Terrestrial Plant Site and Linear Infrastructure Corridor.	**Level 1 with some elements of Level 2** (Basic and Targeted; extended site inspe scheduled and priority species). Aim of field surveys was to develop understand and general ecological processes of the site, and search for evidence of significa Review of databases. Site inspection (8-12th September 2008) • Evidence of significant species; walk through habitat recording diggings, bur tracks, droppings etc. • Spotlighting included on foot (with head-torch) and by vehicle (with hand-h counted, identified, and captured if necessary for identification • Micro-habitat searching; focused on mesic refugia likely to be important for invertebrates • Opportunistic sightings recorded during all other survey work.
Survey for Migratory Waterbirds in the Wheatstone LNG Project Area, November 2008 and March 2009.	**Targeted.** Review of databases and literature Two field surveys conducted and birds identified and counted • 12-16th November 2008 – ground surveys, visited all wetlands in survey area coastline. • 15-17th March 2009 – some ground surveys, plus aerial surveys of entire sur purpose of counting waterbirds with some identification

Wheatstone Project Terrestrial Fauna Survey.	**Level 2 survey** (Detailed)
	
	Review of databases and literature
	
	Single phase field survey (14th-23rd April 2009)
	• Systematic census of terrestrial fauna (including birds, mammals, frogs and trapping sites within 7 habitat types.
	• Mammals, frogs, reptiles:
	  ○ Each site contained 10 pitfall traps (connected by drift fence). 5 site funnel traps (n=6) and Elliot traps (n=10)
	  ○ Total trapping effort: 950 pitfall-, 150 funnel-, and 500 Elliot- trap n
	• Bats: sampled via harp nets and echolocation call recordings (using Anabat
	  ○ Total of 12 harp trap nights and 12 echolocation sampling nights
	• Birds: 32 bird surveys conducted over 16 trapping sites.
	  ○ 30-minute censuses conducted between 7am-1pm
	  ○ Total of 16 hours dedicated to systematic bird surveys
	  ○ Opportunistic observations also recorded.
	• Short-range endemic invertebrates
	  ○ sampled at the 16 primary sites, plus an additional 8 sites
	• non-systematic sampling also conducted

	○ habitat specific searches for Schedule and Priority species ○ documentation of opportunistic sightings ○ identification of road-kills and animal remains ○ recording secondary signs (tracks, scats, diggings) • Limitations: single season survey
Wheatstone Project Claypan Ephemeral Fauna Survey	**Targeted survey** (claypan aquatic invertebrates) <u>Desktop review</u> <u>Field survey</u> • Survey conducted in three phases over a two month period in early 2009 fol • Twenty-four wetland sites were sampled; 12 in impacts areas and 12 in refe • Sampling methods were standard for aquatic invertebrates with nets of diffe zooplankton and macroinvertebrates.
Wheatstone Project Subterranean Fauna Assessment	**Targeted survey** (subterranean fauna) <u>Desktop review</u> <u>Field survey</u> • Thirty boreholes sampled for both troglofaunal (above the water table) and water table), across impact and reference areas. • Sampling took place over three phases from July to October 2009, with a tot sampling days (ie traps down boreholes). • Sampling based on traps and modified plankton nets and replicated in each replicates).
ANSIA Stage 2 Fauna Assessment	**Level 1 survey** (Basic) <u>Review of databases and literature</u> <u>Targeted site inspection (6-7th August 2018)</u> • Walking through and driving through areas to familiarise consultants with s ○ Identification of VSAs ○ Targeted search for significant fauna ○ Continuous recording of bird species observed ○ Opportunistic fauna observations
A comparison of an environmental impact assessment (EIA) vertebrate fauna survey with a post-approval fauna salvage program: consequences of not adhering to EIA survey guidelines, a Western Australian example.	• Comparison between EIA fauna survey and fauna salvage program • Does not present species lists or raw data in this document, but discusses d EIA survey and fauna salvage • Identifies major limitations of trapping-based surveys for terrestrial fauna a results of extensive searching carried out for fauna 'salvage' prior to clearin
Review of the Possible Impacts of the Scarborough Project on Birds (particularly Migratory Waterbirds)	**Targeted.** Review of databases and literature on potential for interactions betw facility. Review of literature regarding impacts of oil and gas facilities on wildlife.

Appendix 6) but are also listed with details of their conservation significance in

Table 11. The majority of conservation significant species are expected as irregular visitors or vagrants; only one lizard, one bird and one mammal are expected to be resident, and only three species (again, one lizard, one bird and one mammal) are expected to be regular visitors.

Table 10. The number of conservation significant species in each vertebrate class.

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	1	1	0	**2**
Birds	34	0	1	**35**
Mammals	2	2	1	**5**
Total	**37**	**3**	**2**	**42**

Table 11. Conservation significant 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).
LS = considered by BCE to be of local significance (see Appendix 1).

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE
Lerista planiventralis maryani		CS2 (P1)	Resident
Liasis olivaceus barroni	Pilbara Olive Python	CS1 (V,S3)	Regular Visitor
Phaps histrionica	Flock Bronzewing	CS3 (LS)	Resident
Apus pacificus	Fork-tailed Swift	CS1 (M,S5)	Vagrant
Pluvialis squatarola	Grey Plover	CS1 (M,S5)	Irregular Visitor
Pluvialis fulva	Pacific Golden Plover	CS1 (M,S5)	Irregular Visitor
Charadrius mongolus	Lesser Sand Plover	CS1 (M,S2,S5)	Irregular Visitor
Charadrius leschenaultii	Greater Sand Plover	CS1 (M,S3, S5)	Irregular Visitor
Charadrius veredus	Oriental Plover	CS1 (M,S5)	Irregular Visitor
Numenius phaeopus	Whimbrel	CS1 (M,S5)	Irregular Visitor
Numenius minutus	Little Curlew	CS1 (M,S5)	Irregular Visitor
Numenius madagascariensis	Eastern Curlew	CS1 (C,M,S3,S5)	Irregular Visitor
Limosa lapponica	Bar-tailed Godwit	CS1 (M,S5)	Irregular Visitor
Limosa limosa	Black-tailed Godwit	CS1 (M,S5)	Irregular Visitor
Calidris tenuirostris	Great Knot	CS1 (M,S3,S5)	Irregular Visitor
Calidris canutus	Red Knot	CS1 (M,S5)	Irregular Visitor
Limicola falcinellus	Broad-billed Sandpiper	CS1 (M,S5)	Vagrant
Calidris acuminata	Sharp-tailed Sandpiper	CS1 (M,S5)	Irregular Visitor
Calidris ferruginea	Curlew Sandpiper	CS1 (C,M,S3,S5)	Irregular Visitor
Calidris subminuta	Long-toed Stint	CS1 (M,S5)	Irregular Visitor
Calidris ruficollis	Red-necked Stint	CS1 (M,S5)	Irregular Visitor
Calidris melanotos	Pectoral Sandpiper	CS1 (M,S5)	Vagrant
Xenus cinereus	Terek Sandpiper	CS1 (M,S5)	Vagrant
Actitis hypoleucos	Common Sandpiper	CS1 (M,S5)	Irregular Visitor
Tringa nebularia	Common Greenshank	CS1 (M,S5)	Irregular Visitor
Tringa glareola	Wood Sandpiper	CS1 (M,S5)	Irregular Visitor
Tringa stagnatilis	Marsh Sandpiper	CS1 (M,S5)	Irregular Visitor
Phalaropus lobatus	Red-necked Phalarope	CS1 (M,S5)	Vagrant
Glareola maldivarum	Oriental Pratincole	CS1 (M,S5)	Irregular Visitor
Gelochelidon nilotica	Common Gull-billed Tern	CS1 (M,S5)	Irregular Visitor
Hydroprogne caspia	Caspian Tern	CS1 (M,S5)	Irregular Visitor

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE
Chlidonias leucopterus	White-winged Black Tern	CS1 (M,S5)	Irregular Visitor
Plegadis falcinellus	Glossy Ibis	CS1 (M,S5)	Irregular Visitor
Falco hypoleucos	Grey Falcon	CS1 (S3)	Vagrant
Falco peregrinus	Peregrine Falcon	CS1 (S7)	Irregular Visitor
Pezoporus occidentalis	Night Parrot	CS1 (E,S1)	Vagrant
Hirundo rustica	Barn Swallow	CS1 (M,S5)	Regular Visitor
Dasycercus blythi	Brush-tailed Mulgara	CS2 (P4)	Regular Visitor
Dasyurus hallucatus	Northern Quoll	CS1 (E,S2)	Irregular Visitor
Trichosurus vulpecula	Brush-tailed Possum	CS3 (LS)	Irregular Visitor
Leggadina lakedownensis	Short-tailed Mouse	CS2 (P4)	Resident
Rhinonicteris aurantia (Pilbara)	Pilbara Leaf-nosed Bat	CS1 (V,S3)	Irregular Visitor

3.2.5 Conservation significant species accounts

A list of all conservation significant species expected within the project area is provided in

Table 11; these comprise no invertebrates (see also Section 3.2.3) and 42 vertebrates (see also Section 3.2.4). Information on the conservation status, distribution and habitat, salient ecology and expected occurrence within the project area if provided for each of these species is below.

3.2.5.1 Conservation Significance 1

Pilbara Olive Python (*Liasis olivaceus barroni*) CS1 (V,S3)

Conservation status: Vulnerable under the EBPC Act and Schedule 3 under the BC Act.

Distribution and habitat: This subspecies is restricted to ranges within the Pilbara region and Mount Augustus in the Gascoyne and is often recorded near waterholes (Wilson and Swan 2017). Usually associated with rocky substrates (Burbidge 2004; Wilson and Swan 2017).

Ecology: Usually found in proximity to water, although breeding males and juveniles may disperse widely (Burbidge 2004). An ambush predator that feeds predominately on mammals and birds (Burbidge 2004). Probably cathemeral.

Expected occurrence: Regular Visitor. It has been recorded along the Ashburton River 20 km west of Nanutarra (BCE database) and has been reported by Minderoo Station staff (M. Bamford), also along the Ashburton River. It is thus likely that the occasional animal will pass through the project area as a visitor.

Fork-tailed Swift (*Apus pacificus*) CS1 (M,S5)

Conservation status: Migratory under the EPBC Act and Schedule 5 under the BC Act.

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 2020a). 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 2020a). 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: Vagrant.

Migratory waders (25 species; see Table 11) and Glossy Ibis	CS1 (M, S5 [C, S2,S3])

Conservation status: Migratory under the EPBC Act and Schedule 5 under the BC Act, with some species also listed as Schedule 2 or 3 under the BC Act. Curlew Sandpiper and Eastern Curlew are also listed at Critically Endangered under the EPBC Act.

Distribution and habitat: Migrant wader species that may occur in any areas of suitable habitat throughout Australia, including wetlands, coasts, rivers, lakes, mudflats, mangal and man-made water bodies (e.g. salt ponds and sewage ponds), although some species (e.g. pratincoles, Little Curlew) also utilise dryland habitats (Hayman *et al.* 1991). These species are not just reliant on permanent water bodies and will also regularly use ephemeral wetlands and drainages when suitable conditions prevail (Hayman *et al.* 1991).

Ecology: Migratory waders generally forage diurnally for aquatic invertebrates from wetland substrates and, within the group, have a diverse range of foraging strategies and body forms (e.g. bill morphology) to reflect specialisations towards specific foraging niches (Hayman *et al.* 1991; Rogers *et al.* 2003). These species breed in the higher latitudes of the northern hemisphere and migrate south (including Australia) for the non-breeding season (Hayman *et al.* 1991; Rogers *et al.* 2003). While some species make this journey almost non-stop, most require stopover points along the route to 'refuel' and internationally important staging sites have been identified by Bamford *et al.* (2008). Migratory waders are most abundant in Australia in the non-breeding season (the austral summer) but some birds may be present at any time of year (especially in northern Australia).

Expected occurrence: Irregular Visitors or Vagrants. Many are waterbirds of tidal environments that live nearby but outside the project area, although the levels of abundance of such migratory shorebirds appears to be low in the region, possibly because the tidal flats are composed of fairly coarse, sandy material that supports few invertebrates. For example, waterbird surveys conducted around Onslow for the Macedon and Wheatstone Projects (Bamford *et al.* 2009) found counts to be low (10s and occasionally 100s), with most migratory species on the Onslow Town Beach. Some claypans in the general area were flooded in March 2009 but supported only low numbers of a few migratory waterbirds. The most abundant species were the Straw-necked Ibis (600) and Grey Teal (306), which are both very widespread, non-migratory waterbirds. Claypans in the project area may therefore support small numbers of waterbirds when flooded, and could be locally important for common species. The claypans may have abundant aquatic invertebrates when flooded (Bancroft and Bamford 2018), and therefore do provide food at times.

Common Gull-billed Tern (*Gelochelidon nilotica*), Caspian Tern (*Hydroprogne caspia*) and White-winged Black Tern (*Chlidonias leucopterus*) CS1 (M,S5)

Conservation status: Migratory under the EPBC Act and Schedule 5 under the BC Act.

Distribution and habitat: Migrant tern species that may occur in any areas of suitable habitat throughout Australia, including wetlands, coasts, rivers, lakes and man-made water bodies (e.g. salt ponds and sewage ponds). May use both permanent and ephemeral water sources (Menkhorst *et al.* 2017).

Ecology: Diurnal piscivores that forage aerially and plunge-dive for their prey (Menkhorst *et al.* 2017). These species have at least some proportion of their Australian population that breed in the Northern Hemisphere (usually from April to July), although Australian-breeding residents may regularly occur (DAWE 2020c, e, f).

Expected occurrence: Irregular Visitors. When wetland (i.e. claypan) areas within the project area are flooded these terns may forage over/in the water bodies, but previous observations (Bamford *et al.* 2009) suggest this would be in small numbers only.

