WA Limestone
Wattle Avenue West Project
Fauna Assessment

View over the Wattle Avenue West site. Photo: Wes Bancroft.

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Executive Summary

Bamford Consulting Ecologists (BCE) was commissioned by WA Limestone to conduct a Basic (*sensu* EPA 2020) fauna assessment (desktop review and site inspection) of their proposed Wattle Avenue West quarry expansion in Nowergup. 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

The proposed location ('project area') for the 'Wattle Avenue West' quarry expansion is Lot 8, 259 Wattle Ave, in the suburb of Nowergup, approximately 34 km north of the Perth CBD. The project area is c. 15.5 ha, of which at c. 1.2 ha has previously been cleared (as per DPIRD 2022). The 'development footprint' of the expansion is not expected to take up the entire 14.3 ha of undeveloped lands within the project area.

The project area is within the Swan Coastal Plain 2 (SWA02) subregion of the Swan Coastal Plain bioregion and falls within the 'Cottesloe Complex – Central and South' of Heddle *et al.* (1980) and Webb *et al.* (2016). Bush Forever Site number 293 (Shire View Hill and adjacent bushland, Nowergup, Neerabup) sits just to the south of the project area, with at least one additional Environmentally Sensitive Area extending over the project area. The project area also sits within the 'Northern Swan Coastal Plain' Key Biodiversity Area. There are no known Ramsar Sites or Important Wetlands within the project area.

Key fauna values

Vegetation and Substrate Associations (VSAs) that provide habitat for fauna. Five major Vegetation and Substrate Associations were identified in the project area: Proteaceous heath (VSA 1), Banksia woodland (VSA 2), Limestone Marlock woodland (VSA 3), Rehabilitation (VSA 4), and Cleared (VSA 5).

Fauna assemblage. The desktop study identified 173 vertebrate fauna species as potentially occurring in the project area: no fish, eight frogs, 46 reptiles, 100 birds and 19 mammals. The presence of at least 23 species (20 birds and three mammals) was confirmed during the 2021 site inspection. The fauna assemblage is probably typical of the near-coastal shrublands of the coastal plain north of Perth. The assemblage is likely to be substantially complete except for the mammal component, which is depauperate in both medium-sized and small species. The assemblage is likely to be only moderately rich in a regional context as the environment consists largely of shrublands and lacks the banksia and eucalypt woodlands of the coastal plain slightly further east.

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.

The majority of the 46 conservation significant species (including two reptiles, 35 birds, five mammals and four invertebrates) expected in the project area are likely to be residents or regular visitors/migrants visitors. Only five of the expected conservation species are listed under WA State and/or Commonwealth legislation (category CS1; four bird and one mammal), with seven listed as Priority by DBCA (category CS2; one reptile, two mammals and four invertebrates) and the remaining 34 considered locally significant (category CS3; one reptile, 31 birds and two mammals). Of most concern are Carnaby's Black-Cockatoo (CS1, known to be a regular migrant to the area and to use the project area for foraging), and Quenda (CS2, known to occur within the project area and expected to be resident).

Patterns of biodiversity. The three intact native VSAs can be expected to be richer in species than the rehabilitation and cleared areas. Differences in the fauna assemblage between these three VSAs might be slight, as they contain many of the same plant species and have broadly similar substrates. VSA 1 (proteaceous heath) and VSA 2 (banksia woodland) are notable for high nectar production important for a range of nectarivores (*Banksia* species) and supply of food for Carnaby's Black-Cockatoo. VSA3 (Limestone Marlock woodland) may be less productive in this respect. VSA 3 is notable as having the only eucalypts in the project area and thus may support some birds and invertebrates that are eucalypt specialists.

Key ecological processes. The ecological processes that currently have major effects upon the fauna assemblage include landscape permeability, hydrology, fire, and the presence of feral species.

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 during construction, ongoing mortality, impacts of feral and overabundant native species, hydrological change, fire and disturbance (dust, noise and light). Potential impacts are considered to be negligible to minor because of the small areas involved, the low number of conservation significant species expected to be regularly present within, and wholly reliant on, the project area (and the low likelihood of their disruption), and the general fauna assemblage being well-represented in the general region. The cumulative impact of habitat loss due to the proposed Wattle Avenue West quarry expansion project is not expected to be significant (clearing is expected to contribute less than a further 0.03% to the c. 55.2% of the cleared lands in the region).

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1 Introduction

WA Limestone is proposing to expand operations at its 'Wattle Avenue West' quarry within on Lot 8 - 259 Wattle Ave, in the suburb of Nowergup on the outskirts of the Perth Metropolitan area (see Figure 1).

Bamford Consulting Ecologists (BCE) was commissioned by WA Limestone to conduct a Basic (*sensu* EPA 2020) fauna assessment (desktop review and site inspection) of the proposed Wattle Avenue West quarry expansion. 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 proposed location ('project area') for the 'Wattle Avenue West' quarry expansion location is Lot 8, 259 Wattle Ave, Nowergup, adjacent to existing quarries within Mining Tenement M70/143, approximately 34 km north of the Perth CBD. The project area is c. 15.5 ha, of which at c. 1.2 ha has previously been cleared (as per DPIRD 2022). The 'development footprint' of the expansion is not expected to take up the entire 14.3 ha of undeveloped lands within 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.

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 2022b). 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 Swan Coastal Plain 2 (SWA02) subregion of the Swan Coastal Plain bioregion, as mapped in Figure 2. This bioregion falls within the Bioregion Group 1 (South-West Botanical Province) classification of EPA (2016c) where native vegetation is "extensively cleared for agriculture".

The Swan Coastal Plain 2 subregion was described by Mitchell *et al.* (2003) and a summary of their work follows here. The Swan Coastal Plain is a low lying coastal plain, mainly covered with woodlands. It is dominated by Banksia or Tuart on sandy soils, *Casuarina obesa* on outwash plains, and paperbark in swampy areas. In the east, the plain rises to duricrusted Mesozoic sediments dominated by Jarrah woodland. The climate is Warm Mediterranean. Three phases of marine sand dune development provide relief. The outwash plains, once dominated by *C. obesa*-Marri woodlands and Melaleuca shrublands, are extensive only in the south. The Perth subregion is composed of colluvial and aeolian sands, alluvial river flats, coastal limestone. Heath and/or Tuart woodlands on limestone, Banksia and Jarrah-Banksia woodlands on Quaternary marine dunes of various ages, Marri on colluvial and alluvials. Includes a complex series of seasonal wetlands and also includes Rottnest, Carnac and Garden Islands etc. Rainfall ranges between 600 and 1000 mm annually and the climate is Mediterranean.

1.2.3 Land systems and vegetation complexes

Heddle *et al.* (1980) and Webb *et al.* (2016) have defined and described broad vegetation complexes for the Swan Coastal Plain and the mapping of these is provided by DBCA (2022h). The project area is located wholly within one of these:

- Cottesloe Complex – Central and South: Mosaic of woodland of *Eucalyptus gomphocephala* (Tuart) and open forest of *Eucalyptus gomphocephala* (Tuart) - *Eucalyptus marginata* (Jarrah) - *Corymbia calophylla* (Marri); closed heath on the Limestone outcrops.

Heddle vegetation complexes in the vicinity of the project area are mapped in Figure 3 (data provided by DBCA 2022h).

1.2.4 Land use and tenure

The dominant land uses within the Swan Coastal Plain 2 (SWA02) subregion are cultivation – dry land agriculture, conservation, UCL and Crown reserves, urban, rural residential, cultivation – irrigated horticulture, agriculture and plantations, forestry-plantations, roads and other easements and infrastructure, and grazing – Improved pastures, with smaller areas of mining, and defence lands (Mitchell *et al.* 2003). The project area lies in the central sector of the subregion. At the local scale, the project area is surrounded by areas of agriculture, plantations and mining.

1.2.5 Recognised sensitive sites

Bush Forever Site number 293: Shire View Hill and adjacent bushland, Nowergup, Neerabup (Dell and Banyard 2000) sits just to the south project area, as shown in Figure 4 (data provided by DPLH 2022). This Bush Forever listing is also captured in the database of Environmentally Sensitive Areas (DWER 2022a, b), with other sensitive areas extending over the project area as shown in Figure 5. The project area also sits within the 'Northern Swan Coastal Plain' Key Biodiversity Area (KBA 2022), listed because "supports a considerable portion of the non-breeding population of the endangered Carnaby's Black-Cockatoo and a small number of breeding pairs" (KBAP 2020). There are no known Ramsar Sites (DBCA 2022f) or Important Wetlands (DBCA 2022c), within the project area.

1.2.6 Climate information

The project areas falls within the Köppen climate classification of 'Hot-summer Mediterranean climate (*Csa*)', which is characterised by s characterized by dry summers and mild, wet winters. They usually occur on the western sides of continents between the latitudes of 30° and 45°. Hot-summer Mediterranean climates are in the polar front region in winter, and thus have moderate temperatures and changeable, rainy weather. Summers are hot and dry, due to the domination of the subtropical high pressure systems, except in the immediate coastal areas, where summers are milder due to the nearby presence of cold ocean currents that may bring fog but prevent rain (Anon. 2022; BOM 2022a).

For the Swan Coastal Plain 2 (SWA02) subregion, climate is "Warm Mediterranean" (Mitchell *et al.* 2003).

Climate averages (temperate, rainfall, sunshine) for the project area, as provided by BOM (2022b), are presented in Table 1.

Table 1. Climate averages for the project area.

Data from BOM (2022b) for:
Site name = GINGIN AERO
Site number = 009178

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years		Plot	Map
Temperature																	
Mean maximum temperature (°C)	33.1	33.0	30.8	26.8	22.8	19.7	18.4	19.1	20.8	24.4	28.1	30.9	25.7	25	1996 2021		
Mean minimum temperature (°C)	16.4	17.0	15.4	12.0	8.9	7.2	6.4	6.6	7.4	9.3	12.0	14.4	11.1	25	1996 2021		
Rainfall																	
Mean rainfall (mm)	15.7	15.5	19.1	27.1	73.1	109.3	129.1	108.6	77.3	33.9	19.4	10.1	620.7	20	1996 2021		
Decile 5 (median) rainfall (mm)	1.6	3.0	11.4	23.6	70.0	113.0	123.2	116.8	82.4	29.6	12.2	4.2	605.5	25	1996 2021		
Mean number of days of rain ≥ 1 mm	1.2	1.4	2.5	4.2	8.6	10.3	13.9	12.1	10.1	5.4	3.3	1.9	74.9	24	1996 2021		

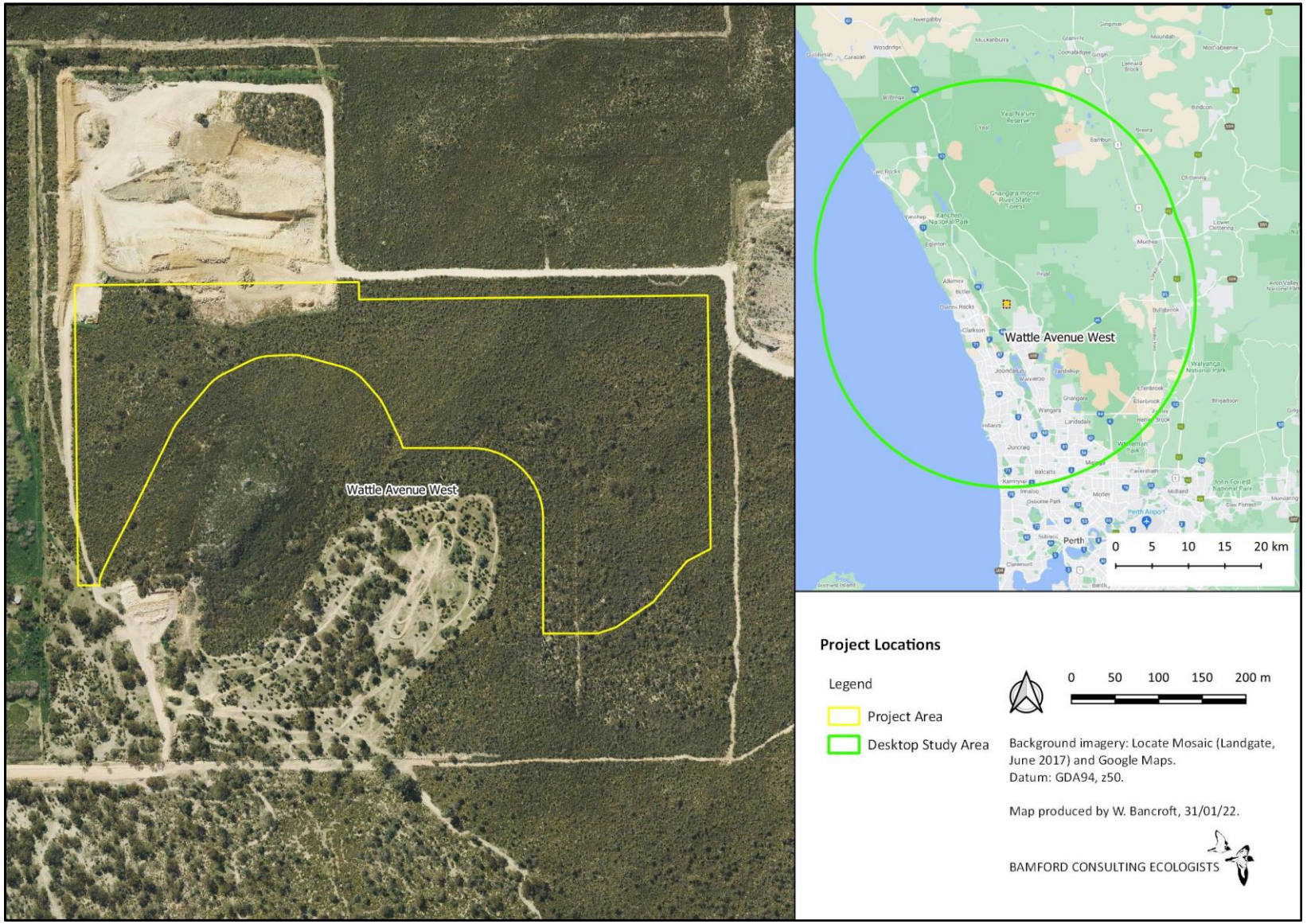

Figure 1. Location of the Wattle Avenue West Project.