Grey Falcon (*Falco hypoleucos*) CS1 (S3)

Conservation status: Schedule 3 under the BC Act.

Distribution and habitat: Sparsely distributed through central, northern and north-western Australia, this species appears to have a distribution that is centred around wooded ephemeral or permanent drainage lines (Menkhorst *et al.* 2017).

Ecology: An aerial, diurnal predator that predominantly forages on pigeons and parrots, although may also take invertebrates, reptiles and small mammals (Debus 2019). Resident when seasonal conditions are favourable, nomadic in times of drought (Debus 2019).

Expected occurrence: Vagrant. The riverine woodland along the nearby Ashburton River appears suitable habitat for this species.

Peregrine Falcon (*Falco peregrinus*) CS1 (S7)

Conservation status: Schedule 7 under the BC Act.

Distribution and habitat: More or less cosmopolitan throughout Australia (Menkhorst *et al.* 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 riverine woodland along the nearby Ashburton River appears suitable habitat for this species. is unlikely to breed in the study area due to the lack of large trees and rocky hills.

Night Parrot (*Pezoporus occidentalis*) CS1 (E,S1)

Conservation status: Endangered under the EBPC Act and Schedule 1 under the BC Act.

Distribution and habitat: Highly elusive and known from only a very small number of records, it is difficult to ascertain the distribution and habitat of this species. DAWE (2020h) lists central Western Australia, north-eastern South Australia and south-western Queensland as 'core' areas, although the Night Parrot may occur throughout any part of inland Australia. Habitat associations are also tenuous but the species may occur in areas of spinifex grassland and/or chenopod shrublands, or in areas of shrubby samphire (TSSC 2016).

Ecology: The Night Parrot was recorded more or less regularly through the late 19th Century but appeared to decline early in the 20th Century, with a lack of reliable records from the 1930s to the end of the century leading to some speculation that it was extinct. In the early 20th Century, however, there have been multiple records including in the eastern Pilbara, northern Murchison and western deserts of Western Australia (Davis and Metcalf 2008; Hamilton *et al.* 2017; Jackett *et al.* 2017), and a population has been studied in south-western Queensland since 2013 (DAWE 2020h). The species has been mired in controversy due to the implications of records close to development proposals, and after researchers falsified recordings and subsequently retracted recent Night Parrot records from South Australia (Jones *et al.* 2019). It is likely to be predominantly nocturnal and granivorous.

Expected occurrence: Vagrant. There are no recent or historical records in the Onslow area despite multiple surveys by several teams of consulting scientists since the early 2000s, so it seems unlikely that the species is present regularly.

Barn Swallow (*Hirundo rustica*) CS1 (M,S5)

Conservation status: Migratory under the EPBC Act and Schedule 5 under the BC Act.

Distribution and habitat: A migrant species that, when present, occurs along the Pilbara and Kimberley coasts in Western Australia (Johnstone and Storr 2005); and also coastal northern Australia (Menkhorst *et al.* 2017). Prefers towns and wetlands (Johnstone and Storr 2005).

Ecology: A diurnal, aerial insectivore that breeds throughout the Northern Hemisphere and visits northern Australia during the non-breeding period from September to April (Johnstone and Storr 2005; Menkhorst *et al.* 2017). It may be a vagrant elsewhere within Australia. The subspecies that is most likely to occur in Australia breeds in north-eastern Asia (Johnstone and Storr 2005).

Expected occurrence: Regular Visitor. It appears to be a regular visitor to Onslow townsite in summer (BCE records) so individuals may fly over the project area occasionally.

Northern Quoll (*Dasyurus hallucatus*) CS1 (E,S2)

Conservation status: Endangered under the EBPC Act and Schedule 2 under the BC Act.

Distribution and habitat: In Western Australia this species is often associated with rocky areas in the Pilbara (but also occurs along watercourses and beaches) and occurs through forests, savannahs and dissected rocky environments in the Kimberley (Van Dyck and Strahan 2008; DAWE 2020d). It also occurs, patchily, across northern Australia to Queeensland (Van Dyck and Strahan 2008; DAWE 2020d). This species formerly occurred across much of northern Australia, from the Pilbara to south-east Queensland, but now only occurs in a number of fragmented populations across its former range, largely due to poisoning by Cane Toads (*Bufo marinus*).

Ecology: A predominantly nocturnal predator of invertebrates, amphibians, reptiles, birds and small mammals (Van Dyck and Strahan 2008). Northern Quoll may be both terrestrial and arboreal (Van Dyck and Strahan 2008). This species undergoes a post-breeding male-die off (semelparity), with most individuals (including females) only surviving for one or two breeding seasons (Van Dyck and Strahan 2008).

Expected occurrence: Irregular Visitor. No evidence of this species was found during the site inspection and preferred habitat was absent from the project area. Adjacent areas along the nearby Ashburton River may, however, be suitable, and Thompson and Thompson (2020) recorded it from the Wheatstone LNG project area. Therefore this species may occasionally make passage through the project area.

Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia* (Pilbara)) CS1 (V,S3)

Conservation status: Vulnerable under the EBPC Act and Schedule 3 under the BC Act.

Distribution and habitat: The Pilbara Leaf-nosed Bat occurs within the Pilbara where it is limited by the availability of very hot (28-32 °C) and very humid (96-100%) roost sites in caves and/or abandoned mine voids (Armstrong 2001; Van Dyck and Strahan 2008). There are also populations of the non-Pilbara form of the Orange Leaf-nosed Bat (*R. aurantia*) in the Kimberley and Northern Territory (Van Dyck and Strahan 2008).

Ecology: A nocturnal, aerial insectivore (DAWE 2020k).

Expected occurrence: Irregular Visitor. Suitable roost sites are not present in the project area, however these bats may over-fly the area while foraging.

3.2.5.2 Conservation Significance 2

Lerista planiventralis maryani CS2 (P1)

Conservation status: Listed as Priority 1 by DBCA and is of concern because this subspecies is restricted to an area between Onslow and Barridale, and is known from a small number of records.

Distribution and habitat: This subspecies occurs in sandy areas along the north-west coast between Onslow and Barridale (Wilson and Swan 2017).

Ecology: A fossorial species that feeds on invertebrates (Wilson and Swan 2017).

Expected occurrence: Resident. It was recorded around Onslow by Bancroft and Bamford (2005b) and was found only in near-coastal sands. VSA 1 consists of sand-dunes which may provide suitable habitat, although they are not near-coastal. Dunes in the Alternative C area are closest to the coast.

Brush-tailed Mulgara (*Dasycercus blythi*) CS2 (P4)

Conservation status: Listed as Priority 4 by DBCA.

Distribution and habitat: Pilbara and inland, central Western Australia, as well as central Australia (southern Northern Territory and northern South Australia). This species is often compared with its congener, the Crest-tailed Mulgara (*D. cristicauda*), as the two are sympatric over parts of their range (Van Dyck and Strahan 2008). In general, the Brush-tailed Mulgara is less closely associated with the dune fields than the Crest-tailed Mulgara (Woolley *et al.* 2013). Where the two co-occur, the Crest-tailed Mulgara is restricted to sandridges with an understorey dominated by spinifex (*Triodia*), whereas the Brush-tailed Mulgara occupies sand plain and gibber plain (Pavey *et al.* 2011).

Ecology: A nocturnal predator, the Brush-tailed Mulgara is among the largest native predatory mammals remaining in Australia's deserts (Pavey *et al.* 2011). It's main prey include rodents, other dasyurid marsupials, reptiles, small birds and a wide range of invertebrate taxa (Pavey *et al.* 2011). Generally solitary (Van Dyck and Strahan 2008). This species constructs characteristic burrows for shelter (Triggs 1996; Van Dyck and Strahan 2008).

Expected occurrence: Regular Visitor. The Brush-tailed Mulgara is found in mature spinifex grasslands on sandy and sandy-loam soils, and it has been recorded nearby (Rapallo 2011; confused with the Crest-tailed Mulgara at the time). Burrows of this species are fairly easy to locate but no evidence of the species was found during the site inspection. Despite this, some suitable habitat was present and therefore with nearby records, it may at least visit the project area occasionally.

Short-tailed Mouse (*Leggadina lakedownensis*) CS2 (P4)

Conservation status: Listed as Priority 4 by DBCA.

Distribution and habitat: Northern Pilbara through the Kimberley and into northern Australia (Van Dyck and Strahan 2008), inhabiting a range of environments including spinifex and tussock grasslands, samphire and sedgelands, *Acacia* shrublands, tropical *Eucalyptus* and *Melaleuca* woodlands and stony ranges (Van Dyck and Strahan 2008). Usually associated with areas that are seasonally inundated on red or white sandy-clay soils (Van Dyck and Strahan 2008). The Pilbara population, which may represent a distinct taxon (Van Dyck and Strahan 2008), has a preference for sandy and cracking clay/gilgai soils (B. Metcalf pers. obs.).

Ecology: Nocturnal and solitary, the Short-tailed Mouse feeds predominately on invertebrates but may also supplement its diet with plant material (Van Dyck and Strahan 2008). Populations of the Short-tailed Mouse appear to fluctuate dramatically, probably in response to environmental conditions and food availability.

Expected occurrence: Resident. The species has been recorded in the area during surveys conducted for Onslow Salt in the 1990s (Biota) and in tussock grassland on clay soils 20 km west of Nanutarra in the late 2000s (BCE database). VSA 2 may thus provide suitable habitat in the project area.

3.2.5.3 Conservation Significance 3

Flock Bronzewing (*Phaps histrionica*) CS3 (LS)

Conservation status: This species has declined across much of its range in Western Australia and was formerly listed as a priority species.

Distribution and habitat: Treeless or sparsely wooded grassy plains of the coastal north-west (Pilbara), south Kimberley and adjacent north-eastern interior of Western Australia (Johnstone and Storr 1998). Also inland Australia (Menkhorst *et al.* 2017).

Ecology: Granivorous and requires open water for drinking (Johnstone and Storr 1998). Gregarious, and irregular in movements and occurrence within Western Australia, with populations fluctuating in response to seasonal conditions (Johnstone and Storr 1998; Menkhorst *et al.* 2017).

Expected occurrence: Resident. Small numbers are consistently recorded around Onslow, including by Bancroft and Bamford (2018). This could even be a local population that is persisting in the western Pilbara. It is therefore considered to be locally significant.

Brush-tailed Possum (*Trichosurus vulpecula*) CS3 (LS)

Conservation status: The Brush-tailed Possum is rarely recorded in the Pilbara and a recent request from the DBCA has been made for records.

Distribution and habitat: Formerly distributed across almost the whole of Australia, the Brush-tailed Possum's range has now been reduced in Western Australia to the south-west, the Kimberley and an isolated population within the north-western Pilbara, including offshore islands (Van Dyck and Strahan 2008). There may be other outlying Pilbara records (M. Bamford, pers. obs). It occurs in a wide variety of habitats that usually encompass trees, including forests, woodlands, riparian zones and urban areas, but it also persists in treeless landscapes such as Barrow Island (Van Dyck and Strahan 2008).

Ecology: A nocturnal herbivore, its preferred diet is predominantly leaves, flowers and fruits (Van Dyck and Strahan 2008).

Expected occurrence: Irregular Visitor. It is likely to be resident along the Ashburton River but individuals are expected in the project area only as irregular visitors.

3.3 Patterns of biodiversity

Investigating patterns of biodiversity can be complex and are often beyond the scope even of detailed or targeted investigations (see Section 2.1 above), but it is possible to draw some general conclusions based upon the different landscapes in the project area and on the number of previous studies that have taken place in the Onslow area. The following several patterns of biodiversity can be concluded:

- The most structurally diverse vegetation (VSA 1 where there are abundant low and tall shrubs on sandy and sandy-loam soils) is most likely to support a rich fauna assemblage including fossorial reptiles and a large suite of shrubland-dependent birds.
- Areas of high weed invasion (Mesquite and Buffel Grass), mostly in VSA 2, may be low in fauna species richness, although the value of these introduced species as fauna habitat has not been properly investigated.
- Termite mounds have been identified as supporting concentrations of reptile species at high densities (Thompson and Thompson 2020). These mounds occur within VSA 2.

- Claypans and their margins will be seasonally or intermittently important for waterbirds and while the numbers are not expected to be high, this will contribute to waterbird abundance in the Onslow area. Claypans will support aquatic macro-invertebrates but these are likely to be widespread.

Based on these patterns of biodiversity, the proposed Hydromet process plant site has the best-developed dunes (VSA 1), but Alternative A has the greatest complexity of the three main VSAs; this complexity is likely to support the highest biodiversity of any of the areas. However, Alternative B is notable for a cluster of termite mounds in the south-west corner and this small area may be unusually rich in species and abundance or reptiles.

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 (see Appendix 4 for descriptions and other ecological processes). These include the aspects discussed below.

Local hydrology. The project area includes claypans that are part of an interconnected system of claypans and drainage systems. All except VSA 1 are probably groundwater dependent, and even in VSA1 the larger shrubs that are sometimes present may be affected by local hydrology. Alterations to local hydrology may affect vegetation condition (discussed below under impacts) and therefore fauna habitat.

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.

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. They have contributed to local extinctions and may be affecting populations of extant species. The landscape and vegetation in the project area has been altered through grazing by feral species, such as the Rabbit, and by livestock.

Habitat degradation due to weed invasion. Weed invasion has substantially altered some VSAs. Weed invasion can be exacerbated by earthworks and developments (discussed further in Section 4).

3.5 Summary of fauna values

The desktop study identified 303 vertebrate fauna species as potentially occurring in the project area (7 frogs, 89 reptiles, 166 birds and 41 mammals). The presence of at least 20 species (four reptiles, 15 birds and one mammal) was confirmed during the 2020 site inspection (as indicated in Appendix 5. Details on methodology of key previous surveys sourced in the current assessment.

Title	Methods used

Assessment of the Terrestrial Fauna of the Proposed BHP Billiton Onslow LNG Plant Repeat survey for terrestrial fauna at the proposed site of the BHP Billiton Onslow LNG Plant, Onslow, September 2005 Fauna surveys of the Proposed Locations of BHP Billiton's Onslow Gas Processing Plant Components, November 2006.	**Level 2 survey (Detailed)** Review of databases and literature Site inspection (27-28th September 2004) • All mainland areas of site visited • Notes made regarding available habitat and opportunistic observations of fa Field survey (9-17th December 2004) • Focused on locations that have been poorly represented in previous studies • For frogs, reptiles, and mammals: o 2 transects with 30 pitfall traps, 15 baited Elliot traps, and 24 funne o 1 transect with 20 pitfall traps, 10 baited Elliot traps and 16 funnel t o Each transect was operated for 5 nights. Total sampling effort = 350 280 funnel-trap nights. • For birds: o birds observed or heard within 50m of each trapping transect were o Targeted bird surveys at Four Mile Creek and Beadon Creek (at leas location, low and hide tide). o Opportunistic sightings recorded • One spotlighting survey (on foot) conducted per transect, from dusk until ~2 • Limitations: no bat surveys, limited hand searching Field survey (5-12th September 2005) • Similar transect locations to Bancroft and Bamford (2005a) o Transect 1 relocated to maximise change of capturing *Leggadina lal* For frogs, reptiles, mammals: o Each transect was operated for 5 nights and comprised 20 pitfall tra 10 funnel traps o Total sampling effort = 300 pitfall-, 300 Elliott- and 150 funnel-trap • For birds: o Birds observed or heard within 50m of each trapping transect were o Targeted bird surveys at Four Mile Creek and Beadon Creek o Opportunistic sightings recorded • For bats: survey at Beadon Creek 9-10th September 2005 o Echolocation calls recorded and analysed using Anabat detector and • One spotlighting survey (on foot) conducted per transect, from dusk until ~2 • Limitations: limited hand searching. Motion-sensitive cameras were not ava survey, but fauna that could have been detected by cameras weer detected Update and review of databases and literature (including previous fauna survey Site inspection • To familiarise consultants with the environment and fauna habitats of the a Field survey (12-19th November 2006) • Trapping for frogs, reptiles, and mammals: o Pitfall traps, funnel traps and Elliot traps were deployed in various f sites. Traps at each site were operated for 5 nights. o Total sampling effort: ▪ Beadon Creek, 85 pitfall-, 85 funnel-, 40 Elliot- trap nights ▪ Camp site: 150 pitfall-, 150 funnel-, 0 Elliot- trap nights ▪ LNG plant site: 85 pitfall-, 85 funnel-, 150 Elliot- trap nights

Fauna Assessment: BHP Billiton Petroleum Pty Ltd Macedon Gas Development. Terrestrial Plant Site and Linear Infrastructure Corridor.	**Level 1 with some elements of Level 2** (Basic and Targeted; extended site inspe scheduled and priority species). Aim of field surveys was to develop understand and general ecological processes of the site, and search for evidence of significa Review of databases. Site inspection (8-12th September 2008) • Evidence of significant species; walk through habitat recording diggings, bur tracks, droppings etc. • Spotlighting included on foot (with head-torch) and by vehicle (with hand-h counted, identified, and captured if necessary for identification • Micro-habitat searching; focused on mesic refugia likely to be important for invertebrates • Opportunistic sightings recorded during all other survey work.
Survey for Migratory Waterbirds in the Wheatstone LNG Project Area, November 2008 and March 2009.	**Targeted.** Review of databases and literature Two field surveys conducted and birds identified and counted • 12-16th November 2008 – ground surveys, visited all wetlands in survey area coastline. • 15-17th March 2009 – some ground surveys, plus aerial surveys of entire sur purpose of counting waterbirds with some identification

Wheatstone Project Terrestrial Fauna Survey.	**Level 2 survey** (Detailed)
	
	Review of databases and literature
	
	Single phase field survey (14th-23rd April 2009)
	• Systematic census of terrestrial fauna (including birds, mammals, frogs and trapping sites within 7 habitat types.
	• Mammals, frogs, reptiles:
	  ○ Each site contained 10 pitfall traps (connected by drift fence). 5 site funnel traps (n=6) and Elliot traps (n=10)
	  ○ Total trapping effort: 950 pitfall-, 150 funnel-, and 500 Elliot- trap n
	• Bats: sampled via harp nets and echolocation call recordings (using Anabat
	  ○ Total of 12 harp trap nights and 12 echolocation sampling nights
	• Birds: 32 bird surveys conducted over 16 trapping sites.
	  ○ 30-minute censuses conducted between 7am-1pm
	  ○ Total of 16 hours dedicated to systematic bird surveys
	  ○ Opportunistic observations also recorded.
	• Short-range endemic invertebrates
	  ○ sampled at the 16 primary sites, plus an additional 8 sites
	• non-systematic sampling also conducted
	  ○ habitat specific searches for Schedule and Priority species
	  ○ documentation of opportunistic sightings
	  ○ identification of road-kills and animal remains
	  ○ recording secondary signs (tracks, scats, diggings)
	• Limitations: single season survey

Wheatstone Project Claypan Ephemeral Fauna Survey	**Targeted survey** (claypan aquatic invertebrates) Desktop review Field survey • Survey conducted in three phases over a two month period in early 2009 fol • Twenty-four wetland sites were sampled; 12 in impacts areas and 12 in refe • Sampling methods were standard for aquatic invertebrates with nets of diffe zooplankton and macroinvertebrates.
Wheatstone Project Subterranean Fauna Assessment	**Targeted survey** (subterranean fauna) Desktop review Field survey • Thirty boreholes sampled for both troglofaunal (above the water table) and water table), across impact and reference areas. • Sampling took place over three phases from July to October 2009, with a tot sampling days (ie traps down boreholes). • Sampling based on traps and modified plankton nets and replicated in each replicates).

ANSIA Stage 2 Fauna Assessment	**Level 1 survey** (Basic)
	Review of databases and literature
	Targeted site inspection (6-7th August 2018)
	• Walking through and driving through areas to familiarise consultants with s
	  ○ Identification of VSAs
	  ○ Targeted search for significant fauna
	  ○ Continuous recording of bird species observed
	  ○ Opportunistic fauna observations

A comparison of an environmental impact assessment (EIA) vertebrate fauna survey with a post-approval fauna salvage program: consequences of not adhering to EIA survey guidelines, a Western Australian example.	• Comparison between EIA fauna survey and fauna salvage program • Does not present species lists or raw data in this document, but discusses d EIA survey and fauna salvage • Identifies major limitations of trapping-based surveys for terrestrial fauna a results of extensive searching carried out for fauna 'salvage' prior to clearin
Review of the Possible Impacts of the Scarborough Project on Birds (particularly Migratory Waterbirds)	**Targeted.** Review of databases and literature on potential for interactions betw facility. Review of literature regarding impacts of oil and gas facilities on wildlife.

Appendix 6 and listed in Appendix 7).

Fauna assemblage. Moderately intact but with a suite of mammal species locally extinct. The assemblage is not particularly rich because the landscape provides a limited range of habitats, and includes a large proportion of visitors among the birds which may only be present during wet periods. The assemblage is distinctive in that it includes several reptile species that are restricted to sandy soils of the greater Onslow to Exmouth Gulf region.

Species of conservation significance. Of the 42 species of conservation significance recorded or that may be present in the project area, only three are expected to occur as residents: *Lerista planiventralis maryani* (CS2), Flock Bronzewing (CS3) and Short-tailed Mouse (CS2). Only three conservation significant species are expected as regular visitors: Pilbara Olive Python (CS1), Barn Swallow (CS1) and Brush-tailed Mulgara (CS2). The remaining species are expected to be irregular visitors or vagrants; the majority of these are waterbirds that will visit the claypans when they flood. Waterbirds include migratory species but previous studies suggest only small numbers are likely to be present. No currently listed threatened or priority invertebrate fauna are expected to occur within the project area.

Vegetation and Substrate Associations (VSAs). The project area encompasses four VSAs which reflect landscape position and soil type. The VSAs are quite widespread in the great Onslow region, but the claypans are restricted in extent.

Patterns of biodiversity. VSA1 is likely to be richest in fauna species due to the soil type and structural complexity of vegetation. Areas of VSA1 with the greatest shrub development may be particularly rich. Claypans and chenopod shrublands (VSA 2) may not be rich in species, but can be expected to support a distinct assemblage. There are a few significant species with distinct patterns of distribution, including the lizard *L. planiventralis maryani* probably restricted to sandy soils in the north, and the Short-tailed Mouse restricted to heavy soils of VSA 2. Areas of termite mounds in VSA 2 are likely to support high richness and abundance of reptiles.

Key ecological processes. The ecological processes that currently have major effects upon the fauna assemblage include hydrology, the presence of feral species, fire, and habitat degradation (due to weeds).

4 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 adjacent to sites already developed in similar landscapes. Impact categories are defined in Table 8.

Habitat loss leading to population decline. *Minor*

The proposed action will result in loss of native vegetation in an area where some clearing has already occurred. Similar landscapes have been developed for the nearby salt works, gas plant and for nearby industrial developments. Development of the project area will therefore contribute to cumulative impact on the local fauna assemblage and while this is still represented in the greater Onslow region, it does represent further loss. The salt works in particular have led to habitat loss of a very large area from just west of the Onslow road to several kilometres east of Onslow Road. On its own, the proposed Onslow Rare Earth Plant is a Minor impact in terms of habitat loss and population decline, as not all the project area will be developed, but the cumulative impact (i.e. combined impact of the range of developments in the area to which the Hastings Project contributes) is Moderate.

Habitat loss leading to population fragmentation. *Negligible*

The development footprint is compact and therefore will not contribute greatly to population fragmentation. Impact would be Negligible.

Degradation of habitat due to weed invasion. *Minor*

The level of weed invasion is variable through the project area but high in some locations. There is potential for development to increase the spread of weeds but standard hygiene measures are likely to be in place to reduce this risk. Impact could be Minor.

Mortality during construction. *Negligible to Minor*

This is a concern mostly on animal welfare grounds, as the development area is small across the overall landscape and significant species will most likely be unaffected. There is a slight chance of the Brush-tailed Mulgara being present in sandy soils, but the species was not found during the site inspection. There are standard practices for reducing fauna mortality during development, such as managing trenches. Thompson and Thompson (2020) reported large numbers of reptiles in termite mounds in the Onslow area, and while termite mounds were almost absent from the project area, there were a few mounds present and these could be checked and fauna moved if they fell within the clearing footprint. Mortality during construction should have a Negligible to Minor impact.

Ongoing mortality. *Minor*

This results mainly from roadkill, fauna striking infrastructure and effects of lighting. Impacts are likely to be Minor but the risk of birds striking infrastructure may need to be considered. For example, if cables and chain link fences are located close to retained claypans, there may be a risk of waterbird mortality. Impacts of additional lighting upon invertebrates is largely unknown.

Species interactions. *Minor*

Some of the fauna is sensitive to feral species such as Foxes and Cats. These are present already, but during construction in particular, feral species may be attracted to work-sites and may gain improved

access into native vegetation. Impacts can be kept to Minor through standard practices such as not feeding wildlife, managing waste and even implementing some feral species control.

Hydrological change. *Minor*

There may be some risk of hydrological change affecting vegetation outside areas of direct impact, although the hydrological interaction between claypans is uncertain. Hydrological change can probably be minimised through design and planning to ensure no more than a Minor impact.

Altered fire regimes. *Negligible to Minor*

The vegetation of the project area is generally fire-dependent and probably already subject to regular fires. The development of Onslow Rare Earth Plant may lead to an increase in fire frequency, but could also lead to improved fire management such as a reduction in the area of each fire. Given the recent history of probably regular and extensive fires, any slight change in the fire regime is likely to have a Negligible to Minor impact.

Disturbance (dust, noise, light). *Negligible to Minor*

The level of dust, noise and light during construction has the potential to result in short-term impacts, but there are standard management procedures to minimise these. As noted above, impacts of additional lighting upon invertebrates is largely unknown.

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6 Appendices

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.

<u>Conservation Significance (CS) 1: Species listed under State or Commonwealth Acts</u>.

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)" (DAWE 2020i). The EEZ extends to 200 nautical miles (approximately 350 kilometres) from the coast (DAWE 2020i). 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.

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).

Appendix 3. 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 4). 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 DotE (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 (DotE 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 DotE (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.

Appendix 4. 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 20 key threatening processes listed by the federal Department of the Environment (DotE 2014b):

- 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 km^2 (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?

Appendix 5. Details on methodology of key previous surveys sourced in the current assessment.