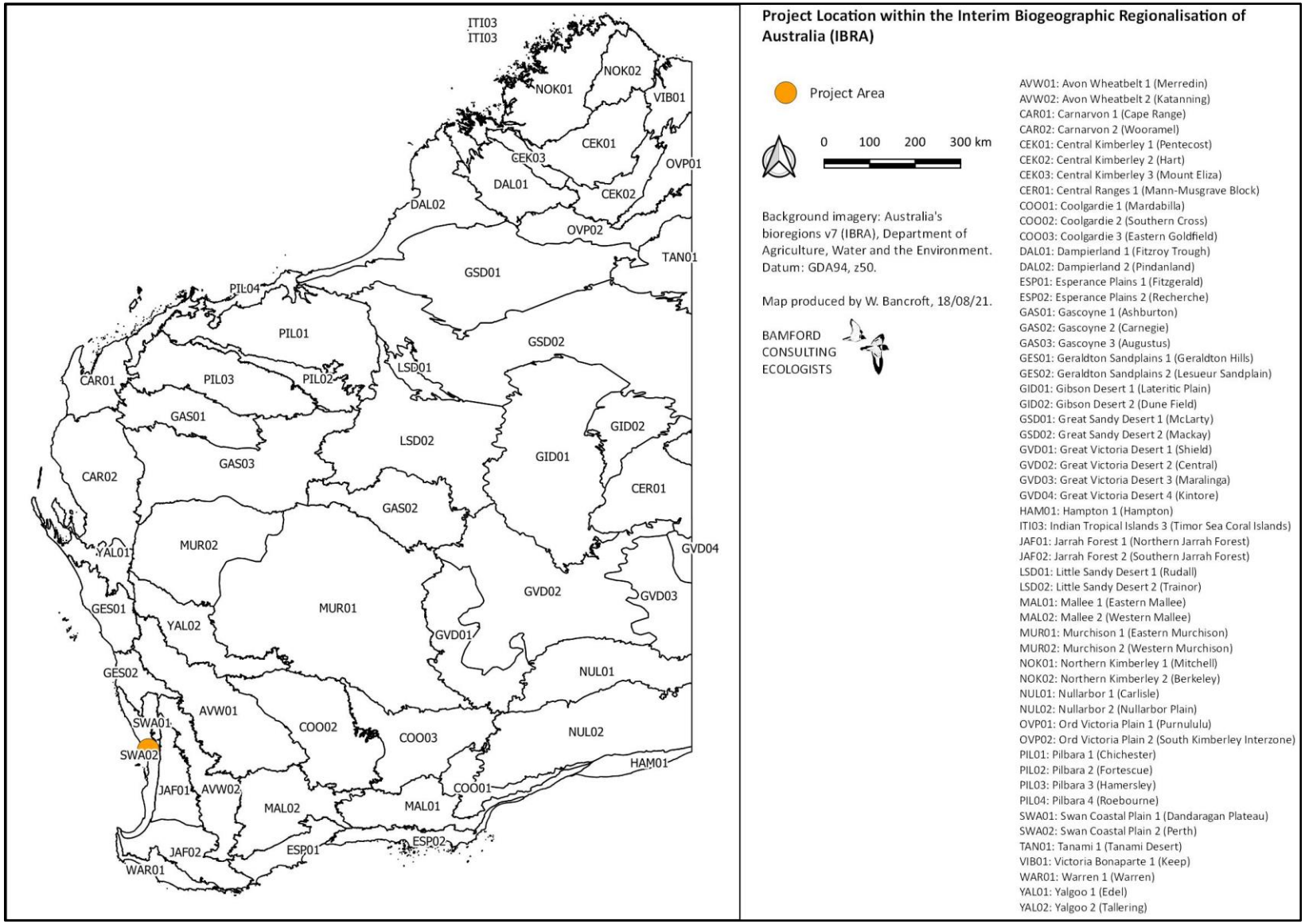

Figure 2. Project location within the Interim Biogeographic Regionalisation of Australia (IBRA).

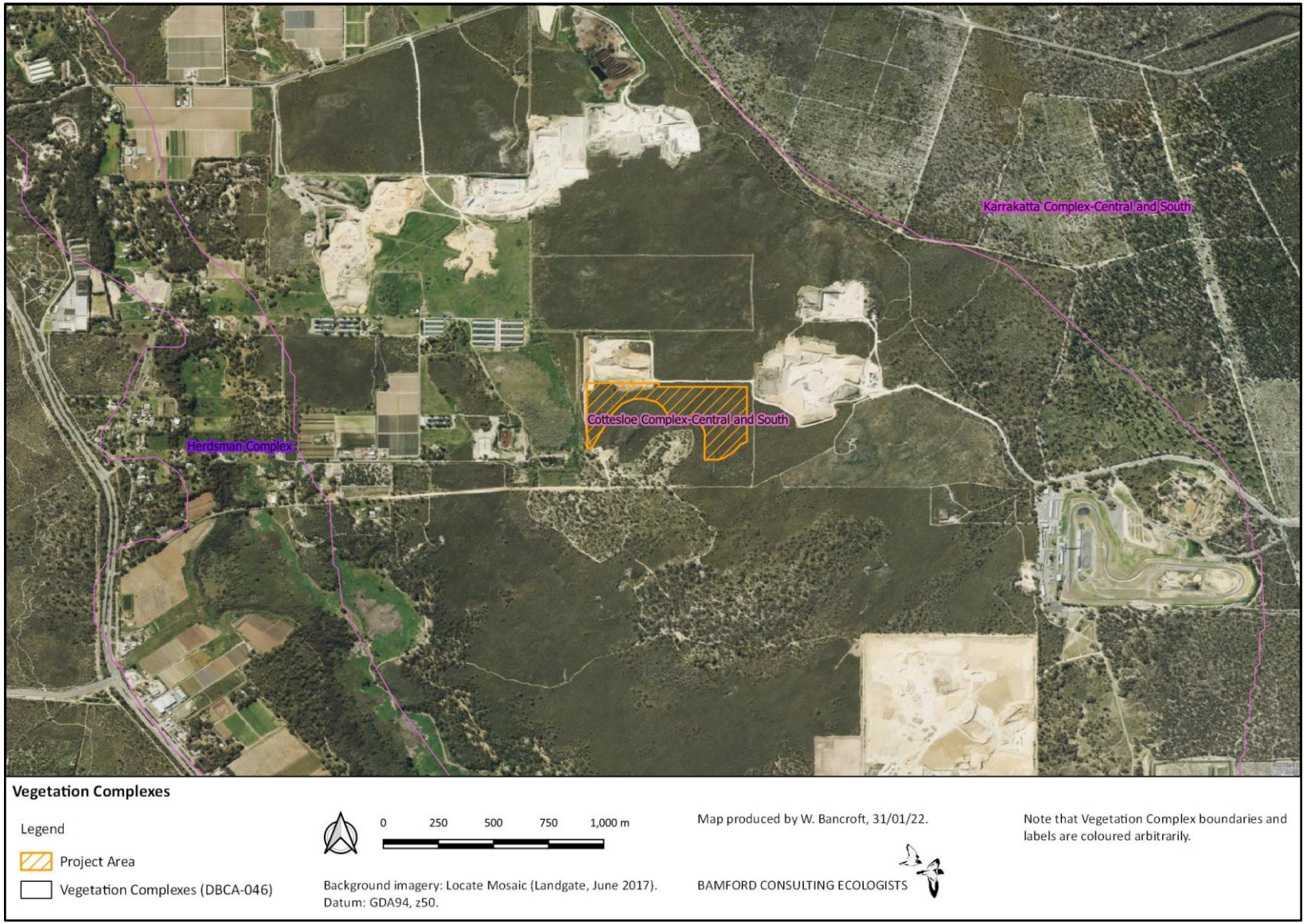

Figure 3. Vegetation Complexes (Heddle *et al*. 1980) in the vicinity of the Wattle Avenue West Project.

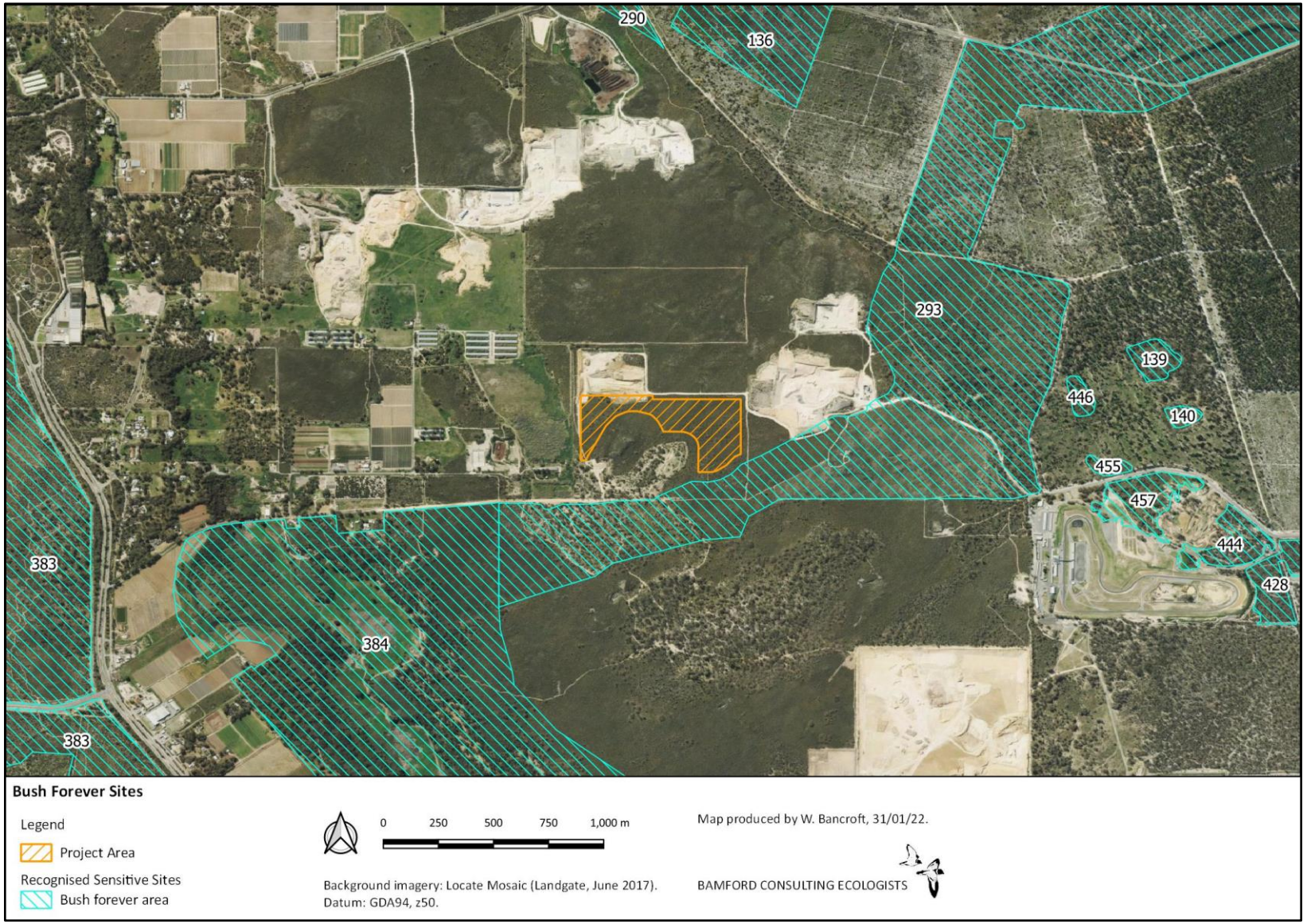

Figure 4. Bush Forever Sites (Dell and Banyard 2000) in the vicinity of the Wattle Avenue West Project.

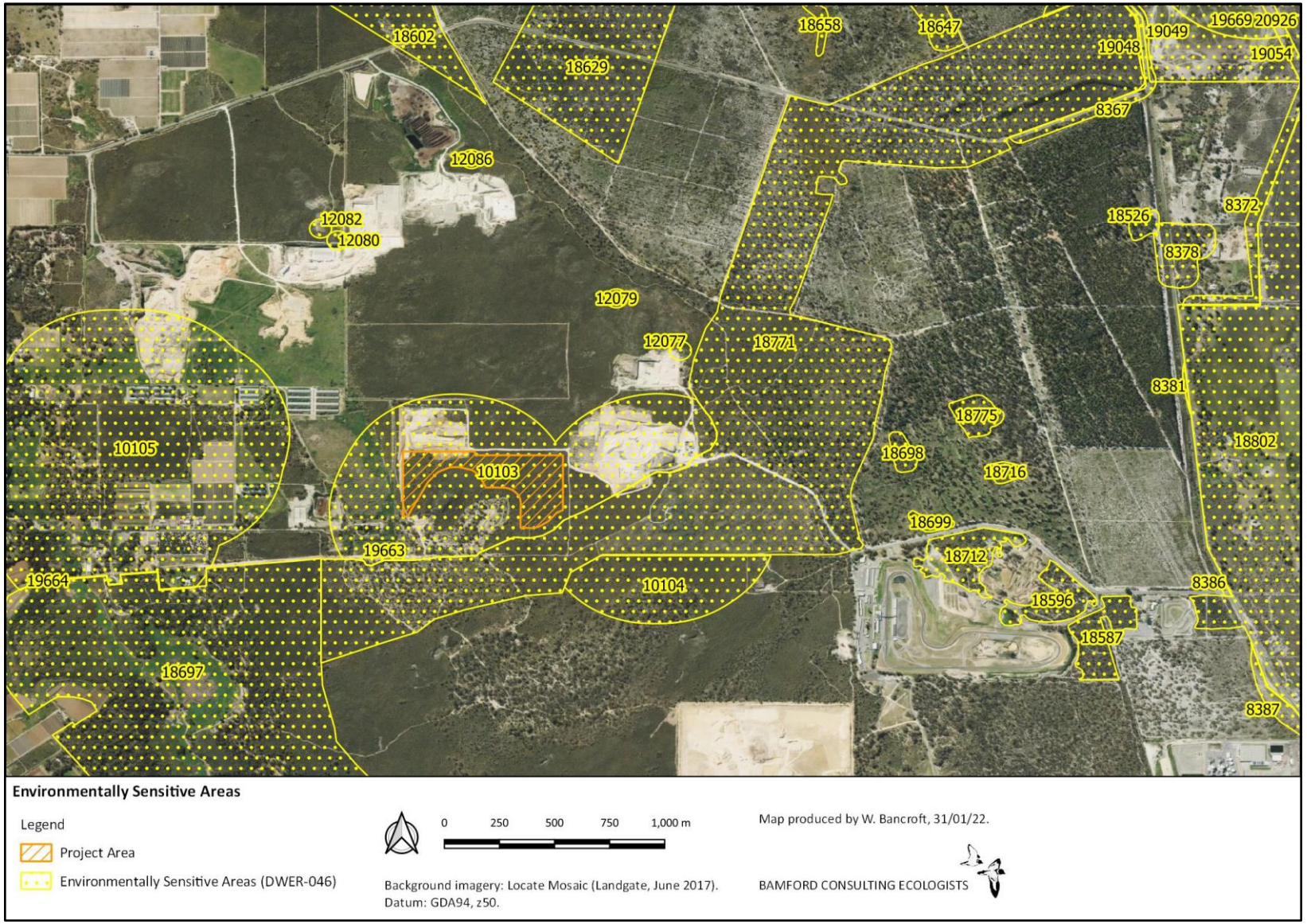

Figure 5. Environmentally Sensitive Areas (DWER 2022 a,b) in the vicinity of the Wattle Avenue West Project.

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 current project. This is based upon the level of existing knowledge (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:

- 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 *survey area*. The study area thus encompasses the *survey area* but includes the area from which databases are sourced.
- Survey area – the *survey area* is the area to which the results of the desktop analysis are directed and/or the area within which field investigations are conducted. 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.
- Project area – this may be equivalent to the *survey area* but is strictly the land over which the proponent has tenure or some control and within which on-site impacts may occur.
- Development footprint – the expected extent of land clearing and/or development.

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 consultant's previous experience in the area, a vegetation assessment of the site (by RPS), 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 2) and reports from other fauna surveys in the region (as listed in Table 3). 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 4.

2.3.2 Previous fauna surveys

Bamford Consulting Ecologists has undertaken multiple previous fauna investigations in the region of the current study area (Table 3). These indicate the local experience of the Bamford Consulting team in the region. Fauna records from almost all these investigations would have been added to NatureMap, and NatureMap will also contain records from other consultants who have worked in the region.

Table 2. Databases searched for the desktop review; accessed August 2021.

Database	Type of records held in database	Area searched
BCE Database	Fauna recorded by BCE in the vicinity of the project area.	25 km buffer around the centroid of the project area (383155E, 6496874N; or 31.657° S, 115.768° E).
Atlas of Living Australia (ALA 2022)	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 area (383155E, 6496874N; or 31.657° S, 115.768° E).
NatureMap (DBCA 2022e)	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 area (383155E, 6496874N; or 31.657° S, 115.768° E).
EPBC Protected Matters Search Tool (DAWE 2022g)	Records on MNES protected under the EPBC Act.	25 km buffer around the centroid of the project area (383155E, 6496874N; or 31.657° S, 115.768° E).
Index of Biodiversity Surveys for Assessment (IBSA) (DWER 2022c)	Flora and fauna data contained in EIA biodiversity survey reports.	25 km buffer around the centroid of the project area (383155E, 6496874N; or 31.657° S, 115.768° E).

Table 3. Literature sources for the desktop review.

Author	Title
Syrinx Environmental and Bamford Consulting Ecologists (2011)	Yellagonga Regional Park Fauna Baseline Survey. Level 2 (Detailed) fauna survey. Unpubl. report to City of Joondalup.
Basnett, G. and Bamford, M. (2013).	Fauna Survey of the Hepburn Heights Conservation Area, Padbury. Unpubl. report to Syrinx Environmental and City of Joondalup. Level 2 (Detailed) fauna survey.
Bamford, M. (2006).	Jindee Fauna Assessment. Unpubl. report to RPS Bowman Bishaw Gorham. Level 2 (Detailed) fauna survey.
Bamford, M. and Everard, C. (2017)	Capricorn Coastal Reserve Fauna Assessment. Level 1 and targeted survey. Unpubl. report to strategen environmental (jbs&g).
Bamford, M (2020)	Neerabup Industrial Estate pre-clearing fauna survey and translocation. Unpubl. notes to EcoLogical Australia. Level 2 (Detailed) fauna survey.
McKenzie *et al.* (2009)	Neerabup Road Fauna Underpass Monitoring Project. Unpubl. report to Main Roads WA. Targeted survey.
Bamford, M., Gamblin, T., McCreery, A. and Huang, N. (2019).	Fauna Assessment for VRX Silica Muchea Silica Sands Project. Unpubl. report to VRX Silica. Level 2 (Detailed) fauna survey.
Valentine, L., Wilson, B., Johnson, B., Huang, N and Reaveley, A. (2008).	Gnangara Sustainability Strategy. Comprehensive survey of fauna and other environmental factors, including chapters on vertebrate fauna and black-cockatoos.
Wadey, J., Huang, N. and Bamford, M. (2022).	Fauna Assessment for Lots 5324 and 8037 Duringen Road, Cowalla. Unpubl. report to Focussed Vision Consulting Pty Ltd. Level 1 ('Basic') fauna investigation and targeted assessment for black-cockatoos.

Table 4. 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 (2022).
Frogs	Tyler and Doughty (2009), Anstis (2017).
Reptiles	Storr *et al*. (1983, 1990, 1999, 2002), Bush and Maryan (2011), Wilson and Swan (2021).
Birds	Johnstone and Storr (1998, 2005), Menkhorst *et al*. (2017).
Mammals	Van Dyck and Strahan (2008), Churchill (2009), Menkhorst and Knight (2011).

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 2021. The authorities used for each vertebrate group were: fish (Morgan *et al.* 2014), frogs (Doughty 2021a), reptiles (Doughty 2021b), birds (BirdLife Australia 2019; Gill *et al.* 2022), and mammals (Travouillon 2021). 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'). Similarly, the group name 'black-cockatoo' is consistently used for all three taxa in the South-West. 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 15th June 2021.

2.4.3 Black-cockatoo habitat analysis

2.4.3.1 Guidelines

The Commonwealth Department of Agriculture, Water and the Environment (DAWE) provides guidelines for the referral of actions that may result in impact to black-cockatoos (for assessment under the EPBC Act). The survey and analysis reported here have been conducted with strong reference to both the existing guidelines (DSEWPaC 2012) as well as the recently revised draft guidelines (DEE 2017). This includes application of the foraging habitat scoring tool in DEE (2017). In addition, survey methodology followed the recommendations listed on the DAWE's Species Profile and Threats Database (DAWE 2022c, d, e). Ecological values for black-cockatoos within the site were based on the definitions of breeding, foraging and roosting habitat as per the EPBC Act referral guidelines for black-cockatoos (DSEWPaC 2012).

The DBCA has also indicated that the methodology developed and applied previously by BCE (e.g. Bancroft and Bamford 2021), and as described below, to score nesting value and foraging habitat is an acceptable approach.

2.4.3.2 Breeding

The aim of the breeding surveys was to record all potential hollow-bearing trees (suitable for black-cockatoo nesting) within the project area. The entire project area (see Figure 1), was examined for the presence of these trees. The following information was recorded for every suitable tree[1] with a diameter at breast height (DBH) equal to or greater than 500 mm:

- tree location;
- tree species;
- life status;
- DBH; and

[1] the draft revised EPBC Act study guidelines (DEE 2017) stress that <u>any</u> tree species may provide suitable hollows. Note that trees where the DBH criterion is >300mm do not occur at Lowlands.

- nest-tree rank: trees were assessed (from the ground) for the potential presence/quality of nest-hollows and allocated a nesting rank (developed by BCE) as described in Table 5.

The BirdLife Australia database of black-cockatoo breeding surveys was also searched for relevant local records (see Peck 2019).

Table 5. Ranking system for the assessment of potential nest-trees for black-cockatoos (revised 08/01/2021).

As per (DAWE 2022c, d, e) guidance, a potential nest-tree is any tree with a diameter at breast height >500 mm (or >300 mm for *Eucalyptus salmonophloia* and *E. wandoo*). Note that black-cockatoos favour vertical hollows for the nest chamber, but the hollow entrance may be vertical (a chimney hollow), have a side entrance or have a horizontal spout entrance.

Rank	Description of tree and hollows/activity
1	Activity at hollow observed; adult (or immature) bird seen entering or emerging from hollow. Can also be used for a known nest tree active in the previous 12 months (although this should be noted in the description). Note that activity at a hollow does not absolutely mean that breeding is occurring unless a young bird in hollow is observed.
2	Hollow of suitable size visible with chew marks around entrance. Record if chew-marks are recent or old.
3	Potentially suitable hollow visible but no chew marks present at entrance; or potentially suitable hollow suspected to be present - as suggested by structure of tree, such as large, vertical trunk broken off at a height of >8m; but note that hollow height is contextual. Carnaby's Black-Cockatoo will nest in hollows <5m so in a Wheatbelt breeding site a lower criterion may be more appropriate.
4	Tree with large hollows or broken branches that might contain large hollows, but hollows or potential hollows (nest chamber) are not vertical or near-vertical; thus a tree with or likely to have hollows of sufficient size but not to have hollows of the angle preferred by Black-Cockatoos. Trees with low but otherwise suitable hollows can also be assigned a rank or 4, depending on the species of black-cockatoo likely to be present.
5	Tree lacking large hollows or broken branches that might have large hollows; a tree with more or less intact branches and a spreading crown.

2.4.3.3 Foraging

The foraging value of the study area was assessed by calculating a foraging score for areas of similar vegetation type/condition (see Appendix 5). The foraging score provides a numerical value that reflects the significance of vegetation as foraging habitat for black-cockatoos, and this numerical value is designed to provide the sort of information needed by DAWE, Department of Water and Environmental Regulation (DWER) and the Environmental Protection Authority (EPA) to assess impact significance and offset requirements. The foraging value of the vegetation depends upon the type, density and condition of trees and shrubs in an area, and can be influenced by the context such as the availability of foraging habitat nearby. The BCE scoring system for value of foraging habitat has three

components as detailed in Appendix 5. These three components are drawn from the DAWE offset calculator but with the scoring approach developed by BCE:

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

Foraging value can thus be assigned a score out of six, based upon site vegetation characteristics, or a score out of 10 if context and species density are also considered. A higher score represents better foraging value. A score out of 10 is presented for the purposes of aiding offset calculations. The approach to assigning scores for vegetation, context and species density are outlined in Appendix 5. Foraging value scores are calculated differently for the three black-cockatoo species (Appendix 5) depending upon the vegetation present; thus a separated score is given for each VSA for each species.

Black-cockatoo foraging signs were also recorded in conjunction with the breeding tree surveys (see Section 2.4.3.2) and general site inspections. When observed, the location, tree species and approximate age of the foraging evidence were recorded. Black-cockatoo foraging evidence may persist for some months or years after the foraging event. There is currently no published evidence documenting the deterioration process of forage. Factors that help to establish the time since foraging include: the colour of nuts/foliage, the degree of weathering or decay of debris, the presence of small fragments of nut debris, the position/compression of the foraging debris relative to surrounding vegetation and leaf litter, and the strength of the eucalypt smell emitted. Despite the absence of empirical data, four categories of foraging activity were recognised, based on the time since foraging:

(i) Active – where birds were observed in the act of foraging;
(ii) Recent – foraging signs (e.g. chewed nuts or vegetation) were 'fresh' (i.e. foraging was likely to have occurred within days to weeks). Recent foraging signs were typically green and/or with very little sign of weathering. Approximately less than four weeks old;
(iii) Intermediate – foraging was likely to have occurred within weeks to months previously. Approximately one to six months old; and
(iv) Old – foraging was likely to have occurred months to years previously. Approximately more than six months old.

As an indication, Appendix 6 shows examples of Forest Red-tailed Black-Cockatoo foraging signs across the range of these categories (note that it is uncertain as to the exact time frame for each stage).

2.4.3.4 Roosting

As the breeding and foraging surveys were conducted, areas likely to be used as roosting sites (e.g. sites adjacent to watercourses with large trees) or areas that had cockatoo activity in the late-afternoon were noted.

The BirdLife Australia Great Cocky Count (GCC) database of roost sites was also searched for relevant local records (see Peck *et al.* 2019).

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 Wes Bancroft *BSc (Zoology/Microbiology), Hons (Zoology), PhD (Zoology)*	24 years	+	+
Dr Mike Bamford *BSc (Biology), Hons (Biology), PhD (Biology)*	40 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	Sufficient 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 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), as summarised in 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 3.

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. A full vegetation assessment of an adjacent site (Wattle Avenue East) was conducted by PGV (2021). From this, and observations made during the field investigations here, five major vegetation and substrate associations (VSAs) were identified in relation to fauna in the project area:

VSA 1. Proteaceous heath. Heath dominated by proteaceous species, particularly *Banksia sessilis*, on orange-brown sands with some limestone outcropping. VSA 1 corresponds to the PGV (2021) vegetation category 'BsXpCq': *Banksia sessilis*/*Xanthorrhoea preissii*/*Calothamnus quadrifidus* Closed Tall Scrub over *Hibbertia hypericoides*/*Melaleuca systena*/*Jacksonia calcicola* Low Shrubland to Closed Low Heath. See Plate 1.

VSA 2. Banksia woodland. Woodland dominated by tree banksias, particularly *B. grandis*, and Christmas Trees (*Nuytsia floribunda*) over shrubland on pale sands. VSA 2 corresponds in part to the PGV (2021) vegetation category 'BsAf': *Banksia attenuata*/*Allocasuarina fraseriana* Low Open Woodland over *Jacksonia sternbergiana* Tall Shrubland over *Xanthorrhoea preissii*/*Hibbertia hypericoides* Open Low Heath. See Plate 2.

VSA 3. Limestone Marlock woodland. Woodland dominated by Limestone Marlock (*Eucalyptus decipiens*) on orange-brown sands with some limestone outcropping. VSA 3 corresponds to the PGV (2021) vegetation category 'Ed': *Eucalyptus decipiens* Low Open Woodland over *Xanthorrhoea preissii*/*Banksia sessilis* Open Shrubland to Tall Open Scrub. This occupies only a small area near the exiting quarry (Figure 6). See Plate 3.

VSA 4. Rehabilitation. Disturbed areas, with limestone substrate, that have undergone some rehabilitation of vegetation. VSA 4 corresponds to the PGV (2021) vegetation category 'Rehabilitation area': *Olearia axillaris*/*Cenchrus setaceus* Low Shrubland.

VSA 5. Cleared. Cleared or largely disturbed areas (e.g. roads, or where quarrying is being undertaken, or has taken place), or roads, tracks or drains. VSA 5 corresponds to the PGV (2021) vegetation category 'Cleared': cleared.

The extent of the VSAs in the project area is mapped in Figure 6.

Plate 1. VSA 1: Proteaceous heath.

Plate 2. VSA 2: Banksia woodland.

Plate 3. VSA 3: Limestone Marlock woodland.

Figure 6. The distribution of VSAs in the project area.

3.1.1 Regional development

The project area is located within a highly fragmented natural landscape that has been largely cleared for housing, agriculture or plantations. Figure 7 illustrates the existing extent of development in a 15 km buffer around the project area. Existing developments (c. 31,484 ha) impact c. 55.2% of the total land area within this buffer (c. 57,041 ha). The proposed Wattle Avenue West site has a total area of c. 15.5 ha, of which at c. 1.2 ha has been cleared. Therefore, up to an additional 14.3 ha may be impacted and this would, at most, contribute 0.03% to the land clearing within the region, taking the total developments in the region to c. 55.23% of the area. It should be noted that the development footprint (see Section 2.1.1) of the Wattle Avenue West quarry within the project area may be less than this figure.