Title	Methods used
Assessment of the Terrestrial Fauna of the Proposed BHP Billiton Onslow LNG Plant Repeat survey for terrestrial fauna at the proposed site of the BHP Billiton Onslow LNG Plant, Onslow, September 2005 Fauna surveys of the Proposed Locations of BHP Billiton's Onslow Gas Processing Plant Components, November 2006.	**Level 2 survey (Detailed)** <u>Review of databases and literature</u> <u>Site inspection (27-28th September 2004)</u> • All mainland areas of site visited • Notes made regarding available habitat and opportunistic observations of fa <u>Field survey (9-17th December 2004)</u> • Focused on locations that have been poorly represented in previous studies • For frogs, reptiles, and mammals: o 2 transects with 30 pitfall traps, 15 baited Elliot traps, and 24 funne o 1 transect with 20 pitfall traps, 10 baited Elliot traps and 16 funnel t o Each transect was operated for 5 nights. Total sampling effort = 350 280 funnel-trap nights. • For birds: o birds observed or heard within 50m of each trapping transect were o Targeted bird surveys at Four Mile Creek and Beadon Creek (at leas location, low and hide tide). o Opportunistic sightings recorded • One spotlighting survey (on foot) conducted per transect, from dusk until ~2 • Limitations: no bat surveys, limited hand searching <u>Field survey (5-12th September 2005)</u> • Similar transect locations to Bancroft and Bamford (2005a) o Transect 1 relocated to maximise change of capturing *Leggadina lal* For frogs, reptiles, mammals: o Each transect was operated for 5 nights and comprised 20 pitfall tra 10 funnel traps o Total sampling effort = 300 pitfall-, 300 Elliott- and 150 funnel-trap • For birds: o Birds observed or heard within 50m of each trapping transect were o Targeted bird surveys at Four Mile Creek and Beadon Creek o Opportunistic sightings recorded • For bats: survey at Beadon Creek 9-10th September 2005 o Echolocation calls recorded and analysed using Anabat detector and • One spotlighting survey (on foot) conducted per transect, from dusk until ~2 • Limitations: limited hand searching. Motion-sensitive cameras were not ava survey, but fauna that could have been detected by cameras weer detected <u>Update and review of databases and literature (including previous fauna survey</u> <u>Site inspection</u> • To familiarise consultants with the environment and fauna habitats of the a <u>Field survey (12-19th November 2006)</u> • Trapping for frogs, reptiles, and mammals: o Pitfall traps, funnel traps and Elliot traps were deployed in various f sites. Traps at each site were operated for 5 nights. o Total sampling effort: ▪ Beadon Creek, 85 pitfall-, 85 funnel-, 40 Elliot- trap nights

	▪ Camp site: 150 pitfall-, 150 funnel-, 0 Elliot- trap nights ▪ LNG plant site: 85 pitfall-, 85 funnel-, 150 Elliot- trap nights
Fauna Assessment: BHP Billiton Petroleum Pty Ltd Macedon Gas Development. Terrestrial Plant Site and Linear Infrastructure Corridor.	**Level 1 with some elements of Level 2** (Basic and Targeted; extended site inspe scheduled and priority species). Aim of field surveys was to develop understand and general ecological processes of the site, and search for evidence of significa Review of databases. Site inspection (8-12th September 2008) • Evidence of significant species; walk through habitat recording diggings, bur tracks, droppings etc. • Spotlighting included on foot (with head-torch) and by vehicle (with hand-h counted, identified, and captured if necessary for identification • Micro-habitat searching; focused on mesic refugia likely to be important for invertebrates • Opportunistic sightings recorded during all other survey work.
Survey for Migratory Waterbirds in the Wheatstone LNG Project Area, November 2008 and March 2009.	**Targeted.** Review of databases and literature Two field surveys conducted and birds identified and counted • 12-16th November 2008 – ground surveys, visited all wetlands in survey area coastline. • 15-17th March 2009 – some ground surveys, plus aerial surveys of entire sur purpose of counting waterbirds with some identification
Wheatstone Project Terrestrial Fauna Survey.	**Level 2 survey** (Detailed) Review of databases and literature Single phase field survey (14th-23rd April 2009) • Systematic census of terrestrial fauna (including birds, mammals, frogs and trapping sites within 7 habitat types. • Mammals, frogs, reptiles: o Each site contained 10 pitfall traps (connected by drift fence). 5 site funnel traps (n=6) and Elliot traps (n=10) o Total trapping effort: 950 pitfall-, 150 funnel-, and 500 Elliot- trap n • Bats: sampled via harp nets and echolocation call recordings (using Anabat o Total of 12 harp trap nights and 12 echolocation sampling nights • Birds: 32 bird surveys conducted over 16 trapping sites. o 30-minute censuses conducted between 7am-1pm o Total of 16 hours dedicated to systematic bird surveys o Opportunistic observations also recorded. • Short-range endemic invertebrates o sampled at the 16 primary sites, plus an additional 8 sites • non-systematic sampling also conducted o habitat specific searches for Schedule and Priority species o documentation of opportunistic sightings o identification of road-kills and animal remains o recording secondary signs (tracks, scats, diggings) • Limitations: single season survey

Wheatstone Project Claypan Ephemeral Fauna Survey	**Targeted survey** (claypan aquatic invertebrates) Desktop review Field survey • Survey conducted in three phases over a two month period in early 2009 fol • Twenty-four wetland sites were sampled; 12 in impacts areas and 12 in refe • Sampling methods were standard for aquatic invertebrates with nets of diffe zooplankton and macroinvertebrates.
Wheatstone Project Subterranean Fauna Assessment	**Targeted survey** (subterranean fauna) Desktop review Field survey • Thirty boreholes sampled for both troglofaunal (above the water table) and water table), across impact and reference areas. • Sampling took place over three phases from July to October 2009, with a tot sampling days (ie traps down boreholes). • Sampling based on traps and modified plankton nets and replicated in each replicates).

ANSIA Stage 2 Fauna Assessment	**Level 1 survey** (Basic)
	Review of databases and literature
	Targeted site inspection (6-7th August 2018)
	• Walking through and driving through areas to familiarise consultants with s
	  ○ Identification of VSAs
	  ○ Targeted search for significant fauna
	  ○ Continuous recording of bird species observed
	  ○ Opportunistic fauna observations

A comparison of an environmental impact assessment (EIA) vertebrate fauna survey with a post-approval fauna salvage program: consequences of not adhering to EIA survey guidelines, a Western Australian example.	• Comparison between EIA fauna survey and fauna salvage program • Does not present species lists or raw data in this document, but discusses d EIA survey and fauna salvage • Identifies major limitations of trapping-based surveys for terrestrial fauna a results of extensive searching carried out for fauna 'salvage' prior to clearin
Review of the Possible Impacts of the Scarborough Project on Birds (particularly Migratory Waterbirds)	**Targeted.** Review of databases and literature on potential for interactions betw facility. Review of literature regarding impacts of oil and gas facilities on wildlife.

Appendix 6. Vertebrate fauna expected to occur in the project area.

The list is derived from the results of database and literature searches, and from previous field surveys conducted in the local area. The sources are: ALA = Atlas of Living Australia database search; BCE (2005) = Bancroft and Bamford (2005a); BCE (2009) = Smith *et al*. (2009); BCE (2018) = Bancroft and Bamford (2018); Biota (2010) = Biota (2010b); ENV (2012) = ENV (2012b) ; NatureMap = NatureMap database search, Thompson (2020) = Thompson and Thompson (2020).
CS1, CS2, CS3 = (summary) levels of conservation significance. See Appendix 1 for full explanation.
EPBC Act listings: E = Endangered, V = Vulnerable, M = Migratory (see Appendix 2).
Wildlife Conservation Act 1950 listings: S1 to S7 = Schedules 1 to 7 (see Appendix 2).
DBCA Priority species: P1 to P4 = Priority 1 to 4 (see Appendix 2).
LS = considered to be of local significance by Bamford Consulting Ecologists (see Appendix 1).
Int = introduced species.
See Section 0 for explanation of expected occurrence categories.
+ = species listed as recorded/expected.
Categories within the '2020 Inspection' (results from this survey, by BCE) field: X = species recorded within the project area; x = indirect evidence of species within the project area; o = species recorded in the general vicinity but outside of the project area.
Species returned from the literature review but omitted from the expected species list because of habitat or range limitations, or because they are considered locally extinct are listed in

Appendix 8.

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	ALA	BCE (2005)	BCE (2009)	BCE (2018)	Biota (2010)	ENV (2012)	NatureMap	Thompson (2020)	2020 Inspection	2020 ANNOTATIONS
FROGS													
Hylidae (Tree frogs)													
Cyclorana maini	Sheep Frog		Resident	+	+	+		+	+	+	+		
Cyclorana occidentalis	Western Water-holding Frog		Irregular visitor								+		
Litoria rubella	Little Red Tree Frog		Regular visitor	+	+	+		+	+	+	+		
Limnodynastidae (Burrowing frogs)													
Neobatrachus aquilonius	Northern Burrowing Frog		Resident	+	+	+		+	+	+	+		
Neobatrachus fulvus	Northern Burrowing Frog		Resident					+		+	+		
Notaden nichollsi	Desert Spadefoot		Resident	+	+	+		+	+	+	+		
Platyplectrum spenceri	Centralian Burrowing Frog		Resident		+								
REPTILES													
Carphodactylidae (Carphodactylid geckoes)													
Nephrurus levis occidentalis			Resident	+	+			+	+	+	+		
Diplodactylidae (Diplodactylid geckoes)													
Crenadactylus occidentalis	Western Clawless Gecko		Resident		+	+							
Crenadactylus pilbarensis	Pilbara Clawless Gecko		Resident		+	+							
Diplodactylus bilybara	Western Fat-tailed Gecko		Resident	+							+		
Diplodactylus pulcher			Resident	+				+	+	+			

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	ALA	BCE (2005)	BCE (2009)	BCE (2018)	Biota (2010)	ENV (2012)	NatureMap	Thompson (2020)	2020 Inspection	2020 ANNOTATIONS
Lucasium stenodactylum			Resident	+				+	+	+	+		
Rhynchoedura ornata	Western Beaked Gecko		Resident	+				+	+	+			
Strophurus jeanae			Resident	+	+	+		+	+	+	+		
Strophurus strophurus			Resident	+	+			+	+	+	+		
Gekkonidae (Gekkonid geckoes)													
Gehyra crypta			Resident				+						
Gehyra pilbara			Resident	+	+			+	+	+	+		
Gehyra purpurascens			Resident	+				+	+	+			
Gehyra variegata			Resident	+	+			+	+	+	+		
Heteronotia binoei	Bynoe's Gecko		Resident	+	+	+		+	+	+	+		
Pygopodidae (Legless lizards)													
Delma borea			Resident		+	+							
Delma butleri			Resident	+				+		+	+		
Delma nasuta			Resident		+	+		+	+	+			
Delma pax			Resident		+	+		+	+				
Delma tincta			Resident	+	+	+		+	+	+	+		
Lialis burtonis	Burton’s Legless-Lizard		Resident	+	+	+		+	+	+	+		
Pygopus nigriceps	Hooded Scaleyfoot		Resident	+	+	+		+	+	+	+		
Agamidae (Dragons)													
Ctenophorus clayi	Collared Dragon		Resident		+								

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	ALA	BCE (2005)	BCE (2009)	BCE (2018)	Biota (2010)	ENV (2012)	NatureMap	Thompson (2020)	2020 Inspection	2020 ANNOTATIONS
Ctenophorus femoralis	Dune Dragon		Resident	+	+	+		+	+	+	+		
Ctenophorus isolepis isolepis	Central Military Dragon		Resident	+	+	+		+	+	+	+	X	Seen in Alternative C.
Ctenophorus nuchalis	Central Netted Dragon		Resident	+	+	+		+	+	+	+		
Ctenophorus reticulatus	Western Netted Dragon		Resident		+	+			+				
Ctenophorus rubens	Red Dragon		Resident	+	+	+		+	+	+	+		
Diporiphora adductus	Carnarvon Dragon		Resident	+	+	+		+	+	+	+		
Gowidon longirostris	Long-nosed Dragon		Resident		+			+	+	+	+		
Lophognathus gilberti	Ta-Ta or Gilbert's Dragon		Irregular visitor								+		
Pogona minor minor	Western Bearded Dragon		Resident	+	+	+		+	+	+	+		
Tympanocryptis cephalus	Coastal Pebble-mimic Dragon		Resident		+			+					
Scincidae (Skinks)													
Carlia munda			Resident		+	+							
Cryptoblepharus plagiocephalus			Resident		+	+							
Ctenotus calurus			Resident					+	+	+	+		
Ctenotus duricola			Resident		+	+		+	+				
Ctenotus grandis titan			Resident	+	+	+		+	+	+	+		
Ctenotus hanloni			Resident	+	+	+		+	+	+	+		
Ctenotus helenae			Resident		+	+		+	+				
Ctenotus iapetus			Resident	+	+	+		+	+	+	+		
Ctenotus maryani			Resident	+	+	+		+	+	+	+		

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	ALA	BCE (2005)	BCE (2009)	BCE (2018)	Biota (2010)	ENV (2012)	NatureMap	Thompson (2020)	2020 Inspection	2020 ANNOTATIONS
Ctenotus pantherinus ocellifer			Resident	+	+	+		+	+	+	+	X	One seen in Alternative A area.
Ctenotus rufescens			Resident		+	+		+	+	+	+		
Ctenotus saxatilis	Rock Ctenotus		Irregular Visitor		+	+		+	+	+			
Ctenotus schomburgkii			Resident		+	+		+	+	+			
Ctenotus serventyi			Resident		+	+							
Cyclodomorphus melanops melanops			Resident		+	+		+	+				
Egernia depressa	Southern Pygmy Spiny-tailed Skink		Resident					+					
Eremiascincus isolepis			Resident	+	+			+	+				
Eremiascincus pallidus	Western Narrow-banded Skink		Resident	+	+	+		+	+	+	+		
Lerista baynesi			Resident						+	+			
Lerista bipes			Resident	+	+	+		+	+	+	+		
Lerista clara			Resident	+				+	+	+	+		
Lerista elegans			Resident	+	+	+		+	+	+			
Lerista muelleri			Resident								+		
Lerista onsloviana			Resident	+	+			+	+	+	+		
Lerista planiventralis maryani		CS2 (P1)	Resident	+	+	+		+	+	+			
Lerista uniduo			Resident	+				+	+	+			
Menetia greyii	Dwarf Skink		Resident	+	+	+		+	+	+	+		
Morethia ruficauda exquisita			Resident	+	+	+		+	+	+			
Notoscincus ornatus ornatus			Resident		+	+		+					

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	ALA	BCE (2005)	BCE (2009)	BCE (2018)	Biota (2010)	ENV (2012)	NatureMap	Thompson (2020)	2020 Inspection	2020 ANNOTATIONS
Tiliqua multifasciata	Central Blue-tongue		Resident	+	+	+		+	+	+	+		
Varanidae (Monitors and goannas)													
Varanus acanthurus	Spiny-tailed Goanna		Resident		+	+		+		+	+		
Varanus brevicauda	Short-tailed Pygmy Goanna		Resident	+	+	+		+	+	+	+		
Varanus caudolineatus			Resident					+	+	+	+		
Varanus eremius	Pygmy Desert Goanna		Resident	+	+	+	+	+	+	+	+	X	One seen in Alternative A area.
Varanus gouldii	Bungarra or Sand Goanna		Resident	+	+	+		+	+	+	+		
Varanus panoptes rubidus	Spotted Monitor		Resident		+	+		+	+	+	+	X	Large adult beside termite mound in in Alternative B area.
Varanus tristis tristis	Tree Goanna		Resident	+	+	+		+	+	+			
Typhlopidae (Blind snakes)													
Anilios ammodytes			Resident	+	+			+	+		+		
Anilios grypus			Resident	+	+			+	+		+		
Anilios hamatus			Resident	+	+			+	+		+		
Anilios pilbarensis			Resident								+		
Pythonidae (Pythons)													
Antaresia perthensis	Pygmy Python		Resident		+	+			+				
Antaresia stimsoni stimsoni	Stimson's Python		Resident	+	+	+		+	+	+	+		
Aspidites melanocephalus	Black-headed Python		Resident		+	+		+	+	+	+		
Liasis olivaceus barroni	Pilbara Olive Python	CS1 (V,S3)	Irregular Visitor					+		+			
Elapidae (Venomous land snakes)													

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	ALA	BCE (2005)	BCE (2009)	BCE (2018)	Biota (2010)	ENV (2012)	NatureMap	Thompson (2020)	2020 Inspection	2020 ANNOTATIONS
Acanthophis pyrrhus	Desert Death Adder		Resident								+		
Acanthophis wellsi	Pilbara Death Adder		Resident		+	+							
Brachyurophis approximans			Resident		+	+							
Demansia psammophis cupreiceps	Yellow-faced Whipsnake		Resident	+	+	+		+	+	+	+		
Demansia rufescens	Rufous Whipsnake		Resident		+	+		+					
Furina ornata	Moon Snake		Resident	+	+			+	+	+	+		
Pseudechis australis	Mulga Snake		Resident	+	+	+		+	+	+	+		
Pseudonaja mengdeni	Gwardar; Western Brown Snake		Resident	+						+	+		
Pseudonaja modesta	Ringed Brown Snake		Resident	+	+	+		+	+	+			
Simoselaps anomalus	Desert Banded Snake		Resident	+	+	+		+	+	+	+		
Suta fasciata	Rosen's Snake		Resident		+	+				+	+		
Suta punctata	Spotted Snake		Resident	+	+	+		+	+	+	+		
BIRDS													
Casuariidae (Emus and Cassowaries)													
Dromaius novaehollandiae	Emu		Resident	+	+	+		+		+			
Anatidae (Ducks, Geese and Swans)													
Cygnus atratus	Black Swan		Irregular Visitor			+							
Dendrocygna eytoni	Plumed Whistling-Duck		Irregular Visitor	+									
Malacorhynchus membranaceus	Pink-eared Duck		Irregular Visitor	+									

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	ALA	BCE (2005)	BCE (2009)	BCE (2018)	Biota (2010)	ENV (2012)	NatureMap	Thompson (2020)	2020 Inspection	2020 ANNOTATIONS
Tadorna tadornoides	Australian Shelduck		Irregular Visitor						+				
Aythya australis	Hardhead		Irregular Visitor	+			o		+	+			
Anas superciliosa	Pacific Black Duck		Irregular Visitor	+	+	+	o	+	+	+			
Anas gracilis	Grey Teal		Irregular Visitor	+	+	+		+	+	+			
Chenonetta jubata	Australian Wood Duck		Irregular Visitor	+					+	+			
Phasianidae (Pheasants and Quail)													
Coturnix pectoralis	Stubble Quail		Resident	+	+	+		+		+			
Coturnix ypsilophora	Brown Quail		Resident	+	+	+				+			
Podicipedidae (Grebes)													
Tachybaptus novaehollandiae	Australasian Grebe		Vagrant	+	+	+		+	+	+			
Poliocephalus poliocephalus	Hoary-headed Grebe		Vagrant	+					+	+			
Columbidae (Pigeons and Doves)													
Geophaps plumifera	Spinifex Pigeon		Resident	+	+	+		+	+	+			
Phaps chalcoptera	Common Bronzewing		Resident	+		+			+	+			
Phaps histrionica	Flock Bronzewing	CS3 (LS)	Regular Visitor	+		+	+		+	+			
Ocyphaps lophotes	Crested Pigeon		Resident	+	+	+	+	+	+	+		X	Few seen in Alternative B and C areas.
Geopelia cuneata	Diamond Dove		Resident	+	+	+	+	+	+	+			
Geopelia striata	Peaceful Dove		Resident	+	+	+	+	+	+	+			
Geopelia humeralis	Bar-shouldered Dove		Resident	+	+	+		+	+	+			
Cuculidae (Cuckoos)													

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	ALA	BCE (2005)	BCE (2009)	BCE (2018)	Biota (2010)	ENV (2012)	NatureMap	Thompson (2020)	2020 Inspection	2020 ANNOTATIONS
Centropus phasianinus	Pheasant Coucal		Irregular Visitor	+					+	+			
Chalcites basalis	Horsfield's Bronze-Cuckoo		Regular Visitor	+	+	+	+	+	+	+			
Chalcites osculans	Black-eared Cuckoo		Regular Visitor			+			+	+			
Cacomantis pallidus	Pallid Cuckoo		Regular Visitor	+	+	+			+	+			
Otididae (Bustards)													
Ardeotis australis	Australian Bustard		Resident	+	+	+	+	+	+	+		X	Tracks in all areas.
Podargidae (Frogmouths)													
Podargus strigoides	Tawny Frogmouth		Resident			+				+			
Eurostopodidae (Eared Nightjars)													
Eurostopodus argus	Spotted Nightjar		Resident	+	+	+			+	+			
Aegothelidae (Owlet-nightjars)													
Aegotheles cristatus	Australian Owlet-nightjar		Resident	+		+		+	+	+			
Apodidae (Swifts and Swiftlets)													
Apus pacificus	Fork-tailed Swift	CS1 (M,S5)	Vagrant	+		+		+	+	+			
Rallidae (Crakes, Rails and Swamphens)													
Tribonyx ventralis	Black-tailed Native-hen		Irregular Visitor	+		+			+	+			
Gruidae (Cranes)													
Grus rubicunda	Brolga		Irregular Visitor	+		+	+			+			
Burhinidae (Stone-curlews)													
Burhinus grallarius	Bush Stone-curlew		Irregular Visitor			+				+			

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	ALA	BCE (2005)	BCE (2009)	BCE (2018)	Biota (2010)	ENV (2012)	NatureMap	Thompson (2020)	2020 Inspection	2020 ANNOTATIONS
Recurvirostridae (Stilts and Avocets)													
Cladorhynchus leucocephalus	Banded Stilt		Irregular Visitor	+					+	+			
Recurvirostra novaehollandiae	Red-necked Avocet		Irregular Visitor	+					+	+			
Himantopus leucocephalus	Pied Stilt		Irregular Visitor	+			o		+	+			
Charadriidae (Plovers, Dotterel and Lapwings)													
Pluvialis squatarola	Grey Plover	CS1 (M,S5)	Irregular Visitor	+					+	+			
Pluvialis fulva	Pacific Golden Plover	CS1 (M,S5)	Irregular Visitor	+					+	+			
Charadrius ruficapillus	Red-capped Plover		Irregular Visitor	+					+	+			
Charadrius mongolus	Lesser Sand Plover	CS1 (M,S2,S5)	Irregular Visitor	+					+	+			
Charadrius leschenaultii	Greater Sand Plover	CS1 (M,S3, S5)	Irregular Visitor	+					+	+			
Charadrius veredus	Oriental Plover	CS1 (M,S5)	Irregular Visitor	+					+	+			
Elseyornis melanops	Black-fronted Dotterel		Irregular Visitor	+			o		+	+			
Vanellus tricolor	Banded Lapwing		Irregular Visitor	+		+							
Erythrogonys cinctus	Red-kneed Dotterel		Irregular Visitor	+			o		+	+			
Scolopacidae (Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes)													
Numenius phaeopus	Whimbrel	CS1 (M,S5)	Irregular Visitor	+					+	+			
Numenius minutus	Little Curlew	CS1 (M,S5)	Irregular Visitor	+					+	+			
Numenius madagascariensis	Eastern Curlew	CS1 (C,M,S3,S5)	Irregular Visitor	+					+	+			
Limosa lapponica	Bar-tailed Godwit	CS1 (M,S5)	Irregular Visitor	+			o		+	+			

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	ALA	BCE (2005)	BCE (2009)	BCE (2018)	Biota (2010)	ENV (2012)	NatureMap	Thompson (2020)	2020 Inspection	2020 ANNOTATIONS
Limosa limosa	Black-tailed Godwit	CS1 (M,S5)	Irregular Visitor	+					+	+			
Calidris tenuirostris	Great Knot	CS1 (M,S3,S5)	Irregular Visitor	+					+	+			
Calidris canutus	Red Knot	CS1 (M,S5)	Irregular Visitor	+					+	+			
Limicola falcinellus	Broad-billed Sandpiper	CS1 (M,S5)	Vagrant	+					+	+			
Calidris acuminata	Sharp-tailed Sandpiper	CS1 (M,S5)	Irregular Visitor	+					+	+			
Calidris ferruginea	Curlew Sandpiper	CS1 (C,M,S3,S5)	Irregular Visitor	+					+	+			
Calidris subminuta	Long-toed Stint	CS1 (M,S5)	Irregular Visitor	+					+	+			
Calidris ruficollis	Red-necked Stint	CS1 (M,S5)	Irregular Visitor	+					+	+			
Calidris melanotos	Pectoral Sandpiper	CS1 (M,S5)	Vagrant	+					+	+			
Xenus cinereus	Terek Sandpiper	CS1 (M,S5)	Vagrant	+					+	+			
Actitis hypoleucos	Common Sandpiper	CS1 (M,S5)	Irregular Visitor	+					+	+			
Tringa nebularia	Common Greenshank	CS1 (M,S5)	Irregular Visitor	+					+	+			
Tringa glareola	Wood Sandpiper	CS1 (M,S5)	Irregular Visitor	+					+	+			
Tringa stagnatilis	Marsh Sandpiper	CS1 (M,S5)	Irregular Visitor	+					+	+			
Phalaropus lobatus	Red-necked Phalarope	CS1 (M,S5)	Vagrant	+					+	+			
Turnicidae (Button-quail)													
Turnix velox	Little Button-quail		Resident	+		+	+	+	+	+		x	Tracks in Alternative B and C areas.
Glareolidae (Pratincoles)													
Stiltia isabella	Australian Pratincole		Irregular Visitor	+		+							

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	ALA	BCE (2005)	BCE (2009)	BCE (2018)	Biota (2010)	ENV (2012)	NatureMap	Thompson (2020)	2020 Inspection	2020 ANNOTATIONS
Glareola maldivarum	Oriental Pratincole	CS1 (M,S5)	Irregular Visitor	+	+	+			+	+			
Laridae (Gulls, Terns and Noddies)													
Chroicocephalus novaehollandiae	Silver Gull		Irregular Visitor	+	+	+	o	+	+	+			
Gelochelidon nilotica	Common Gull-billed Tern	CS1 (M,S5)	Irregular Visitor	+	+	+		+	+	+			
Hydroprogne caspia	Caspian Tern	CS1 (M,S5)	Irregular Visitor	+	+	+		+	+	+			
Chlidonias hybrida	Whiskered Tern		Irregular Visitor	+	+	+			+	+			
Chlidonias leucopterus	White-winged Black Tern	CS1 (M,S5)	Irregular Visitor	+	+	+			+	+			
Ciconiidae (Storks)													
Ephippiorhynchus asiaticus	Black-necked Stork		Irregular Visitor	+	+	+			+	+			
Ardeidae (Herons, Egrets and Bitterns)													
Ardea ibis	Cattle Egret		Irregular Visitor	+		+			+				
Ardea pacifica	White-necked Heron		Irregular Visitor	+	+	+	o		+	+			
Ardea modesta	Great Egret		Irregular Visitor	+	+	+	o		+	+			
Ardea intermedia	Intermediate Egret		Irregular Visitor	+	+	+			+	+			
Egretta novaehollandiae	White-faced Heron		Irregular Visitor	+	+	+	o		+	+			
Egretta garzetta	Little Egret		Irregular Visitor	+	+	+			+	+			
Threskiornithidae (Ibis and Spoonbills)													
Threskiornis moluccus	Australian White Ibis		Irregular Visitor	+		+							
Threskiornis spinicollis	Straw-necked Ibis		Irregular Visitor	+	+	+	o		+	+			
Platalea flavipes	Yellow-billed Spoonbill		Irregular Visitor	+	+	+			+	+			