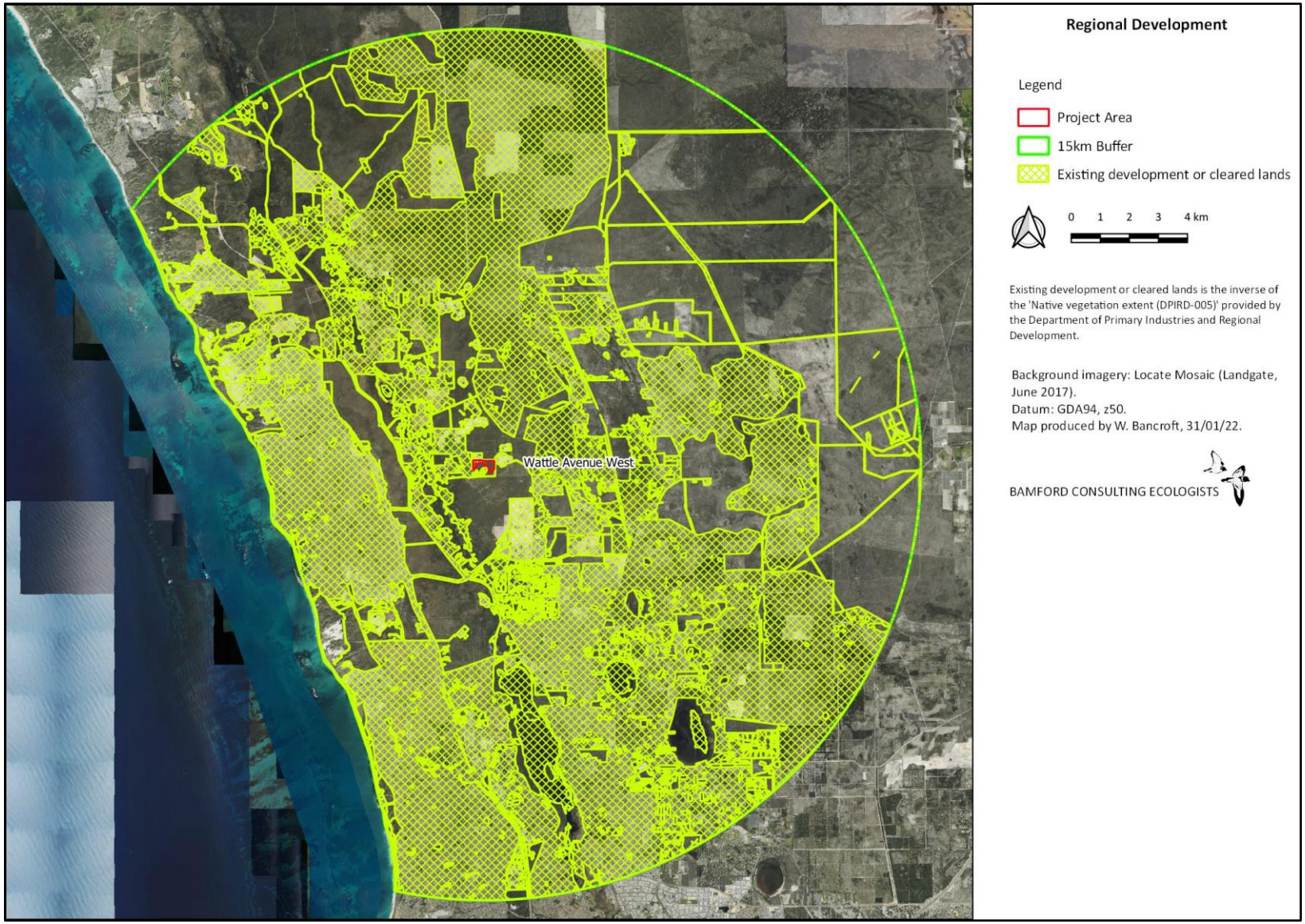

Figure 7. Estimated existing development within the region (15 km).

3.2 Fauna assemblage

3.2.1 Overview of vertebrate fauna assemblage

The desktop study identified 173 vertebrate fauna species as potentially occurring in the project area: no fish, eight frogs, 46 reptiles, 100 birds and 19 mammals. These species are listed in Appendix 7. The presence of at least 23 species (20 birds and three mammals) was confirmed during the 2021 site inspection (as presented in Appendix 8, but also indicated in Appendix 7).

Two hundred and forty-seven species (six fish, nine frogs, 30 reptiles, 174 birds and 28 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. These species are listed in Appendix 9.

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 species 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
Fish	0	0	0	0	0	0	0
Frogs	8	0	4	0	4	0	0
Reptiles	46	0	44	1	1	0	0
Birds	100 (6)	23	39	36	20	5	4
Mammals	19 (5)	3	11	7	0	1	9
Total	173 (11)	**23**	**98**	**42**	**27**	**6**	**13**

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

While freshwater fish are known from the region, there was no suitable habitat for this group within the project area.

The eight frog species include four that are considered to be residents within the project area. These species spend much, or all, of their life cycle away from wetlands/damplands and may be wide-ranging through woodlands and heathlands. The remaining four species are more dependent on regular seasonal or permanent standing fresh water and are expected to be irregular visitors to the site; passing through when suitable conditions prevail and/or in very low numbers. There are no introduced species of frog expected.

The 46 reptile species are all considered to be residents with the exception of *Lerista lineopunctulata* and the Carpet Python which may occur as irregular or regular visitors. There are no introduced species of reptiles expected.

The bird assemblage of 100 species is much smaller than would be expected in the broader region. This is due to a limited range of VSAs present and, notably, the absence, or all-but-absence, of eucalypt woodlands, Banksia woodlands and wetlands. Thirty-nine of the bird species are considered to be resident in the project area, with a further 36 that are regular visitors or migrants. A further 20 are expected to be irregular visitors and there are five vagrant species. There are six introduced species of birds expected to occur within the project area (three pigeons/doves, the Laughing Kookaburra, the Long-billed Corella and the Rainbow Lorikeet).

Most of the 19 mammal species are considered to be residents (11) or regular visitors (7), with the Chuditch considered to be a vagrant to the area. A large proportion of the original indigenous local mammal fauna has become extinct (9 species), as listed in Appendix 9, although several of these (e.g. dunnarts, pygmy-possum, Ash Grey Mouse) persist in less developed/impacted areas of the Swan Coastal Plain (e.g. well to the north of the project area). There are five introduced species of mammal expected to occur within the project area including two feral predators, two rodents and the Rabbit.

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

- **Uniqueness:** The fauna assemblage is probably typical of the near-coastal shrublands of the coastal plain north of Perth. This assemblage is only moderately well-represented due to extensive clearing.
- **Completeness:** The assemblage is likely to be substantially complete except for the mammal component, which is depauperate in both medium-sized and small species.
- **Richness:** The assemblage is likely to be only moderately rich in a regional context as the environment consists largely of shrublands and lacks the banksia and eucalypt woodlands of the coastal plain slightly further east.

3.2.3 Invertebrate fauna of conservation significance

The project area sits within DBCA's Swan management region (DBCA 2022b). DBCA (2022g) listed 21 threatened or priority invertebrate fauna in this region, as outlined in Appendix 10. At least nine of these species can be immediately ruled out from occurring within the project area and the reasons for exclusion are presented in Appendix 10 (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 12 species, all location records from ALA (2022) and WAM (2022) 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 8. Note that no records for *Australotomurus morbidus* (Cemetery Springtail) were available.

There are no records of threatened invertebrate fauna within the project area. Six species have been recorded from within the regional (15 km) buffer:

(i) *Austrosaga spinifer* (Spiny Katydid [Swan Coastal Plain]) – known from only a few records in 'heath habitats' (Rentz 1993) from Cervantes to Boya (ALA 2022). Habitat that is potentially suited to this species exists within the project area, therefore this species may be present.

(ii) *Hesperocolletes douglasi* (Douglas's Broad-headed Bee) – known only from one or two records in the Pinjar/Muchea area (Arnold *et al.* 2019). A single female specimen was collected with a sweep net by Arnold *et al.* (2019) in a Banksia woodland remnant, c. 15km west of Muchea. While this record is only c. 7 km from the project area there is a low prevalence of this habitat type within the project area. Therefore, it is difficult to ascertain the likelihood of this species' occurrence. It is probably not present.

(iii) *Hylaeus globuliferus* (Woollybush Bee) – there have been a number of records of this species within 15 km of the project area, all of which are to the south. The Woollybush Bee occurs across a fairly broad region of south-western Australia, north to about Eneabba, east to the eastern edge of the wheatbelt and along the southern coast to Fitzgerald National Park near Hopetoun (ALA 2022). Houston (2018) notes that this species is known to forage on the flowers of Woollybush (*Adenanthos cygnorum*) and Candlestick Banksia (*Banksia attenuata*) which are very limited, if not absent, in occurrence within the project area. Therefore, it is unlikely that the project area would support the Woollybush Bee and that it is probably absent.

(iv) *Idiosoma sigillatum* (Swan Coastal Plain Shield-backed Trapdoor Spider) – there are several records of this species within 15 km of the project area, and tens of records to the south. Rix *et al.* (2017) noted that this species has a "relatively widespread although strictly … substrate-specific distribution along the Swan Coastal Plain of south-western Western Australia, from Dalyellup north to at least Ledge Point (including Rottnest Island and Garden Island)". While much of its previous range has been developed (as part of the greater Perth Metropolitan area) it still persists in areas of remnant bushland with "Banksia woodland and heathland on sandy soils". These habitats are present within the project area and, therefore, it is likely that Swan Coastal Plain Shield-backed Trapdoor Spider is present.

(v) *Leioproctus contrarius* (a short-tongued bee) – several historical records of this species occur within 15 km of the project area, to the east. Moulds (2019) suggested *L. contrarius* that prefers areas where the plant species *Scaevola repens* var. *repens* and *Lechenaultia* spp. are present. While *Scaevola* is present in the project area it is a different species and it is uncertain

as to whether this will be used by *L. contrarius*. Therefore, the occurrence of this species is uncertain but it may be present.

(vi) *Synemon gratiosa* (Graceful Sun-Moth) – a number of records of this species are known from within 15 km of the project area, to the south. The Graceful Sun-Moth was previously listed as specially protected fauna under the WA Wildlife Conservation Act 1950 (rare or likely to become extinct) and also as Endangered under the EPBC Act (Bishop *et al.* 2010a; Bishop *et al.* 2010b) but extensive surveys between 2009 and 2018 dramatically increased the known range of this species and it has been subsequently re-evaluated as a priority-listed species (Williams *et al.* 2021; ALA 2022). The moth is now known from a series of disjunct subpopulations between Binningup and Kalbarri, a range of 625 km, where it is mainly restricted to coastal and near-coastal sand dunes but extends into Banksia woodlands near Perth (Williams *et al.* 2021). Larvae feed on two host plants, *Lomandra maritima* (on coastal dunes) and *L. hermaphrodita* (in Banksia woodlands), the former of which is known from the project area (PGV 2021). It is therefore likely that this species is present.

Therefore, four known invertebrate species of conservation significance are most likely to occur in the vicinity of the project area:

- Spiny Katydid [Swan Coastal Plain] – CS2 (P2)
- Swan Coastal Plain Shield-backed Trapdoor Spider – CS2 (P3)
- *Leioproctus contrarius* (a short-tongued bee) – CS2 (P3)
- Graceful Sun-Moth – CS2 (P4)

It should be noted that the ecology and distribution of short-range endemic invertebrates is often poorly understood or documented, and the project area occurs in a region that is remote and likely to be poorly-surveyed for these groups. Thus there may be undetected SRE species present.

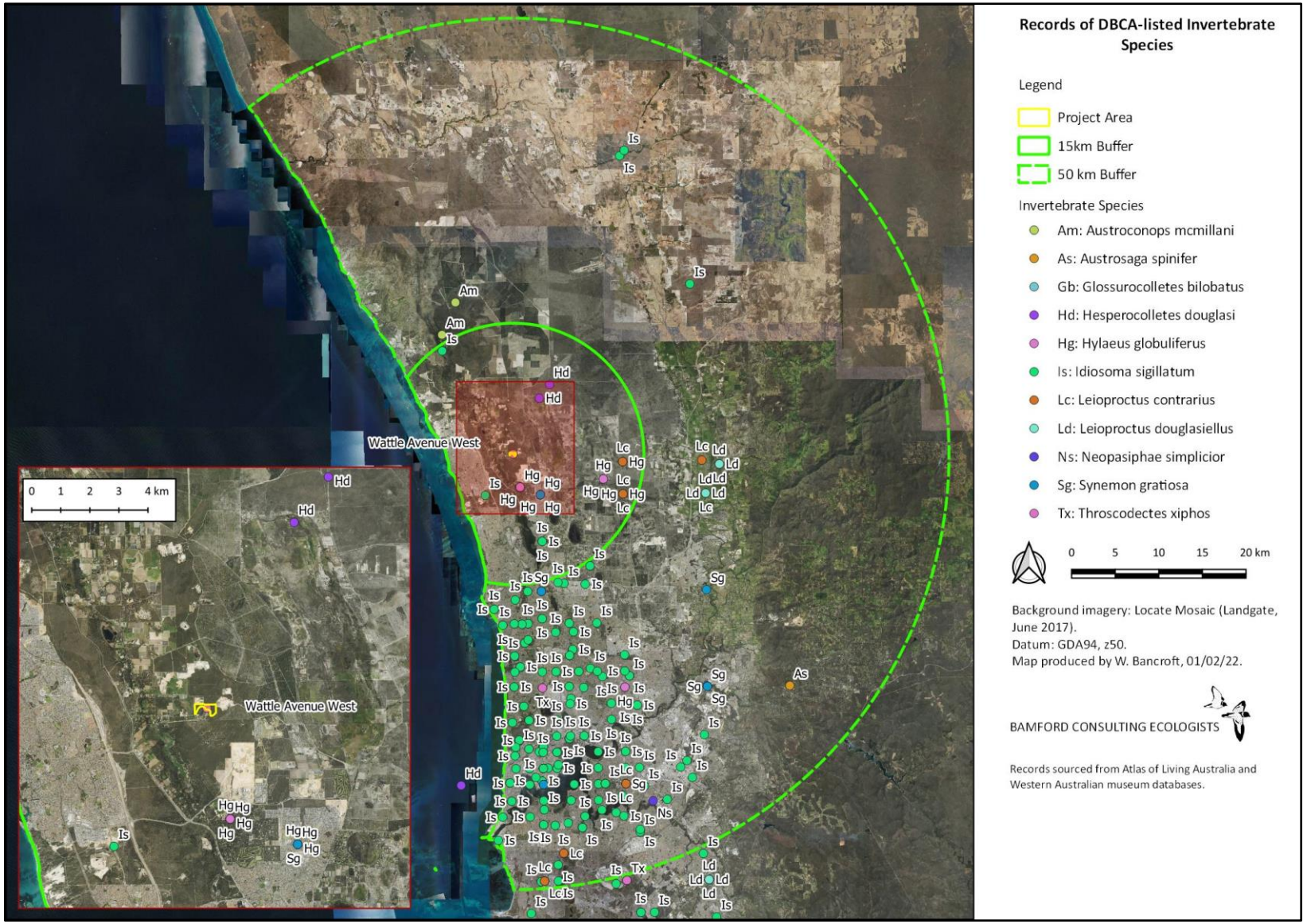

Figure 8. Records of DBCA-listed (threatened or priority) invertebrate species within 50 km of the project area.