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	ALA	BCE (2005)	BCE (2009)	BCE (2018)	Biota (2010)	ENV (2012)	NatureMap	Thompson (2020)	2020 Inspection	2020 ANNOTATIONS
Platalea regia	Royal Spoonbill		Irregular Visitor	+	+	+	o		+	+			
Plegadis falcinellus	Glossy Ibis	CS1 (M,S5)	Irregular Visitor	+									
Accipitridae (Eagles, Kites, Goshawks)													
Elanus axillaris	Black-shouldered Kite		Resident	+	+	+		+	+	+			
Hamirostra melanosternon	Black-breasted Buzzard		Regular Visitor	+	+	+		+	+	+			
Lophoictinia isura	Square-tailed Kite		Irregular Visitor	+						+			
Aquila audax	Wedge-tailed Eagle		Resident	+	+	+		+	+	+			
Hieraaetus morphnoides	Little Eagle		Resident	+	+	+		+	+	+			
Circus approximans	Swamp Harrier		Vagrant	+	+	+		+	+	+			
Circus assimilis	Spotted Harrier		Regular Visitor	+	+	+		+	+	+			
Accipiter fasciatus	Brown Goshawk		Resident	+		+			+	+			
Accipiter cirrocephalus	Collared Sparrowhawk		Resident	+	+	+	o		+	+			
Haliastur sphenurus	Whistling Kite		Resident	+	+	+	+	+	+	+		X	One over proposed plant area.
Milvus migrans	Black Kite		Resident	+	+	+	+	+	+	+			
Tytonidae (Masked Owls)													
Tyto alba	Barn Owl		Resident	+		+		+	+	+			
Strigidae (Hawk-Owls)													
Ninox connivens	Barking Owl		Resident	+		+			+				
Ninox novaeseelandiae	Southern Boobook		Resident	+	+	+		+	+				
Meropidae (Bee-eaters)													

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	ALA	BCE (2005)	BCE (2009)	BCE (2018)	Biota (2010)	ENV (2012)	NatureMap	Thompson (2020)	2020 Inspection	2020 ANNOTATIONS
Merops ornatus	Rainbow Bee-eater		Resident	+	+	+	+	+	+	+		X	Several in proposed plant area.
Alcedinidae (Kingfishers)													
Todiramphus sanctus	Sacred Kingfisher		Resident	+	+	+		+	+	+			
Todiramphus pyrrhopygius	Red-backed Kingfisher		Resident	+	+	+	+		+	+			
Dacelo leachii	Blue-winged Kookaburra		Irregular Visitor	+	+	+		+	+	+			
Falconidae (Falcons)													
Falco cenchroides	Nankeen Kestrel		Resident	+	+	+	+	+	+	+		X	One in Alternative B and C area.
Falco longipennis	Australian Hobby		Resident	+	+	+	o	+	+	+			
Falco berigora	Brown Falcon		Resident	+	+	+	o		+	+			
Falco hypoleucos	Grey Falcon	CS1 (S3)	Vagrant			+							
Falco subniger	Black Falcon		Vagrant	+				+	+	+			
Falco peregrinus	Peregrine Falcon	CS1 (S7)	Irregular Visitor	+		+			+	+			
Cacatuidae (Cockatoos and Corellas)													
Nymphicus hollandicus	Cockatiel		Resident	+	+	+		+	+	+			
Eolophus roseicapillus	Galah		Resident	+	+	+	o	+	+	+			
Cacatua sanguinea	Little Corella		Resident	+	+	+	o	+	+	+			
Psittaculidae (Parrots, Lorikeets and Rosellas)													
Barnardius zonarius	Australian Ringneck		Resident	+	+	+	o	+	+	+			
Pezoporus occidentalis	Night Parrot	CS1 (E,S1)	Vagrant			+			+	+			
Melopsittacus undulatus	Budgerigar		Resident	+	+	+		+	+	+			

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	ALA	BCE (2005)	BCE (2009)	BCE (2018)	Biota (2010)	ENV (2012)	NatureMap	Thompson (2020)	2020 Inspection	2020 ANNOTATIONS
Maluridae (Fairy-wrens, Emu-wrens and Grasswrens)													
Malurus lamberti	Variegated Fairy-wren		Resident	+	+	+		+	+	+		X	Party with coloured male in Alternative B and C area.
Malurus splendens	Splendid Fairy-wren		Resident							+			
Malurus leucopterus	White-winged Fairy-wren		Resident	+	+	+	+	+	+	+		X	Parties in Alternative A, B and C areas. Coloured males present and very dark; almost black.
Meliphagidae (Honeyeaters and Chats)													
Sugomel niger	Black Honeyeater		Irregular Visitor	+		+		+	+				
Lichmera indistincta	Brown Honeyeater		Resident	+	+	+	+	+	+	+			
Certhionyx variegatus	Pied Honeyeater		Irregular Visitor	+		+	+		+	+			
Epthianura tricolor	Crimson Chat		Regular Visitor	+	+	+	+	+	+	+			
Epthianura aurifrons	Orange Chat		Irregular Visitor	+	+	+		+	+	+			
Acanthagenys rufogularis	Spiny-cheeked Honeyeater		Resident	+		+				+			
Lichenostomus virescens	Singing Honeyeater		Resident	+	+	+	+	+	+	+		X	Few in all areas.
Lichenostomus keartlandi	Grey-headed Honeyeater		Resident	+	+	+		+	+				
Lichenostomus penicillatus	White-plumed Honeyeater		Resident	+	+	+	+	+	+				
Manorina flavigula	Yellow-throated Miner		Resident	+	+	+	o	+	+	+			
Pardalotidae (Pardalotes)													
Pardalotus rubricatus	Red-browed Pardalote		Resident	+		+	o		+	+			
Pardalotus striatus	Striated Pardalote		Resident			+							
Acanthizidae (Thornbills and Gerygones)													

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	ALA	BCE (2005)	BCE (2009)	BCE (2018)	Biota (2010)	ENV (2012)	NatureMap	Thompson (2020)	2020 Inspection	2020 ANNOTATIONS
Gerygone fusca	Western Gerygone		Resident	+	+	+			+				
Smicrornis brevirostris	Weebill		Resident	+		+			+	+			
Acanthiza chrysorrhoa	Yellow-rumped Thornbill		Resident			+							
Pomatostomidae (Australian Babblers)													
Pomatostomus temporalis	Grey-crowned Babbler		Resident	+	+	+	o	+	+	+			
Neosittidae (Sittellas)													
Daphoenositta chrysoptera	Varied Sittella		Resident	+									
Campephagidae (Cuckoo-shrikes and Trillers)													
Coracina novaehollandiae	Black-faced Cuckoo-shrike		Resident	+	+	+	+	+	+	+			
Lalage tricolor	White-winged Triller		Resident	+	+	+	+	+	+	+			
Pachycephalidae (Whistlers, Shrike-thrushes and allies)													
Pachycephala rufiventris	Rufous Whistler		Resident	+		+			+				
Colluricincla harmonica	Grey Shrike-thrush		Resident			+			+	+			
Oreoicidae (Australo-Papuan Bellbirds)													
Oreoica gutturalis	Crested Bellbird		Resident	+	+	+	+	+	+	+			
Psophodidae (Whipbirds and Wedgebills)													
Psophodes occidentalis	Chiming Wedgebill		Resident	+	+	+	+	+	+	+			
Artamidae (Woodswallows, Currawongs, Butcherbirds and Magpie)													
Cracticus tibicen	Australian Magpie		Resident	+	+	+		+	+	+			
Cracticus nigrogularis	Pied Butcherbird		Resident	+	+	+	o	+	+	+			

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	ALA	BCE (2005)	BCE (2009)	BCE (2018)	Biota (2010)	ENV (2012)	NatureMap	Thompson (2020)	2020 Inspection	2020 ANNOTATIONS
Cracticus torquatus	Grey Butcherbird		Resident	+		+		+	+	+			
Artamus personatus	Masked Woodswallow		Regular Visitor	+	+	+		+	+	+			
Artamus cinereus	Black-faced Woodswallow		Resident	+	+	+	+	+	+	+		X	Several in Alternative A, B and C areas.
Artamus leucorynchus	White-breasted Woodswallow		Regular Visitor	+	+	+	o	+	+	+			
Rhipiduridae (Fantails)													
Rhipidura leucophrys	Willie Wagtail		Resident	+	+	+	+	+	+	+			
Rhipidura fuliginosa	Grey Fantail		Resident	+		+				+			
Corvidae (Crows and Ravens)													
Corvus orru	Torresian Crow		Resident	+	+	+	+	+	+	+			
Corvus bennetti	Little Crow		Resident	+	+	+	+	+	+	+			
Monarchidae (Monarch and Flycatchers)													
Grallina cyanoleuca	Magpie-lark		Resident	+	+	+	o	+	+	+			
Petroicidae (Australian Robins)													
Petroica goodenovii	Red-capped Robin		Resident			+							
Melanodryas cucullata	Hooded Robin		Resident			+							
Dicaeidae (Flowerpeckers)													
Dicaeum hirundinaceum	Mistletoebird		Resident	+		+							
Estrildidae (Weaver Finches)													
Emblema pictum	Painted Finch		Irregular visitor	+	+	+		+	+	+			
Neochmia ruficauda	Star Finch		Regular visitor	+	+	+		+	+	+			

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	ALA	BCE (2005)	BCE (2009)	BCE (2018)	Biota (2010)	ENV (2012)	NatureMap	Thompson (2020)	2020 Inspection	2020 ANNOTATIONS
Taeniopygia guttata	Zebra Finch		Resident	+	+	+	+	+	+	+			
Motacillidae (Pipits and Wagtails)													
Anthus novaeseelandiae	Australasian Pipit		Resident	+	+	+	o	+	+	+		X	Several in Alternative B and C areas.
Alaudidae (Larks)													
Mirafra javanica	Horsfield's Bushlark		Resident	+	+	+	+	+	+	+		X	One in Alternative C area.
Locustellidae (Grassbirds)													
Cincloramphus cruralis	Brown Songlark		Resident	+	+	+	+	+	+				
Cincloramphus mathewsi	Rufous Songlark		Resident	+	+	+	+	+	+			X	One in Alternative C area.
Eremiornis carteri	Spinifexbird		Resident	+	+	+	+	+		+		X	One heard in Alternative C area.
Hirundinidae (Swallows and Martins)													
Cheramoeca leucosterna	White-backed Swallow		Resident	+	+	+		+	+	+			
Petrochelidon ariel	Fairy Martin		Resident	+	+	+	o	+	+	+		X	Few over Alternative B and C areas.
Petrochelidon nigricans	Tree Martin		Resident	+	+	+	+	+	+	+			
Hirundo neoxena	Welcome Swallow		Resident	+	+	+	+	+	+	+			
Hirundo rustica	Barn Swallow	CS1 (M,S5)	Regular visitor	+	+	+			+				
MAMMALS													
Tachyglossidae (Echidnas)													
Tachyglossus aculeatus acanthion	Short-beaked Echidna		Resident		+	+		+	+	+	+		
Dasyuridae (Dasyurids)													
Dasycercus blythi	Brush-tailed Mulgara	CS2 (P4)	Regular Visitor		+	+			+				

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	ALA	BCE (2005)	BCE (2009)	BCE (2018)	Biota (2010)	ENV (2012)	NatureMap	Thompson (2020)	2020 Inspection	2020 ANNOTATIONS
Dasykaluta rosamondae	Kaluta		Resident	+	+	+		+	+	+	+		
Dasyurus hallucatus	Northern Quoll	CS1 (E,S2)	Vagrant		+	+				+	+		
Ningaui timealeyi	Pilbara Ningaui		Resident	+	+	+		+	+	+			
Planigale 'species 1'	Pilbara Planigale		Resident								+		
Sminthopsis macroura stalkeri	Stripe-faced Dunnart		Resident	+	+			+	+	+	+		
Sminthopsis youngsoni	Lesser Hairy-footed Dunnart		Resident	+	+	+		+	+	+	+		
Phalangeridae (Brushtail possums)													
Trichosurus vulpecula hypoleucus	Brushtail Possum	CS3 (LS)	Irregular visitor			+							
Macropodidae (Kangaroos)													
Osphranter robustus erubescens	Euro, Biggada		Resident		+		?	+	+	+	+		
Osphranter rufus	Red Kangaroo, Marlu		Resident	+			?	+	+	+	+		
Muridae (Rats and mice)													
Leggadina lakedownensis	Short-tailed Mouse	CS2 (P4)	Resident	+	+	+		+	+	+	+		
Mus musculus	House Mouse	Int	Resident	+	+	+		+	+	+	+		
Notomys alexis alexis	Spinifex Hopping-mouse		Resident	+	+			+	+	+	+		
Pseudomys delicatulus	Delicate Mouse		Resident			+		+	+				
Pseudomys desertor	Desert Mouse		Resident			+		+	+	+	+		
Pseudomys hermannsburgensis	Sandy Inland Mouse		Resident	+	+	+		+	+	+	+		
Rattus rattus	Black Rat	Int	Resident		+	+				+	+		
Zyzomys argurus	Common Rock-rat		Vagrant		+	+		+					

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	ALA	BCE (2005)	BCE (2009)	BCE (2018)	Biota (2010)	ENV (2012)	NatureMap	Thompson (2020)	2020 Inspection	2020 ANNOTATIONS
Leporidae (Rabbits and hares)													
Oryctolagus cuniculus	Rabbit	Int	Resident						+	+			
Pteropodidae (Fruit bats)													
Pteropus alecto gouldii	Black Flying-fox		Resident					+					
Pteropus scapulatus	Little Red Flying-fox		Resident			+				+			
Rhinonycteridae (Orange Leaf-nosed Bat)													
Rhinonicteris aurantia (Pilbara)	Pilbara Leaf-nosed Bat	CS1 (V,S3)	Regular Visitor		+			+					
Emballonuridae (Sheathtail bats)													
Saccolaimus flaviventris	Yellow-bellied Sheath-tailed Bat		Resident					+	+				
Taphozous georgianus	Common Sheath-tailed Bat		Resident			+							
Molossidae (Freetail bats)													
Austronomus australis	White-striped Free-tailed Bat		Resident	+	+			+	+				
Chaerephon jobensis colonicus	Greater Northern Free-tailed Bat		Resident					+		+			
Ozimops cobourgianus	Northern Coastal Free-tailed Bat		Resident					+					
Ozimops lumsdenae	Northern Free-tailed Bat		Resident										
Vespertilionidae (Vespertillionid bats)													
Chalinolobus gouldii	Gould's Wattled Bat		Resident		+	+		+	+	+			
Nyctophilus arnhemensis	Arnhem Long-eared Bat		Resident			+							
Nyctophilus geoffroyi geoffroyi	Lesser Long-eared Bat		Resident					+		+			
Scotorepens greyii	Little Broad-nosed Bat		Resident			+		+	+				

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	ALA	BCE (2005)	BCE (2009)	BCE (2018)	Biota (2010)	ENV (2012)	NatureMap	Thompson (2020)	2020 Inspection	2020 ANNOTATIONS
Vespadelus finlaysoni	Finlayson's Cave-bat		Resident		+	+		+	+				
Canidae (Dogs)													
Canis familiaris dingo	Dingo		Resident				?	+	+		+		
Canis familiaris	Dog	Int	Resident				?	+		+			
Vulpes vulpes	Red Fox	Int	Resident			+		+	+	+	+		
Felidae (Cats)													
Felis catus	Cat	Int	Resident		+	+	+	+	+	+	+	X	Tracks in all areas. One flushed from termite mound in Alternative B area.
Equidae (Horses)													
Equus caballus	Horse	Int	Resident					+		+			
Bovidae (Horned ruminants)													
Bos taurus	European Cattle	Int	Resident					+	+	+			
Capra hircus	Goat	Int	Resident			+		+	+				

Appendix 7. Species recorded in the field investigations.