3.2.4 Vertebrate fauna of conservation significance

Of the 173 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 (five CS1, three CS2 and 34 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 7) but are also listed with details of their conservation significance in Table 11. The majority of conservation significant species are expected as residents or regular visitors/migrants visitors (30 species), with some irregular visitors (9 species) or vagrants (3 species).

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
Fish	0	0	0	**0**
Frogs	0	0	0	**0**
Reptiles	0	1	1	**2**
Birds	4	0	31	**35**
Mammals	1	2	2	**5**
Total	**5**	**3**	**34**	**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).
Bush Forever (Dell and Banyard 2000) status: HS = habitat specialists with a reduced distribution on the Swan Coastal Plain, WR = wide ranging species with reduced populations on the Swan Coastal Plain.
LS = considered by BCE to be of local significance (see Appendix 1).

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE
Morelia spilota imbricata	Carpet Python (southwest)	CS3 (LS)	Regular visitor
Neelaps calonotos	Black-striped Snake	CS2 (P3)	Resident (if present)
Dromaius novaehollandiae	Emu	CS3 (WR)	Regular visitor
Phaps chalcoptera	Common Bronzewing	CS3 (HS)	Resident
Phaps elegans	Brush Bronzewing	CS3 (HS)	Irregular visitor
Apus pacificus	Fork-tailed Swift	CS1 (M,Mar,S5)	Vagrant
Turnix varius	Painted Button-quail	CS3 (WR)	Resident
Lophoictinia isura	Square-tailed Kite	CS3 (WR)	Regular visitor
Aquila audax	Wedge-tailed Eagle	CS3 (WR)	Regular visitor
Hieraaetus morphnoides	Little Eagle	CS3 (WR)	Regular visitor
Accipiter fasciatus	Brown Goshawk	CS3 (WR)	Regular visitor
Accipiter cirrocephalus	Collared Sparrowhawk	CS3 (WR)	Regular visitor
Haliastur sphenurus	Whistling Kite	CS3 (WR)	Regular visitor
Falco peregrinus	Peregrine Falcon	CS1 (S7)	Regular visitor
Calyptorhynchus banksii naso	Forest Red-tailed Black-Cockatoo	CS1 (V,S3)	Irregular visitor
Calyptorhynchus latirostris	Carnaby's Black-Cockatoo	CS1 (E,S2)	Regular migrant
Malurus assimilis	Purple-backed Fairy-wren	CS3 (HS)	Resident
Malurus splendens	Splendid Fairy-wren	CS3 (HS)	Resident
Malurus leucopterus	White-winged Fairy-wren	CS3 (HS)	Regular visitor
Stipiturus malachurus	Southern Emu-wren	CS3 (HS)	Regular visitor
Phylidonyris novaehollandiae	New Holland Honeyeater	CS3 (WR)	Resident
Phylidonyris niger	White-cheeked Honeyeater	CS3 (WR)	Resident
Glyciphila melanops	Tawny-crowned Honeyeater	CS3 (WR)	Regular visitor
Anthochaera lunulata	Western Wattlebird	CS3 (WR)	Regular visitor
Manorina flavigula	Yellow-throated Miner	CS3 (WR)	Irregular visitor
Smicrornis brevirostris	Weebill	CS3 (HS)	Resident
Sericornis frontalis	White-browed Scrubwren	CS3 (HS)	Resident
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	CS3 (HS)	Resident

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE
Acanthiza apicalis	Inland Thornbill	CS3 (HS)	Resident
Acanthiza inornata	Western Thornbill	CS3 (HS)	Irregular visitor
Daphoenositta chrysoptera	Varied Sittella	CS3 (HS)	Irregular visitor
Colluricincla harmonica	Grey Shrike-thrush	CS3 (HS)	Resident
Strepera versicolor	Grey Currawong	CS3 (WR)	Irregular visitor
Artamus personatus	Masked Woodswallow	CS3 (WR)	Vagrant
Artamus cyanopterus	Dusky Woodswallow	CS3 (WR)	Regular visitor
Petroica boodang	Scarlet Robin	CS3 (HS)	Regular visitor
Quoyornis georgianus	White-breasted Robin	CS3 (HS)	Irregular visitor
Dasyurus geoffroii fortis	Chuditch	CS1 (V,S3)	Vagrant
Isoodon fusciventer	Quenda	CS2 (P4)	Resident
Tarsipes rostratus	Honey Possum, Noolbenger	CS3 (LS)	Resident
Notamacropus irma	Brush Wallaby	CS2 (P4)	Regular visitor
Rattus fuscipes fuscipes	Western Bush Rat, Moodit	CS3 (LS)	Resident
Austrosaga spinifer	Spiny Katydid [Swan Coastal Plain]	CS2 (P2)	Resident (if present)
Idiosoma sigillatum	Swan Coastal Plain Shield-backed Trapdoor Spider	CS2 (P3)	Resident
Leioproctus contrarius	a short-tongued bee	CS2 (P3)	Resident (if present)
Synemon gratiosa	Graceful Sun-Moth	CS2 (P4)	Resident

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 four 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 (and, for invertebrates, in Section 3.2.3).

3.2.5.1 Conservation Significance 1

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 2022a). 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 2022a). 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. Likely to be regularly present, unpredictably, within the region and to pass over the project area on an occasional basis.

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: Regular visitor. Wide-ranging and likely to pass over the project area on a regular basis.

Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksii naso*) CS1 (V,S3)

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

Distribution and habitat: Endemic to the deeper south-west of Western Australia, from around Gingin in the north, east to Mount Helena, North Bannister and Mount Saddleback, and south to around Albany (Johnstone and Storr 1998). In recent years there appears to have been a distinct expansion of the range of this species on to the Swan Coastal Plain, including many suburbs within the Perth metropolitan area. Generally restricted to areas of Jarrah-Marri forest, farmlands with remnant trees and urban landscapes. Forest Red-tailed Black-Cockatoos are currently considered not to undergo regular migration (DAWE 2022c). Two other sub-species occur in Western Australia: *C. b. escondidus* in the western mid-west and Pilbara, and *C. b. macrorhynchus* in the Kimberley (Johnstone and Storr 1998). Neither of these is a conservation significant taxon.

Ecology: Diurnal granivore, feeding predominantly on the seeds of Jarrah and Marri (Johnstone and Kirkby 1999; Johnstone *et al.* 2013b) but is also adapting to foraging on urban (introduced) plant species. Reliant on large tree-hollows in eucalypts (especially Marri) for breeding (Johnstone *et al.* 2013a; DAWE 2022c). Threatened by habitat loss, habitat degradation, nest hollow shortage, and competition for available nest hollows from other parrots and feral Honeybees (DAWE 2022c).

Expected occurrence: Irregular visitor. The project area is at the limit of this species' range and supports very little suitable foraging or breeding habitat but, given the expansion of this species' distribution on the Swan Coastal Plain, irregular occurrence cannot be ruled out.

Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*) CS1 (E,S2)

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

Distribution and habitat: Endemic to south-western Western Australia, from Kalbarri in the north, east to Merredin and Ravensthorpe, and then further east along the south coast to the Esperance area (Johnstone and Storr 1998; DAWE 2022e). Breeds (July to December) predominantly in the east of its range with a migration to coastal areas in the non-breeding period. In recent years, however, the species has expanded its breeding range westward and south into the Jarrah-Marri forests of the Darling Scarp and into the Tuart forests of the Swan Coastal Plain (DAWE 2022e). Heavily reliant on areas of Banksia woodland and proteaceous shrubland/heath for foraging (Johnstone and Storr 1998; DAWE 2022e).

Ecology: Diurnal granivore, feeding predominantly on the seeds of the Proteaceae (especially banksias) but also known to feed on a very wide variety of plants, including non-native ornamentals and plantation species such as pine (Valentine and Stock 2008; Groom 2011; DPaW 2013; Johnston *et al.* 2016; DAWE 2022e). Reliant on large tree-hollows in eucalypts (especially smooth-barked species such as Wandoo and Salmon Gum) for breeding (Saunders 1974; Johnstone and Storr 1998; Morgan *et al.* 1998; DAWE 2022e). Threatened by habitat loss, habitat degradation, nest hollow shortage, and competition for available nest hollows from other parrots and feral Honeybees, illegal shooting and illegal trade (Burbidge 2004; DAWE 2022e).

Expected occurrence: Regular migrant. Known to occur within the project area with some foraging plants available (in particular *Banksia sessilis*). Foraging and nesting values of the project area for the species are assessed in section 3.3.

Chuditch (*Dasyurus geoffroii fortis*) CS1 (V,S3)

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

Distribution and habitat: The Chuditch is a wide-ranging resident in Marri-Jarrah forest of the south-west of Western Australia and also in heaths and eucalypt woodlands of the eastern wheatbelt and goldfields (Van Dyck and Strahan 2008). This species was formerly distributed throughout much of western and inland Australia but its range has contracted to the region approximately south-west of a line between Shark Bay and Esperance (Burbidge 2004; Van Dyck and Strahan 2008; DAWE 2022f).

Ecology: The Chuditch is a nocturnal, terrestrial carnivore, feeding mainly on smaller vertebrates (e.g. reptiles, birds and mammals) and large invertebrates (Burbidge 2004; Van Dyck and Strahan 2008). During the day Chuditch shelter in dens; predominantly hollow logs and earth burrows (Van Dyck and Strahan 2008). Chuditch have a large home range, with females in the deeper south-west occupying 55-120 ha and males ranging over 400 ha or more (Van Dyck and Strahan 2008). Further east, Rayner *et al.* (2012) found that Chuditch in the Forrestania area occurred at an average density of 0.039 individuals/km^2, with home ranges as small as 189 ha (a female) and as large as 2,125 ha (a male).

Expected occurrence: Vagrant. Wide-ranging and likely to be present in the project area only as a vagrant. A juvenile male was caught about 10km to the east in 2004, in dense riparian vegetation in the Gnangara pine plantation (M. Bamford pers obs.).

3.2.5.2 Conservation Significance 2

Black-striped Snake (*Neelaps calonotos*) CS2 (P3)

Conservation status: Listed as Priority 3 by DBCA.

Distribution and habitat: Restricted to coastal sandplains from near Dongara to Mandurah (Bush *et al.* 2010). Appears to be absent from the eastern coastal plain (M. Bamford pers. obs.). Within the Perth Metropolitan area this species may be restricted to large reserves (How and Shine 1999).

Ecology: A fossorial species that preys upon small, fossorial skinks in the upper layers of loose sand (Bush *et al.* 2010).

Expected occurrence: Resident (if present). Some suitable habitat is present within the project area.

Quenda (*Isoodon fusciventer*) CS2 (P4)

Conservation status: Listed as Priority 4 by DBCA.

Distribution and habitat: The Quenda formerly occurred across the south-west of Western Australia from Geraldton to east of Esperance, including the wheatbelt, but it now has a much-reduced range, with few records north of Yanchep/Muchea on the coastal plain, and it is more or less extinct across the Wheatbelt (Van Dyck and Strahan 2008; Travouillon and Phillips 2018). It persists around Perth, particularly in areas of dense vegetation around wetlands, and it remains locally common in suitable environments (Howard *et al.* 2014).

Ecology: Omnivorous and cathemeral (active throughout the day and night) Quenda feed on invertebrates, plant material and fungi (Van Dyck and Strahan 2008). It is one of the few native, terrestrial mammals to persist in semi-urban landscapes in the south-west. Populations of this species have declined due to ongoing threats from feral predators and land-clearing (Van Dyck and Strahan 2008; Howard *et al.* 2014).

Expected occurrence: Resident. Known to occur within the project area and suitable habitat present.

3.2.5.3 Conservation Significance 3

Carpet Python (southwest) (*Morelia spilota imbricata*) CS3 (LS)

Conservation status: This subspecies was formerly listed under the Western Australian *Wildlife Conservation Act 1950* as 'other specially protected fauna' but that status has, more recently, been removed in the WA *Biodiversity Conservation Act 2016* (DBCA 2022g). It is likely to remain uncommon or at risk in the proximity of development.

Distribution and habitat: Patchily distributed through south-west Western Australia in a wide range of habitats including woodlands, heaths and rock outcrops (Bush *et al.* 2010; Wilson and Swan 2021). It is particularly common in areas of exposed limestone, including offshore islands (Bush *et al.* 2010).

Ecology: Predominantly a nocturnal carnivore, the Carpet Python preys mainly on birds and mammals, although reptiles are occasionally taken (Bush *et al.* 2010).

Expected occurrence: Regular visitor. Parts of the project area are well suited to this species and it is known to occur in nearby Neerabup National Park, so individuals can at least be expected as regular visitors.

Habitat specialist or wide-ranging bird species with reduced populations on the Swan Coastal Plain (31 species; see Table 11) CS3 (LS)

Conservation status: These species have all been noted by Dell and Banyard (2000) as either habitat specialists or wide ranging species with a reduced population on the Swan Coastal Plain and are, therefore, considered locally significant.

Distribution and habitat: Generally species that require larger areas of intact native remnants to persist.

Ecology: There is a wide range of foraging strategies in this group but the majority of the species are small insectivores or honeyeaters. Also includes ground-foraging granivores (e.g. Emu, bronzewings, button-quail) and nectarivores (honeyeaters).

Expected occurrence: Most species are expected to be residents or regular visitors, although a number are expected as irregular visitors or vagrants (see Table 11).

Honey Possum (*Tarsipes rostratus*) CS3 (LS)

Conservation status: While locally abundant in good seasons in suitable habitat, this species is struggling to persist on the Swan Coastal Plain in the vicinity of development (e.g. urban areas, agriculture, plantations etc.).

Distribution and habitat: Occurs in sandplain heaths and woodlands of south-western Australia (south-west from Kalbarri area to Esperance) and along the south-eastern coast (Van Dyck and Strahan 2008; ALA 2022).

Ecology: A nocturnal nectarivore, the Honey Possum is dependent on a high diversity of nectar-producing plants that can provide year-around food resources (Van Dyck and Strahan 2008).