Species	2020 Annotations
Ctenophorus isolepis isolepis (Central Military Dragon)	Seen in lot 540.
Ctenotus pantherinus ocellifer	One seen in Alternative A area.
Varanus eremius (Pygmy Desert Goanna)	One seen in Alternative A area.
Varanus panoptes rubidus (Spotted Monitor)	Large adult beside termite mound in in Alternative B area.
Ocyphaps lophotes (Crested Pigeon)	Few seen in Alternative B and C areas.
Ardeotis australis (Australian Bustard)	Tracks in all areas.
Turnix velox (Little Button-quail)	Tracks in Alternative B and C areas.
Haliastur sphenurus (Whistling Kite)	One over proposed plant area.
Merops ornatus (Rainbow Bee-eater)	Several in proposed plant area.
Falco cenchroides (Nankeen Kestrel)	One in Alternative B and C area.
Malurus lamberti (Variegated Fairy-wren)	Party with coloured male in Alternative B and C area.
Malurus leucopterus (White-winged Fairy-wren)	Parties in Alternative A, B and C areas. Coloured males present and very dark; almost black.
Lichenostomus virescens (Singing Honeyeater)	Few in all areas.
Artamus cinereus (Black-faced Woodswallow)	Several in Alternative A, B and C areas.
Anthus novaeseelandiae (Australasian Pipit)	Several in Alternative B and C areas.
Mirafra javanica (Horsfield's Bushlark)	One in Alternative C area.
Cincloramphus mathewsi (Rufous Songlark)	One in Alternative C area.
Eremiornis carteri (Spinifexbird)	One heard in Alternative C area.
Petrochelidon ariel (Fairy Martin)	Few over Alternative B and C areas.
Felis catus (Cat)	Tracks in all areas. One flushed from termite mound in Alternative B area.

Appendix 8. Species returned from the literature review that have been omitted from the expected species list because of habitat or range limitations, or because they are now considered locally extinct.

Note that some birds could still occur as extremely rare vagrants.

SPECIES	COMMON NAME	REASON FOR EXCLUSION
Hylidae (Tree frogs)		
Litoria caerulea	Green Tree Frog	Outside of normal range (Kimberley). They have been recorded in Onslow (presumably transported animals) but are not known to have established a viable population. The project area does not provide suitable habitat.
Myobatrachidae (Ground frogs)		
Pseudophryne douglasi	Gorge Toadlet	Lack of suitable habitat (deep gorges).
Crocodylidae (Crocodiles)		
Crocodylus porosus	Saltwater Crocodile	Lack of suitable habitat (marine/estuarine).
Cheloniidae (Hard-shelled sea turtles)		
Caretta caretta	Loggerhead Turtle	Lack of suitable habitat (marine).
Chelonia mydas	Green Turtle	Lack of suitable habitat (marine).
Eretmochelys imbricata	Hawksbill Turtle	Lack of suitable habitat (marine).
Natator depressus	Flatback Turtle	Lack of suitable habitat (marine).
Dermochelyidae (Leathery Sea Turtle)		
Dermochelys coriacea	Leatherback Turtle	Lack of suitable habitat (marine).
Carphodactylidae (Carphodactylid geckoes)		
Nephrurus levis pilbarensis		Outside of range (central and eastern Pilbara).
Nephrurus wheeleri cinctus		Both outside of range and lack of suitable habitat (central Pilbara; rocky ranges).
Diplodactylidae (Diplodactylid geckoes)		
Diplodactylus conspicillatus	Variable Fat-tailed Gecko	Taxonomic division: outside of range (now *D. bilybara; D. conspicillatus* central-eastern WA).
Lucasium wombeyi		Outside of range (central Pilbara).

SPECIES	COMMON NAME	REASON FOR EXCLUSION
Strophurus spinigerus spinigerus		Outside of range (south-west WA).
Gekkonidae (Gekkonid geckoes)		
Gehyra australis		Outside of range (Kimberley).
Gehyra punctata		Lack of suitable habitat (rock).
Hemidactylus frenatus	Asian House Gecko	Lack of suitable habitat (human dwellings). Present in Onslow.
Agamidae (Dragons)		
Ctenophorus caudicinctus	Western Ring-tailed Dragon	Lack of suitable habitat (rock).
Ctenophorus isolepis gularis	Central Military Dragon	Outside of range (southern Kimberley).
Ctenophorus rufescens	Red Rock Dragon	Outside of range (SW Northern Territory).
Scincidae (Skinks)		
Ctenotus angusticeps		Outside of range (north and north-eastern Pilbara coastline and islands).
Ctenotus inornatus		Outside of range (Kimberley).
Ctenotus quattuordecimlineatus		Outside of range (eastern Pilbara).
Eremiascincus richardsonii	Broad-banded Sand Swimmer	Outside of range (non-coastal Pilbara).
Eremiascincus rubiginosus	Rusty Skink	Lack of suitable habitat (rock).
Lerista praepedita		Outside of range (western coast of WA).
Lerista rolfei		Outside of range (Gascoyne).
Lerista verhmens		Outside of range (north-eastern Pilbara).
Morethia ruficauda ruficauda		Outside of range (northern Australia).
Varanidae (Monitors and goannas)		
Varanus bushi	Pilbara Mulga Goanna	Both outside of range and lack of suitable habitat (central Pilbara; mulga/eucalypt woodlands).
Varanus giganteus	Perentie	Outside of range (non-coastal in western NW WA).
Colubridae (Colubrid snakes)		

SPECIES	COMMON NAME	REASON FOR EXCLUSION
Fordonia leucobalia	White-bellied Mangrove Snake	Lack of suitable habitat (mangroves).
Elapidae (Venomous land snakes)		
Pseudonaja nuchalis	Northern Brown Snake	Outside of range (Northern Territory and NE Queensland.
Aipysurus apraefrontalis		Lack of suitable habitat (marine).
Aipysurus laevis		Lack of suitable habitat (marine).
Ephalophis greyae		Lack of suitable habitat (marine).
Hydrelaps darwiniensis		Lack of suitable habitat (marine).
Hydrophis major		Lack of suitable habitat (marine).
Hydrophis ornatus		Lack of suitable habitat (marine).
Hydrophis stokesii		Lack of suitable habitat (marine).
Columbidae (Pigeons and Doves)		
Columba livia	Rock Dove/Feral Pigeon	Lack of suitable habitat (in the vicinity of infrastructure).
Rallidae (Crakes, Rails and Swamphens)		
Gallirallus philippensis	Buff-banded Rail	Lack of suitable habitat (vegetated wetlands).
Porzana fluminea	Australian Spotted Crake	Lack of suitable habitat (vegetated wetlands).
Porzana pusilla	Baillon's Crake	Lack of suitable habitat (vegetated wetlands).
Porzana tabuensis	Spotless Crake	Lack of suitable habitat (vegetated wetlands).
Gallinula tenebrosa	Dusky Moorhen	Lack of suitable habitat (deep wetlands).
Fulica atra	Eurasian Coot	Lack of suitable habitat (deep wetlands).
Burhinidae (Stone-curlews)		
Esacus giganteus	Beach Stone-curlew	Lack of suitable habitat (coastlines).
Haematopodidae (Oystercatchers)		
Haematopus longirostris	Australian Pied Oystercatcher	Lack of suitable habitat (coastlines).
Haematopus fuliginosus	Sooty Oystercatcher	Lack of suitable habitat (coastlines).

SPECIES	COMMON NAME	REASON FOR EXCLUSION
Charadriidae (Plovers, Dotterel and Lapwings)		
Vanellus miles	Masked Lapwing	Outside of range (Kimberley and SW WA, eastern Australia).
Rostratulidae (Painted Snipe)		
Rostratula australis	Australian Painted-snipe	Outside of range (Kimberley, central and eastern Pilbara and SW WA, eastern Australia).
Scolopacidae (Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes)		
Arenaria interpres	Ruddy Turnstone	Lack of suitable habitat (coastlines).
Calidris alba	Sanderling	Lack of suitable habitat (coastlines).
Gallinago stenura	Pintail Snipe	Lack of suitable habitat (vegetated wetlands).
Tringa brevipes	Grey-tailed Tattler	Lack of suitable habitat (coastlines).
Laridae (Gulls, Terns and Noddies)		
Anous stolidus	Common Noddy	Lack of suitable habitat (marine).
Onychoprion anaethetus	Bridled Tern	Lack of suitable habitat (marine).
Sternula albifrons	Little Tern	Lack of suitable habitat (marine/estuarine).
Sternula nereis	Fairy Tern	Lack of suitable habitat (marine/estuarine).
Sterna dougallii	Roseate Tern	Lack of suitable habitat (marine).
Sterna hirundo	Common Tern	Lack of suitable habitat (marine).
Thalasseus bengalensis	Lesser Crested Tern	Lack of suitable habitat (marine).
Thalasseus bergii	Crested Tern	Lack of suitable habitat (marine/estuarine).
Oceanitidae (Southern Storm-Petrels)		
Oceanites oceanicus	Wilson's Storm-Petrel	Lack of suitable habitat (marine).
Procellariidae (Petrels and Shearwaters)		
Macronectes giganteus	Southern Giant-Petrel	Lack of suitable habitat (marine).
Ardenna pacifica	Wedge-tailed Shearwater	Lack of suitable habitat (marine).
Calonectris leucomelas	Streaked Shearwater	Lack of suitable habitat (marine).

SPECIES	COMMON NAME	REASON FOR EXCLUSION
Pelicanidae (Pelican)		
Pelecanus conspicillatus	Australian Pelican	Lack of suitable habitat (deep wetlands).
Ardeidae (Herons, Egrets and Bitterns)		
Nycticorax caledonicus	Nankeen Night-Heron	Lack of suitable habitat (rocky coastlines, mangroves, rivers, vegetated wetlands).
Butorides striatus	Striated Heron	Lack of suitable habitat (mangroves).
Egretta sacra	Eastern Reef Egret	Lack of suitable habitat (rocky coastlines).
Fregatidae (Frigatebirds)		
Fregata ariel	Lesser Frigatebird	Lack of suitable habitat (marine).
Phalacrocoracidae (Cormorants and Shags)		
Microcarbo melanoleucos	Little Pied Cormorant	Lack of suitable habitat (deep wetlands).
Phalacrocorax carbo	Great Cormorant	Lack of suitable habitat (deep wetlands).
Phalacrocorax sulcirostris	Little Black Cormorant	Lack of suitable habitat (deep wetlands).
Phalacrocorax varius	Pied Cormorant	Lack of suitable habitat (deep wetlands).
Anhingidae (Darter)		
Anhinga novaehollandiae	Australasian Darter	Lack of suitable habitat (deep wetlands).
Pandionidae (Osprey)		
Pandion haliaetus	Osprey	Lack of suitable habitat (marine/estuarine).
Accipitridae (Eagles, Kites, Goshawks)		
Elanus scriptus	Letter-winged Kite	Outside of range (central Australia). Slight chance as a very rare vagrant
Haliaeetus leucogaster	White-bellied Sea-Eagle	Lack of suitable habitat (marine/estuarine). Could overfly site.
Haliastur indus	Brahminy Kite	Lack of suitable habitat (marine/estuarine). Could overfly site
Alcedinidae (Kingfishers)		
Todiramphus sordidus	Torresian Kingfisher	Lack of suitable habitat (mangroves).
Ptilonorhynchidae (Bowerbirds and Catbirds)		

SPECIES	COMMON NAME	REASON FOR EXCLUSION
Ptilonorhynchus guttatus	Western Bowerbird	Lack of suitable habitat (woodlands).
Acanthizidae (Thornbills and Gerygones)		
Gerygone tenebrosa	Dusky Gerygone	Lack of suitable habitat (mangroves).
Gerygone levigaster	Mangrove Gerygone	Lack of suitable habitat (mangroves).
Pachycephalidae (Whistlers, Shrike-thrushes and allies)		
Pachycephala lanioides	White-breasted Whistler	Lack of suitable habitat (mangroves).
Pachycephala melanura	Mangrove Golden Whistler	Lack of suitable habitat (mangroves).
Artamidae (Woodswallows, Currawongs, Butcherbirds and Magpie)		
Artamus cyanopterus	Dusky Woodswallow	Outside of range (south-west WA, eastern Australia).
Artamus minor	Little Woodswallow	Lack of suitable habitat (rocky hills, gorges, deep mine pits).
Rhipiduridae (Fantails)		
Rhipidura phasiana	Mangrove Grey Fantail	Lack of suitable habitat (mangroves).
Monarchidae (Monarch and Flycatchers)		
Myiagra inquieta	Restless Flycatcher	Outside of range (south-west WA, eastern Australia).
Petroicidae (Australian Robins)		
Peneonanthe pulverulenta	Mangrove Robin	Lack of suitable habitat (mangroves).
Estrildidae (Weaver Finches)		
Heteromunia pectoralis	Pictorella Mannikin	Outside of range (Kimberley, northern Australia).
Passeridae (Weaver Finches)		
Passer montanus	Eurasian Tree Sparrow	Outside of range (south-eastern Australia).
Motacillidae (Pipits and Wagtails)		
Motacilla flava	Yellow Wagtail	Outside of range (coastal Kimberley and NE Pilbara).
Motacilla cinerea	Grey Wagtail	Lack of suitable habitat (coastlines, rivers).
Acrocephalidae (Reed-Warblers)		