Expected occurrence: Resident. Suitable habitat, with good nectar supply, exists within the project area. The Honey Possum persists in moderate numbers in suitable habitat on the northern margins of Perth, with records within a few kilometres of the Wanneroo City Centre (M. Bamford pers. obs.).

Moodit or Western Bush Rat (*Rattus fuscipes fuscipes*) CS3 (LS)

Conservation status: While locally common in suitable habitat, this species is struggling to persist on the Swan Coastal Plain in the vicinity of development (e.g. urban areas, agriculture, plantations etc.).

Distribution and habitat: The Bush Rat (*R. fuscipes*) occurs along the south-west, southern and eastern coastlines of Australia in coastal scrubs, heaths, eucalypt forests and rainforests that provide dense cover (Van Dyck and Strahan 2008). The western subspecies, the Western Bush Rat, occurs generally within 100 km of the coast between Geraldton and Israelite Bay, east of Esperance, in Western Australia (ALA 2022).

Ecology: The Western Bush Rat is nocturnal and secretive omnivore, feeding on fungi, seeds, fruits and invertebrates (Van Dyck and Strahan 2008). The availability of food through the winter appears to limit populations of this species (Van Dyck and Strahan 2008).

Expected occurrence: Resident. Suitable habitat exists within the project area. The species was recorded in Neerabup in 2020 during fauna translocation prior to clearing in the nearby Neerabup industrial area (M. Bamford pers obs).

3.3 Black-cockatoo habitat analysis

3.3.1 Black-cockatoo presence

Only one of the three species of black-cockatoo known to occur in the south-west of Western Australia was directly recorded on the site during the site inspection: Carnaby's Black-Cockatoo. This was outside of the project area; two birds were seen perched in trees to the north of the project area. Anecdotal evidence suggested a number of Carnaby's Black-Cockatoos had been seen in the project in the previous weeks and this is supported by the indirect (foraging) evidence presented in Section 3.3.3 below.

Given these direct observations, indirect (foraging) records (see Section 3.3.3 below), roosting data (see Section 3.3.4 below) and the literature review (including current species distributions), it is considered that, currently:

- Carnaby's Black-Cockatoo is likely to be a regular non-breeding migrant to the site in moderate numbers.
- Forest Red-tailed Black-Cockatoo is likely to be an irregular visitor to the site. The project area is at the limit of this species' range and supports very little suitable foraging or breeding habitat but, given the expansion of this species' distribution on the Swan Coastal Plain, irregular occurrence cannot be ruled out.
- Baudin's Black-Cockatoo is unlikely to use the site as it is outside its normal/expected range.

3.3.2 Black-cockatoo breeding habitat

No trees that met the potential nest-tree criteria of (DAWE 2022c, d, e) and DEE (2017) were recorded within the project area.

3.3.3 Black-cockatoo foraging habitat

3.3.3.1 Carnaby's Black-Cockatoo

Foraging habitat for the Carnaby's Black-Cockatoo was present throughout the Wattle Avenue West site. This is predominantly due to the presence of two tree species and one shrub species known to be mainstays of the Carnaby's Black-Cockatoo diet: *Banksia attenuata, B. grandis* and *B. sessilis* (Groom 2011). Where it occurred, the most widespread of these was *B. sessilis* and, where it occurred, it was generally in moderate to high density. There were also some areas of low to no *B. sessilis* density. Based upon guidance on the assessment of foraging values of vegetation (Appendix 5), the areas of moderate density *B. sessilis* are assigned a vegetation score of 4 out of 6. There were also some small pockets of the tree banksias (see Figure 6) that were also scored 4 out of 6. The areas (and percentages) of each vegetation score for each VSA are shown for the Carnaby's Black-Cockatoo in Table 12. A map of vegetation scores for Carnaby's Black-Cockatoo foraging within the project area is presented in Figure 9.

There are approximately 25,558 ha of remnant native vegetation (as assessed by DPIRD 2022) within 15 km of the project area, which itself has c. 14.3 ha of native vegetation. Therefore, the site comprises c. 0.03% of the native vegetation in the 'local area' (as per the methods outlined in Appendix 5). It is likely that the Carnaby's Black-Cockatoo breeds within the local area, given the proximity to Tuart forests in the region. Thus, a 'context' score of 1 (out of 3) has been assigned to the project area for this species (see Appendix 5). This low context score is assigned because despite the high quality of foraging habitat and the presence of breeding nearby, the area of habitat is small and foraging habitat is widespread nearby.

There was extensive evidence of foraging by the Carnaby's Black-Cockatoo throughout the project area. This was almost entirely foraging on *B. sessilis* (with recent and intermediate-aged signs noted); wherever this plant species occurred there was evidence of foraging by Carnaby's Black-Cockatoo. There were also several records of Carnaby's Black-Cockatoos pruning Nuytsia floribunda trees (and possibly using this as a food source). The locations of these records is shown in Figure 10. It is expected that Carnaby's Black-Cockatoo will occur regularly (including foraging) within the project area. Therefore the project area was assigned a species 'density' score for Carnaby's Black-Cockatoo of 1 (out of 1; see Appendix 5).

The context and density values have been added on to the vegetation scores to yield the overall foraging value scores (with areas and percentages) that are also presented in Table 12.

The project area is, generally, of moderate value for foraging by the Carnaby's Black-Cockatoo and there was evidence to show that this species has previously used the site for feeding.

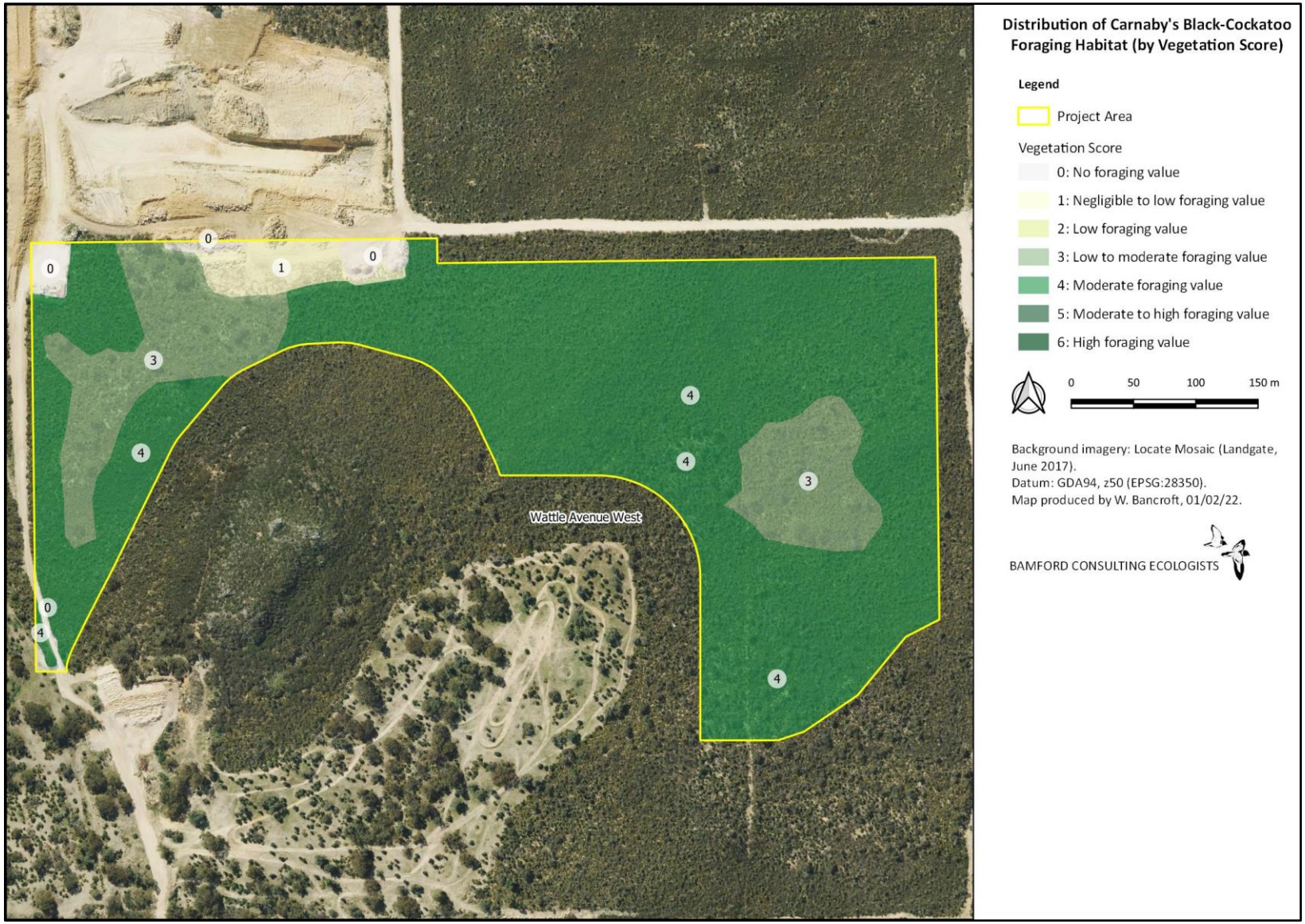

Figure 9. Distribution of Carnaby's Black-Cockatoo vegetation scores within the project area.

Table 12. Areas (ha) and proportions (%) of each category (vegetation score, combined foraging score) of foraging habitat at the survey area for Carnaby's Black-Cockatoo and Forest Red-tailed Black-Cockatoo.

See Section 2.4.3.3 and Appendix 8 for explanation of vegetation, context, species density and (combined) foraging scores.

	Carnaby's Black-Cockatoo		Forest Red-tailed Black-Cockatoo	
Vegetation Score/Value	**Area (ha)**	**%**	**Area (ha)**	**%**
6: High	0.0	0.0	0.0	0.0
5: Moderate to High	0.0	0.0	0.0	0.0
4: Moderate	12.0	77.1	0.0	0.0
3: Low to Moderate	2.7	17.5	0.0	0.0
2: Low	0.0	0.0	0.0	0.0
1: Negligible	0.4	2.7	0.0	0.0
0: Nil	0.4	2.7	15.5	100.0
TOTAL	15.5	100.0	15.5	100.0
Context Score	1		0	
Species Density Score	1		0	
Foraging Score				
10	-	-	-	-
9	-	-	-	-
8	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0
6	12.0	77.1	0.0	0.0
5	2.7	17.5	0.0	0.0
NA (Vegetation Score < 3)	0.8	5.4	15.5	100.0
TOTAL	15.5	100.0	15.5	100.0

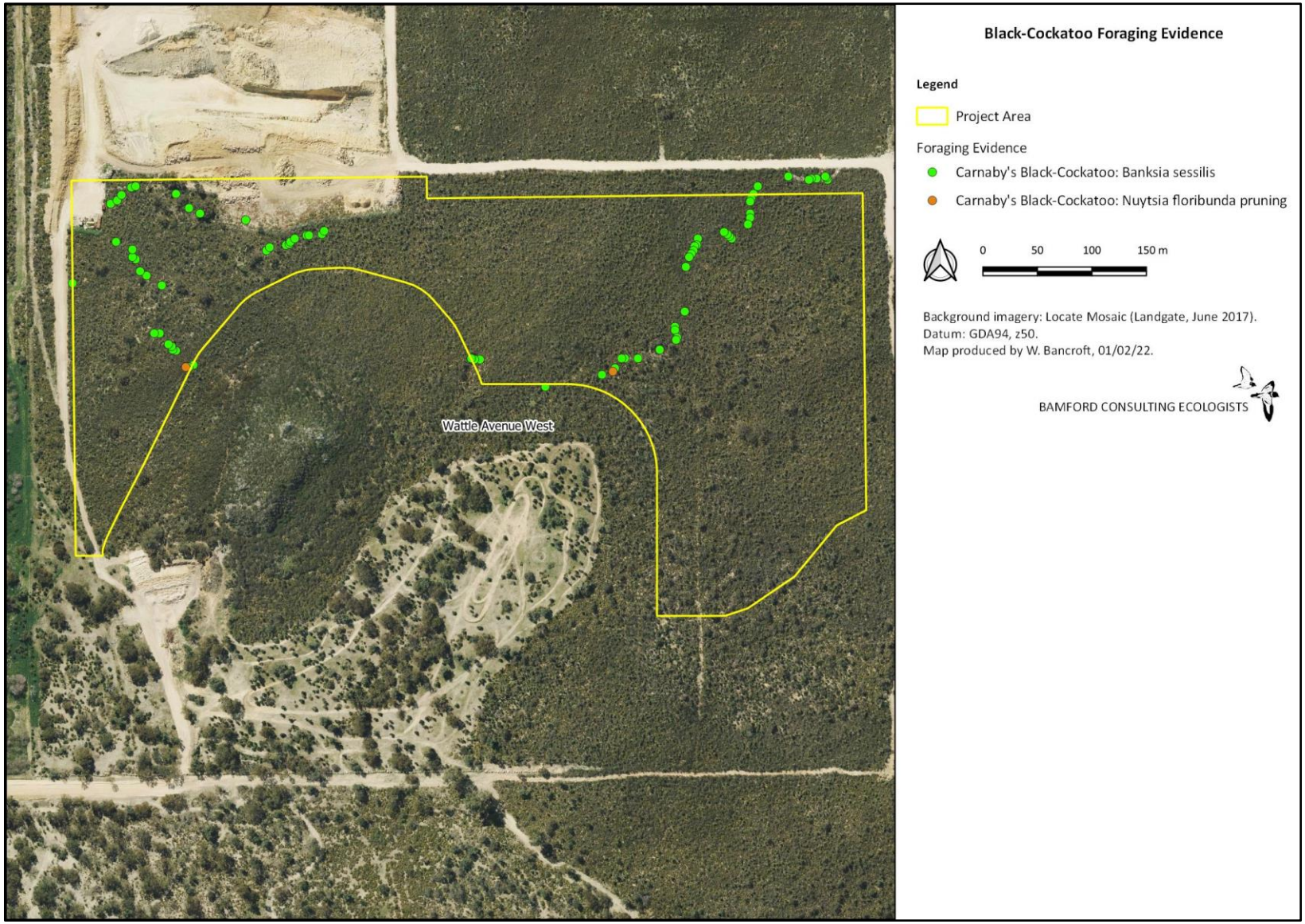

Figure 10. Location of black-cockatoo foraging records (from the June 2021 inspection) within the project area.

3.3.3.2 Forest Red-tailed Black-Cockatoo

Foraging habitat for the Forest Red-tailed Black-Cockatoo was all but absent within the Wattle Avenue West site. This is due to the absence of plant species known to be a mainstays of the Forest Red-tailed Black-Cockatoo diet, such as Marri, Jarrah and She-oak (Groom 2011). Some of these species are present in areas near to the project area (e.g. to the east of the project area) but these were not investigated as part of this assessment. The areas (and percentages) of each vegetation score for each VSA are shown for the Forest Red-tailed Black-Cockatoo in Table 12. No map of the vegetation scores for Forest Red-tailed Black-Cockatoo foraging within the project area is provided, as the entire project area was assessed as 'no value'.