SPECIES	COMMON NAME	REASON FOR EXCLUSION
Acrocephalus australis	Australian Reed-Warbler	Lack of suitable habitat (vegetated wetlands).
Zosteropidae (True Babblers)		
Zosterops luteus	Yellow White-eye	Lack of suitable habitat (mangroves).
Zosterops lateralis	Silvereye	Outside of range (south-west WA).
Muscicapidae (Old world flycatchers)		
Monticola solitarius	Blue Rock-Thrush	Lack of suitable habitat (rocky coastlines).
Dasyuridae (Dasyurids)		
Planigale ingrami	Long-tailed Planigale	Taxonomic revision: outside of range (now Planigale 'species 1'; *P. ingrami* eastern Queensland).
Planigale maculata	Common Planigale	Taxonomic revision: outside of range (now Planigale 'species 1'; *P. maculata* northern Australia).
Sminthopsis longicaudata	Long-tailed Dunnart	Outside of range (central and eastern Pilbara, central WA).
Peramelidae (Bandicoots)		
Perameles bougainville	Shark Bay Bandicoot, Little Marl	Outside of range (Shark Bay).
Thylacomyidae (Bilbies)		
Macrotis lagotis	Bilby, Dalgyte	Locally extinct.
Macropodidae (Kangaroos)		
Lagorchestes conspicillatus	Spectacled Hare-wallaby	Locally extinct.
Petrogale lateralis lateralis	Black-footed Rock-wallaby	Lack of suitable habitat (rocky hills and gorges).
Dugonidae (Dugong)		
Dugong dugon	Dugong	Lack of suitable habitat (marine).
Muridae (Rats and mice)		
Pseudomys chapmani	Western Pebble-mound Mouse	Lack of suitable habitat (rocky substrates).
Rattus tunneyi tunneyi	Pale Field-rat	Locally extinct.
Megadermatidae (Ghost Bat)		

SPECIES	COMMON NAME	REASON FOR EXCLUSION
Macroderma gigas	Ghost Bat	Outside of range (central and eastern Pilbara).
Balaenidae (Right whales)		
Eubalaena australis	Southern Right Whale	Lack of suitable habitat (marine).
Balaenopteridae (Rorquals)		
Balaenoptera musculus brevicauda	Pygmy Blue Whale	Lack of suitable habitat (marine).
Megaptera novaeangliae australis	Humpback Whale	Lack of suitable habitat (marine).
Deliphinidae (Dolphins, pilot whales and Killer Whale)		
Orcaella heinsohni	Australian Snubfin Dolphin	Lack of suitable habitat (marine).
Sousa sahulensis	Indo-Pacific Humpback Dolphin	Lack of suitable habitat (marine).
Tursiops aduncus	Indo-Pacific Bottlenose Dolphin	Lack of suitable habitat (marine).

Appendix 9. Conservation significant invertebrate fauna species expected to occur in the Pilbara management region (as per DBCA 2019, 2020a), including conservation status and likely residency status in the project area.

Status codes:
- CS1, CS2, CS3 = (summary) levels of conservation significance. See Appendix 1 for full explanation.
- EPBC Act listings: E = Endangered, V = Vulnerable, M = Migratory, Mar = Marine (see Appendix 2).
- Biodiversity Conservation Act 2016 listings: S1 to S7 = Schedules 1 to 7 (see Appendix 2).
- DBCA Priority species: P1 to P4 = Priority 1 to 4 (see Appendix 2).

Expected Occurrence categories:
- See Section 0 for explanation of expected occurrence categories.

Wetland dependence:
- ~ = species is dependent on wetland environments for the entirety its lifecycle.
- w = species is dependent on wetland environments for the majority of its lifecycle.
- w† = species is dependent on wetland environments for some its lifecycle (often breeding) but can spend a substantial portion of time in dryland environments.
- o = species is dependent on oceanic environments (including coastlines and islands).

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.

Species	Common Name	Status	Expected Occurrence
Antichiropus sp. 'DIP004'	Roy Hill Antichiropus millipede	CS2 (P1)	Absent. Restricted to Roy Hill area (c. 90 km NE of Newman) and nearby (WAM 2021a). Project area more than 500 km outside of the species' known range.
Antichiropus sp. 'DIP005'	Abydos Antichiropus millipede	CS2 (P1)	Absent. Restricted to Abydos Plain (near Marble Bar) and nearby (WAM 2021b). Project area more than 400 km outside of the species' known range.
Antichiropus sp. 'DIP006'	Area C Antichiropus millipede	CS2 (P1)	Absent. Restricted to Area C (c. 80 km NW of Newman) and nearby (WAM 2021c). Project area more than 400 km outside of the species' known range.

Species	Common Name	Status	Expected Occurrence
Antichiropus sp. 'DIP007'	Bond's Antichiropus millipede	CS2 (P1)	Absent. Restricted to Area C (c. 80 km NW of Newman) and nearby (WAM 2021d). Project area more than 400 km outside of the species' known range.
Antichiropus sp. 'DIP008'	Flinders Antichiropus millipede	CS2 (P1)	Absent. Restricted to Flinders (c. 100 km NW of Tom Price) and nearby (WAM 2021e). Project area more than 200 km outside of the species' known range.
Antichiropus sp. 'DIP013'	Cloudbreak Antichiropus millipede	CS2 (P1)	Absent. Restricted to Cloudbreak area (WAM 2021f). Project area more than 400 km outside of the species' known range.
Antichiropus sp. 'DIP029'	Mt Bruce Antichiropus millipede	CS2 (P1)	Absent. Restricted to Mt Bruce area (near Tom Price) and nearby (WAM 2021g). Project area more than 300 km outside of the species' known range.
Antipodogomphus hodgkini	Pilbara dragonfly (Pilbara Dragon)	CS2 (P3)	Probably absent. Project area more than 100 km outside of species known range.
Bamazomus subsolanus	eastern Cape Range bamazomus	CS1 (S2)	Absent. Restricted to Cape Range. Project area more than 100 km outside of the species known range.
Bamazomus vespertinus	western Cape Range bamazomus	CS1 (S2)	Absent. Restricted to Cape Range. Project area more than 100 km outside of the species known range.
Bogidomma australis	Barrow Island bogidomma amphipod	CS1 (S3)	Absent. Restricted to Barrow Island. Project area more than 100 km outside of the species known range.
Bunderia misophaga	a copepod (Bundera Sinkhole)	CS1 (S1)	Absent. Restricted to Cape Range. Project area more than 100 km outside of the species known range.

Species	Common Name	Status	Expected Occurrence
Draculoides bramstokeri	Barrow Island draculoides	CS1 (S3)	Absent. Restricted to Barrow Island. Project area more than 100 km outside of the species known range.
Draculoides brooksi	northern Cape Range draculoides	CS1 (S2)	Absent. Restricted to Cape Range. Project area more than 100 km outside of the species known range.
Draculoides julianneae	western Cape Range draculoides	CS1 (S2)	Absent. Restricted to Cape Range. Project area more than 100 km outside of the species known range.
Draculoides mesozeirus	Middle Robe draculoides	CS1 (S3)	Absent. Restricted to middle of Robe Valley. Project area more than 100 km outside of the species' known range.
Dupucharopa millestriata	Depuch Island charopid land snail	CS2 (P2)	Absent. Restricted to Depuch Island (and nearby islands?). Project area more than 100 km outside of the species' known range.
Ideoblothrus linnaei	Linnaeus' pseudoscorpion (Mesa A)	CS2 (P1)	Absent. Restricted to Mesa A and nearby.
Ideoblothrus sp. 'Mesa A' (WAM T81374)	an Ideoblothrus pseudoscorpion (Mesa A)	CS2 (P1)	Absent. Restricted to Mesa A and nearby. Project area more than 100 km outside of the species' known range.
Indohya damocles	Cameron's Cave pseudoscorpion	CS1 (S1)	Absent. No caves.
Kumonga exleyi	Cape Range remipede	CS1 (S1)	Absent. Restricted to Cape Range. Project area more than 100 km outside of the species known range.
Lagynochthonius asema	Mesa A Lagynochthonius pseudoscorpion	CS2 (P1)	Absent. Restricted to Mesa A and nearby. Project area more than 100 km outside of the species' known range.

Species	Common Name	Status	Expected Occurrence
Liagoceradocus branchialis	Cape Range liagoceradocus amphipod	CS1 (S2)	Absent. Restricted to Cape Range. Project area more than 100 km outside of the species known range.
Liagoceradocus subthalassicus	Barrow Island liagoceradocus amphipod	CS1 (S3)	Absent. Restricted to Barrow Island. Project area more than 100 km outside of the species known range.
Nedsia chevronia	Chevron's freshwater amphipod (Barrow Island)	CS2 (P2)	Absent. Restricted to Barrow Island. Project area more than 100 km outside of the species known range.
Nedsia fragilis	a freshwater amphipod	CS1 (S3)	Absent. Restricted to Barrow Island (Humphreys *et al.* 2013). Project area more than 100 km outside of the species known range.
Nedsia humphreysi	a freshwater amphipod	CS1 (S3)	Absent. Restricted to Barrow Island (Humphreys *et al.* 2013). Project area more than 100 km outside of the species known range.
Nedsia hurlberti	a freshwater amphipod	CS1 (S3)	Absent. Restricted to Barrow Island (Humphreys *et al.* 2013). Project area more than 100 km outside of the species known range.
Nedsia macrosculptilis	a freshwater amphipod	CS1 (S3)	Absent. Restricted to Barrow Island (Humphreys *et al.* 2013). Project area more than 100 km outside of the species known range.
Nedsia sculptilis	a freshwater amphipod	CS1 (S3)	Absent. Restricted to Barrow Island (Humphreys *et al.* 2013). Project area more than 100 km outside of the species known range.
Nedsia straskraba	a freshwater amphipod	CS1 (S3)	Absent. Restricted to Barrow Island (Humphreys *et al.* 2013). Project area more than 100 km outside of the species known range.

Species	Common Name	Status	Expected Occurrence
Nedsia urifimbriata	a freshwater amphipod	CS1 (S3)	Absent. Restricted to Barrow Island (Humphreys *et al.* 2013). Project area more than 100 km outside of the species known range.
Nocticola flabella	Cape Range blind cockroach, Cape Range delicate cockroach	CS2 (P4)	Absent. Restricted to Cape Range. Project area more than 100 km outside of the species known range.
Nososticta pilbara	Pilbara threadtail	CS2 (P2)	Probably absent. Project area more than 100 km outside of species known range.
Paradraculoides anachoretus	Mesa A paradraculoides	CS1 (S3)	Absent. Restricted to Mesa A and nearby. Project area more than 100 km outside of the species' known range.
Paradraculoides bythius	Mesa B/C paradraculoides	CS1 (S3)	Absent. Restricted to Mesa B/C and nearby. Project area more than 100 km outside of the species' known range.
Paradraculoides gnophicola	Mesa G paradraculoides	CS1 (S3)	Absent. Restricted to Mesa G and nearby. Project area more than 100 km outside of the species' known range.
Paradraculoides kryptus	Mesa K paradraculoides	CS1 (S3)	Absent. Restricted to Mesa K and nearby. Project area more than 100 km outside of the species' known range.
Prionospio thalanji	Bundera Sinkhole worm	CS1 (S1)	Absent. Restricted to Cape Range. Project area more than 100 km outside of the species known range.
Speleophria bunderae	a copepod (Bundera Sinkhole)	CS1 (S1)	Absent. Restricted to Cape Range. Project area more than 100 km outside of the species known range.

Species	Common Name	Status	Expected Occurrence
Speleostrophus nesiotes	Barrow Island millipede	CS1 (S3)	Absent. Restricted to Barrow Island. Project area more than 100 km outside of the species known range.
Stygiocaris lancifera	lance-beaked cave shrimp	CS1 (S3)	Absent. No caves.
Stygiocaris stylifera	spear-beaked cave shrimp	CS2 (P4)	Absent. No caves.
Stygiochiropus isolatus	a stygiochiropus millipede (Cape Range)	CS1 (S3)	Absent. Restricted to Cape Range. Project area more than 100 km outside of the species known range.
Stygiochiropus peculiaris	Cameron's Cave millipede	CS1 (S1)	Absent. No caves.
Stygiochiropus sympatricus	a stygiochiropus millipede (Cape Range)	CS1 (S3)	Absent. Restricted to Cape Range. Project area more than 100 km outside of the species known range.
Stygocyclopia australis	a copepod (Bundera Sinkhole)	CS1 (S1)	Absent. Restricted to Cape Range. Project area more than 100 km outside of the species known range.
Tyrannochthonius sp. 'Mesa A' (WAM T81480)	a Tyrannochtonius pseudoscorpion (Mesa A)	CS2 (P1)	Absent. Restricted to Mesa A and nearby. Project area more than 100 km outside of the species' known range.
Welesina kornickeri	Kornicker's Bundera Sinkhole ostracod	CS1 (S1)	Absent. Restricted to Cape Range. Project area more than 100 km outside of the species known range.