There are approximately 25,558 ha of remnant native vegetation (as assessed by DPIRD 2022) within 15 km of the project area, which itself has c. 14.3 ha of native vegetation. Therefore, the site comprises c. 0.03% of the native vegetation in the 'local area' (as per the methods outlined in Appendix 5). It is unlikely that the Forest Red-tailed Black-Cockatoo breeds within the local area. Thus, a 'context' score of 0 (out of 3) has been assigned to the project area for this species (see Appendix 5).

There was no evidence of foraging by Forest Red-tailed Black-Cockatoo within the project area. Therefore the project area was assigned a species density score for Forest Red-tailed Black-Cockatoo of 0 (out of 1; see Appendix 5).

The context and density values have been combined with the vegetation scores to yield the overall foraging value scores (with areas and percentages) that are also presented in Table 12.

The project area is, generally, of no value for foraging by the Forest Red-tailed Black-Cockatoo and there was no evidence to suggest that this species has previously used the site for feeding.

3.3.4 Black-cockatoo roosting habitat

The area around the project area is known to support black-cockatoo roosting, however there are no records of roost sites within the project area itself. Previously known roost locations (provided by DBCA (2022a) and that reflect data collected in BirdLife Australia's Great Cocky Counts) and are within 12 km of the project area are mapped in Figure 11. The nearest of these known roosts are within c. 1 km of the project area boundary.

The absence of roosts within the project area is reasonable; there is little, if any, suitable roosting habitat. There is an almost complete absence of taller trees (e.g. eucalypts, pines) preferred by black-cockatoos as roost locations. It is highly unlikely that either of the black-cockatoo species expected in the region (Carnaby's and Forest Red-tailed Black-Cockatoos) are dependent on the project area for roosting habitat.

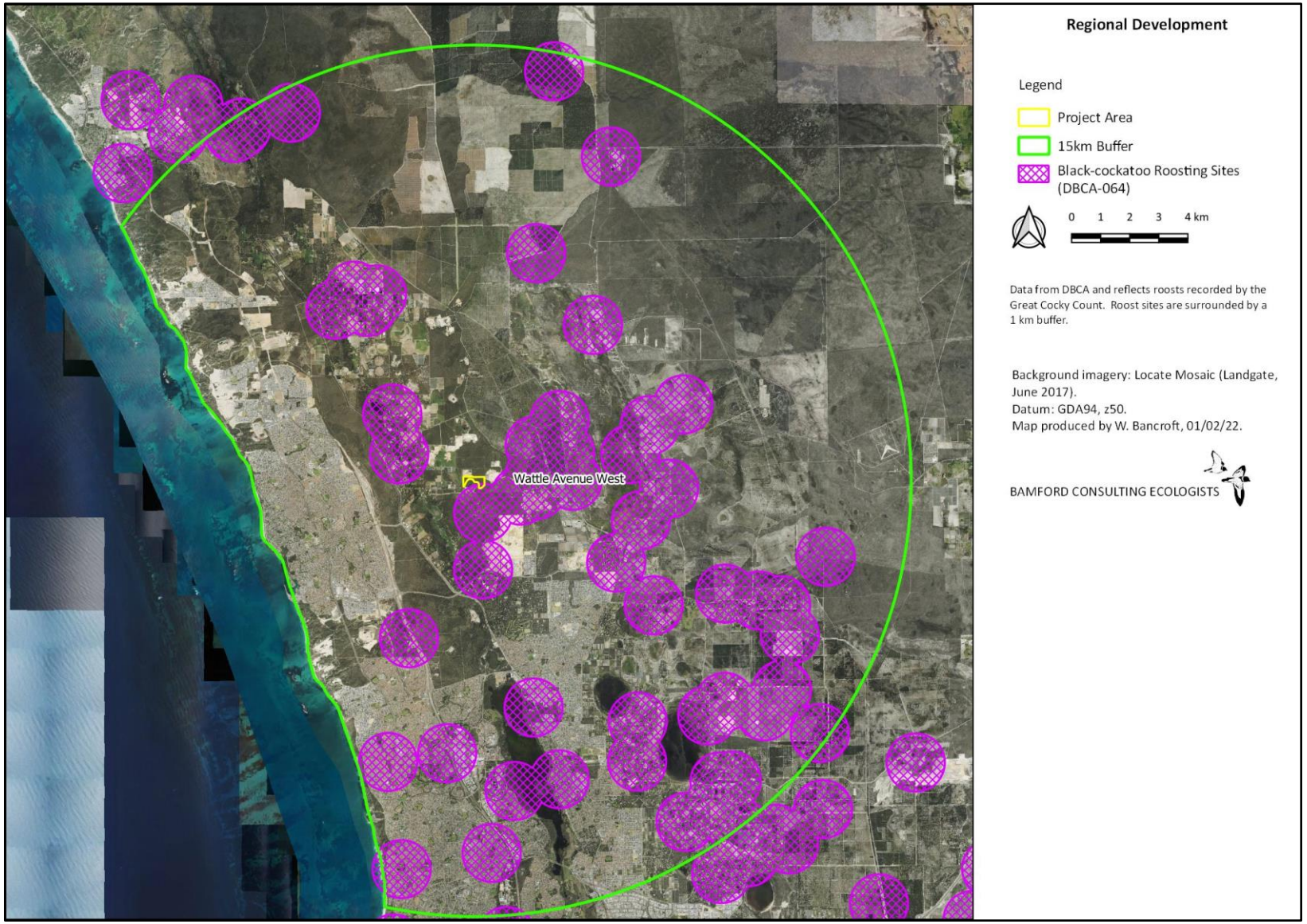

Figure 11. Known black-cockatoo roost locations within 12 km of the project area.

3.4 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. The three intact native VSAs (VSA 1 – proteaceous heath; VSA 2 – banksia woodland; and VSA 3 – Limestone Marlock woodland) can be expected to be richer in species than the rehabilitation and cleared areas. Differences in the fauna assemblage between these three VSAs might be slight, as they contain many of the same plant species and have broadly similar substrates. VSAs 1 and 2 are notable for high nectar production important for a range of nectarivores (*Banksia* species) and supply of food for Carnaby's Black-Cockatoo. VSA 3 may be less productive in this respect. VSA 3 is notable as having the only eucalypts in the project area and thus may support some birds and invertebrates that are eucalypt specialists.

3.5 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 1 for descriptions and other ecological processes). These include the aspects discussed below.

Connectivity and landscape permeability. The project area is part of a larger area of native vegetation that is itself surrounded by development. This makes it likely that the fauna assemblage is already affected by fragmentation and loss of connectivity. This is likely to have resulted in the loss of some mammal species. It also makes the larger area vulnerable to further fragmentation (see Section 4 below).

Local hydrology. The project area contains no wetlands, but elements of the native vegetation are likely to have some reliance on groundwater. The limestone topography suggests that a subterranean fauna assemblage is present, and this may include species that occur in the groundwater (Stygofauna).

Fire. Native vegetation throughout the project area is subject to fire and is likely to be burnt on a regular basis. While appropriate fire regimes can benefit biodiversity, inappropriate regimes can lead to a loss of biodiversity. Most of the project area was burnt in 2015, with the south-eastern corner burnt in 2017 (PGV 2021). The project area (and surrounds) is part of a DBCA-managed fire regime, and a prescribed burn appears to be planned (SWC_081) but no timing is available (DBCA 2022d).

Feral species and interactions with over-abundant native species. Feral species occur throughout Western Australia and are a considerable component of the current mammal fauna of the project area (see Section 3.2.1). They have contributed to local extinctions (see Appendix 9) and may be affecting populations of extant species. Feral Cats, Foxes and Rabbits, and to a lesser extent the Rainbow Lorikeet, are likely to be placing considerable pressure on the native fauna in the region. Feral Bees may be competing with native nectarivores.

3.6 Summary of fauna values

The desktop study identified 173 vertebrate fauna species as potentially occurring in the project area: no fish, eight frogs, 46 reptiles, 100 birds and 19 mammals. The presence of at least 23 species (20 birds and three mammals) was confirmed during the 2021 site inspection.

Fauna assemblage. The fauna assemblage is probably typical of the near-coastal shrublands of the coastal plain north of Perth. The assemblage is likely to be substantially complete except for the mammal component, which is depauperate in both medium-sized and small species. The assemblage is likely to be only moderately rich in a regional context as the environment consists largely of shrublands and lacks the banksia and eucalypt woodlands of the coastal plain slightly further east.

Species of conservation significance. The majority of the 46 conservation significant species (including two reptiles, 35 birds, five mammals and four invertebrates) expected in the project area are likely to be residents or regular visitors/migrants. Only five of the expected conservation species are listed under WA State and/or Commonwealth legislation (category CS1; four bird and one mammal), with seven listed as Priority by DBCA (category CS2; one reptile, two mammals and four invertebrates) and the remaining 34 considered locally significant (category CS3; one reptile, 31 birds and two mammals). Of most concern are Carnaby's Black-Cockatoo (CS1, known to be a regular migrant to the area and to use the project area for foraging), and Quenda (CS2, known to occur within the project area and expected to be resident).

Vegetation and Substrate Associations (VSAs). The project area encompasses five VSAs which reflect landscape position and soil type: Proteaceous heath (VSA 1), Banksia woodland (VSA 2), Limestone Marlock woodland (VSA 3), Rehabilitation (VSA 4), and Cleared (VSA 5). The three intact (i.e. not-disturbed) native VSAs are regionally widespread.

Patterns of biodiversity. The three intact native VSAs can be expected to be richer in species than the rehabilitation and cleared areas. Differences in the fauna assemblage between these three VSAs might be slight, as they contain many of the same plant species and have broadly similar substrates. VSA 1 (proteaceous heath) and VSA 2 (banksia woodland) are notable for high nectar production important for a range of nectarivores (*Banksia* species) and supply of food for Carnaby's Black-Cockatoo. VSA3 (Limestone Marlock woodland) may be less productive in this respect. VSA 3 is notable as having the only eucalypts in the project area and thus may support some birds and invertebrates that are eucalypt specialists.

Key ecological processes. The ecological processes that currently have major effects upon the fauna assemblage include landscape permeability, hydrology, fire, and the presence of feral species.

4 Impact assessment

Threatening processes have to be considered in the context of fauna values, the surrounding landscape and the nature of the proposed action, and are examined below. Landscape context is important, as the project area contains areas of previously cleared or disturbed lands and is in a local, and regional, landscape that is relatively continuous and intact. Impact categories are defined in Table 8.

Habitat loss leading to population decline. *Negligible to Minor*

The area to be cleared is small and is already partly disturbed. The 14.3 ha of native vegetation to be cleared represents 0.03% of native vegetation within the region (15 km radius) and would bring the total regional clearing to 55.23%. Population decline due to habitat loss is therefore very small.

Habitat loss leading to population fragmentation. *Minor*

The development footprint is expected to be compact and expands on existing developed areas, with native vegetation surrounding. However, the project area is within a region with multiple other small developments (see Figure 5), so the potential exists for these multiple areas to coalesce over time with further approvals, which could result in the fragmentation of the large area of native vegetation that aligns north-south, and within which the current project area and nearby developments lie.

Degradation of habitat due to weed invasion. *Minor*

The level of weed invasion is low in the native vegetation, but weeds are present in degraded areas. There is potential for development to increase the spread of weeds (particularly during clearing), but standard hygiene measures are likely to be in place to reduce this risk.

Mortality during construction. *Negligible to Minor*

This is a concern mostly on animal welfare grounds, as the development footprint is small in the context of the overall landscape. Animals will inevitably be killed during clearing but there are standard practices for reducing fauna mortality during such activities. Removal trapping and relocation of species such as Quenda and large reptiles, while avoiding clearing during spring reduces impact on breeding birds.

Ongoing mortality. *Negligible*

This results mainly from roadkill due to vehicle movements close to native vegetation, fauna striking infrastructure and effects of lighting. The numbers of animals affected are likely to be very small although the long-term impacts of lighting close to native vegetation is poorly understood.

Species interactions. *Negligible to Minor*

Feral species are already present on the site, but feral species may be attracted to work-sites and increase in abundance. Impacts to native fauna can be kept to Negligible/Minor through standard practices such as not feeding wildlife, managing waste and even implementing some feral species control.

Hydrological change. *Negligible*

There is no surface water and activities will not interact with groundwater, so hydrological change should be minimal. If drainage and runoff management of work areas is required, this should not be diverted into native vegetation but should be infiltrated into groundwater.

Altered fire regimes. *Negligible*

The vegetation of the project area is tolerant of and to some extent dependent on fire, but the fire regime is important. There have been recent fires that are likely to have affected the fauna, and any increase in fire frequency is likely to have adverse impacts. The proposed development has the potential to lead to increased fire frequency, but given the small areas involved this risk should be readily managed.

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

The level of dust, noise and light during development and operation has the potential to result in some impacts, but there are standard management procedures to minimise these. There is also existing activity so these forms of disturbance will not be new to the location. 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 (Dell and Banyard 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 2020b). The EEZ extends to 200 nautical miles (approximately 350 kilometres) from the coast (DAWE 2020b). 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 2020a) 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 area may be affected and effectively determined by processes such as:

- fire regime.
- landscape patterns (such as fragmentation and/or linkage).
- the presence of feral species.
- hydrology.

Some of the 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 (2013c) 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. Scoring system for the assessment of foraging value of vegetation for Black-Cockatoos.

Bamford Consulting Ecologists
Revised 4th April 2021

Introduction

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

The foraging value score provides a numerical value that reflects the significance of vegetation as foraging habitat for Black-Cockatoos, and this numerical value is designed to provide the information needed by the Federal Department of Agriculture, Water and the Environment (DAWE) to assess impact significance and offset requirements. The foraging value of the vegetation depends upon the type, density and condition of trees and shrubs in an area and can be influenced by the context such as the availability of foraging habitat nearby. The BCE scoring system for value of foraging habitat has three components as detailed above. These three components are drawn from the DAWE offsets guide but the scoring approach was developed by BCE and includes a fourth (moderation) component. Note that the scoring system can only be applied within the range of the species or at least where the species could reasonably be expected to occur based upon existing information.

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

A. Site condition. Determining a score out of six for the vegetation composition, condition and structure; plus
B. Site context. Determining a score out of three for the context of the site; plus
C. Species stocking rate. Determining a score out of one for species density.
D. Determining the total score out of 10, which may require moderation for context and species density with respect to the site condition (vegetation) score. Moderation also includes consideration of pine plantations as a special case for foraging value.

The BCE scoring system places the greatest weight on site condition (scale of 0 to 6) because this has the highest influence on the foraging values of a site, which in turn is the fundamental driver in meeting ecological requirements for continued survival.

Site context has a lower weight (scale of 0 to 3) in recognition of the mobility of the species, which means they can access good foraging habitat even in fragmented landscapes, but allowing for recognition of the extent of available habitat in a region and context in relation to activity (such as breeding and roosting). The application of scoring site context is further discussed below.

Species stocking rate is given a low weight (0 to 1) as it is a means only of recognising that a species may or may not be abundant at a site, but that abundance is dependent upon site condition and context and is thus not an independent variable. The abundance of a species is also sensitive to

sampling effort, and to seasonal and annual variation, and is therefore an unreliable indicator of actual importance of a site to a species.

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

A. Site condition. Vegetation composition, condition and structure scoring

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	**Baudin's Black-Cockatoo**	**Forest Red-tailed Black-Cockatoo**
0	No foraging value. No Proteaceae, eucalypts or other potential sources of food. Examples: • Water bodies (e.g. salt lakes, dams, rivers); • Bare ground; • Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits) or with vegetation of no food value, such as some suburban landscapes. • Mown grass	No foraging value. No eucalypts or other potential sources of food. Examples: • Water bodies (e.g. dams, rivers); • Bare ground; • Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits).	No foraging value. No eucalypts or other potential sources of food. Examples: • Water bodies (e.g. dams, rivers); • Bare ground; • Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits).
1	Negligible to low foraging value. Examples: • Scattered specimens of known food plants but projected foliage cover of these is < 2%. This could include urban areas with scattered foraging trees; • Paddocks that are lightly vegetated with melons or other known food-source weeds (e.g. *Erodium* spp.) that represent a short-term and/or seasonal food source; • Blue Gum plantations (foraging by Carnaby's Black-Cockatoos has been reported but appears to be unusual).	Negligible to low foraging value. Scattered specimens of known food plants but projected foliage cover of these < 1%. This could include urban areas with scattered foraging trees.	Negligible to low foraging value. Scattered specimens of known food plants but projected foliage cover of these < 1%. Could include urban areas with scattered foraging trees.

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	**Baudin's Black-Cockatoo**	**Forest Red-tailed Black-Cockatoo**
2	Low foraging value. Examples: • Shrubland in which species of foraging value, such as shrubby banksias, have < 10% projected foliage cover; • Woodland with tree banksias 2-5% projected foliage cover; • Woodland with tree banksias (of key species *B. attenuata* and *B. menziesii*) with <10% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Open eucalypt woodland/mallee of small-fruited species; • Paddocks that are densely vegetated with melons or other known food-source weeds (e.g. *Erodium* spp.) that represent a short-term and/or seasonal food source.	Low foraging value. Examples: • Woodland with scattered specimens of known food plants (e.g. Marri and Jarrah) 1-5% projected foliage cover; • Marri-Jarrah Woodland with <10% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Parkland-cleared Eucalypt Woodland/Forest with known food plants <10% projected foliage cover (poor long-term viability without management); • Younger areas of (managed) revegetation with known food plants <10% projected foliage cover (establishing food sources with good long-term viability); • Urban areas with scattered foraging trees.	Low foraging value. Examples: • Woodland with scattered specimens of known food plants (e.g. Marri, Jarrah) 1-5% projected foliage cover; • Marri-Jarrah Woodland with <10% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Sheoak Woodland with <10% projected foliage cover; • Parkland-cleared Eucalypt Woodland/Forest with known food plants <10% projected foliage cover (poor long-term viability without management); • Younger areas of (managed) revegetation with known food plants <10% projected foliage cover (establishing food sources with good long-term viability); • Urban areas with scattered food plants such as Cape Lilac, *Eucalyptus caesia* and *E. erythrocorys*.

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	**Baudin's Black-Cockatoo**	**Forest Red-tailed Black-Cockatoo**
3	Low to Moderate foraging value. Examples: • Shrubland in which species of foraging value, such as shrubby banksias, have 10-20% projected foliage cover; • Woodland with tree banksias 5-20% projected foliage cover; • Woodland with tree banksias (of key species *B. attenuata* and *B. menziesii*) with 10-40% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Eucalypt Woodland/Mallee of small-fruited species; • Eucalypt Woodland with Marri < 10% projected foliage cover.	Low to Moderate foraging value. Examples: • Eucalypt Woodland with known food plants (especially Marri) 5-20% projected foliage cover; • Marri-Jarrah Woodland with 10-40% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Parkland-cleared Eucalypt Woodland/Forest with known food plants 10-40% projected foliage cover (poor long-term viability without management); • Younger areas of (managed) revegetation with known food plants 10-40% projected foliage cover (establishing food sources with good long-term viability).	Low to Moderate foraging value. Examples: • Eucalypt Woodland with known food plants (especially Marri and Jarrah) 5-20% projected foliage cover; • Marri-Jarrah Woodland with 10-40% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Sheoak Forest with 10-40% projected foliage cover; • Parkland-cleared Eucalypt Woodland/Forest with known food plants 10-40% projected foliage cover (poor long-term viability without management); • Younger areas of (managed) revegetation with known food plants 10-40% projected foliage cover (establishing food sources with good long-term viability).

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	**Baudin's Black-Cockatoo**	**Forest Red-tailed Black-Cockatoo**
4	Moderate foraging value. Examples: • Woodland/low forest with tree banksias (of key species *B. attenuata* and *B. menziesii*) 20-40% projected foliage cover; • Woodland/low forest with tree banksias (of key species *B. attenuata* and *B. menziesii*) with 40-60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Kwongan/ Shrubland in which species of foraging value, such as shrubby banksias, have 20-40% projected foliage cover; • Eucalypt Woodland/Forest with Marri 20-40% projected foliage cover.	Moderate foraging value. Examples: • Marri-Jarrah Woodland/Forest with 20-40% projected foliage cover; • Marri-Jarrah Forest with 40-60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Parkland-cleared Eucalypt Woodland/Forest with known food plants 40-60% projected foliage cover (poor long-term viability without management); • Younger areas of (managed) revegetation with known food plants 40-60% projected foliage cover (establishing food sources with good long-term viability); • Orchards with highly desirable food sources (e.g. apples, pears, some stone fruits).	Moderate foraging value. Examples: • Marri-Jarrah Woodland/Forest with 20-40% projected foliage cover; • Marri-Jarrah Forest with 40-60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Sheoak Forest with 40-60% projected foliage cover; • Parkland-cleared Eucalypt Woodland/Forest with known food plants 40-60% projected foliage cover (poor long-term viability without management); • Younger areas of (managed) revegetation with known food plants 40-60% projected foliage cover (establishing food sources with good long-term viability).

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	**Baudin's Black-Cockatoo**	**Forest Red-tailed Black-Cockatoo**
5	Moderate to High foraging value. Examples: • Banksia Low Forest (of key species *B. attenuata* and *B. menziesii*) with 40-60% projected foliage cover; • Banksia Low Forest (of key species *B. attenuata* and *B. menziesii*) with > 60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Kwongan/ Shrubland in which species of foraging value, such as shrubby banksias, have 40-60% projected foliage cover; • Marri-Jarrah Forest with 40-60% projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term). • Pine plantations with trees more than 10 years old (but see pine note below in moderation section).	Moderate to High foraging value. Examples: • Marri-Jarrah Forest with 40-60% projected foliage cover; • Marri-Jarrah Forest with > 60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Parkland-cleared Eucalypt Woodland/Forest with known food plants >60% projected foliage cover (poor long-term viability without management); • Younger areas of (managed) revegetation with known food plants >60% projected foliage cover (establishing food sources with good long-term viability).	Moderate to High foraging value. Examples: • Marri-Jarrah Forest with 40-60% projected foliage cover; • Marri-Jarrah Forest with > 60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Sheoak Forest with > 60% projected foliage cover; • Parkland-cleared Eucalypt Woodland/Forest with known food plants >60% projected foliage cover (poor long-term viability without management); • Younger areas of (managed) revegetation with known food plants >60% projected foliage cover (establishing food sources with good long-term viability).

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	**Baudin's Black-Cockatoo**	**Forest Red-tailed Black-Cockatoo**
6	High foraging value. Example: • Banksia Low Forest (of key species *B. attenuata* and *B. menziesii*) with > 60% projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term). • Kwongan/ Shrubland in which species of foraging value, such as shrubby banksias, have >60% projected foliage cover; • Marri-Jarrah Forest with > 60% projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term).	High foraging value. Example: • Marri-Jarrah Forest with > 60% projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term).	High foraging value. Example: • Marri-Jarrah Forest with > 60% projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term).

Vegetation structural class terminology follows Keighery (1994).

B. Site context.

Site Context is a function of site size, availability of nearby habitat and the availability of nearby breeding areas. Site context includes consideration of connectivity, although Black-Cockatoos are very mobile and will fly across paddocks to access foraging sites. Based on BCE observations, Black-Cockatoos are unlikely to regularly go over open ground for a distance of more than a few kilometres and prefer to follow tree-lines.

The maximum score for site context is 3, and because it is effectively a function of presence/absence of nearby breeding and the distribution of foraging habitat across the landscape, the following table, developed by Bamford Consulting in conjunction with the Department of the Environment and Energy (DEE), provides a *guide* to the assignation of site context scores. Note that 'local area' is defined as within a 15 km radius of the centre point of the study site. This is greater than the maximum distance of 12km known to be flown by Carnaby's Black-Cockatoo when feeding chicks in the nest.

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

The table above provides weighting for where nearby breeding is known (or suspected) and for the proportion of foraging habitat within 15 km represented by the site being assessed. Some adjustments may be needed based on the judgement of the assessor and in relation to the likely function of the site. For example, a small area of foraging habitat (e.g. 0.5% of such habitat within 15 km) could be upgraded to a context of 2 if it formed part of a critical movement corridor. In contrast, the same sized area of habitat, of the same local proportion, could be downgraded if it were so isolated that birds could never access it.

C. Species density (stocking rate).

Species stocking rate is described as "the usage and/or density of a species at a particular site" in the offsets guide. The description also implies that a site supports a discrete population, which is unlikely in the case of very mobile black-cockatoos. Assignation of the species density score (0 or 1) is based upon the black-cockatoo species being either abundant or not abundant. A score of 1 is used where the species is seen or reported regularly and/or there is abundant foraging evidence. Regularly is when the species is seen at intervals of every few days or weeks for at least several months of the year. A score of 0 is used when the species is recorded or reported very infrequently and there is little or no foraging evidence. Where information on actual presence of birds is lacking, a species density score can be assigned by interpreting the landscape and the site context. For example, a site with a moderate condition score that is part of a network of such habitat where a black-cockatoo species is

known would get a species density score of 1 even without clear presence data, while a species density score of 0 can be assigned to a site where the level of usage can confidently be predicted to be low.

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

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

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

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

Note that this moderation approach may require interpretation depending on the context. For example, vegetation with a condition score of 2 could be given a context score of 1 under special circumstances. Such as when very close to a major breeding area or if strategically located along a movement corridor.

Pine plantations

Pine plantations are an important foraging resource for Carnaby's Black-Cockatoo (only) but are not directly comparable with native vegetation. In comparing native vegetation with pine plantations for the purpose of calculating offsets, the following should be noted:

- Pine plantations are a commercial crop established with the intention of being harvested and thus have short-term availability (30-50 years), whereas native vegetation is available indefinitely if protected. Due to the temporary nature of pines as a food source, site condition and context differs between pines and native vegetation.
- Although pines provide a high abundance of food in the form of seeds, they are a limited food resource compared with native vegetation which provides seeds, insect larvae, flowers and nectar. The value of insect larvae in the diet of Carnaby's Black-Cockatoo has not been quantified, but in the vicinity of Perth, the birds forage very heavily on insect larvae in young cones of *Banksia attenuata* in winter, ignoring the seeds in these cones and seeds in older cones on the same trees (Scott and Black 1981; M. Bamford pers. obs.). This suggests that insect larvae are of high nutritional importance immediately prior to the breeding season.
- Pine plantations have very little biodiversity value other than their importance as a food source for Carnaby's Black-Cockatoos. They inhibit growth of other flora. While this is not a factor for direct consideration with respect to Carnaby's Black-Cockatoo, it is a factor in regional conservation planning of which offsets for the cockatoos are a part.

Taking the above points into consideration, it is possible to assign pine plantations a foraging value as follows:

- Site condition. The actual foraging value of pines is high. Stock *et al.* (2013) report that it takes nearly twice as many seeds of *Pinus pinaster* to meet the daily energy requirements for Carnaby's Black-Cockatoo compared with Marri, and three times as many *P. pinaster* seeds compared with Slender Banksia. However, pines are planted at a high density so the food supply per hectare can be high. Taking account of the lack of variety of food from pines, this suggests a site condition score of 4 or 5 out of 6 (5 is used in Section A above). As a source of food, pines are thus comparable to the best banksia woodland. This site condition score then needs to be adjusted to take account of the short-term nature of the food supply (for pine plantations to be harvested. Where pines are 'ornamental, such as in some urban contexts, they can be treated as with other trees in urban landscapes). The foraging value of a site after pines are harvested will effectively be 0, or possibly 1 if there is some retention. It is proposed that this should approximately halve the site condition score; young pine plantations could be redacted slightly less than old plantations on the basis that a young plantation provides a slightly longer term food supply. If a maximum site condition score of 5 is given, then a young plantation (>10 but <30 years old) could be assigned a score of 3, and an old plantation (>30 years old) could be assigned a score of 2. Plantations <10 years old and thus not producing large quantities of cones could also get a score of 2, but recognising they may increase in value.
- Site context. Although a temporary food source, pines can be very important for Carnaby's Black-Cockatoo in some contexts; they could be said to carry populations in areas where there is little native vegetation. The system for assigning a context score as outlined above (Section B) also applies to pines. Thus, a context score of 3 can be given where pines are a significant

proportion of foraging habitat (>5% if breeding occurs; >10% if no breeding), but where pines are a small part of the foraging landscape they will receive a context score of less than this.

- Species density. As outlined above (Section C), pines will receive a species density score of 1 where Carnaby's Black-Cockatoo are regular visitors. This is irrespective of an old plantation having a moderated condition score of 2.

Based on the above, pine plantations that represent a substantial part of the foraging landscape, such as in the region immediately north of Perth, would receive a total score (out of 10) of 6; young plantations in this area would receive a score of 7. In contrast, isolated and small plantations in rural landscapes could receive a score of just 2 if they are only a small proportion of foraging habitat and Carnaby's Black-Cockatoos are not regularly present.

Appendix 6. Examples of Forest Red-tailed Black-Cockatoo foraging signs across the range of age categories used in this study.

Active/Recent ↔ Intermediate ↔ Old

Jarrah nuts

Jarrah leaves

Marri nuts

Appendix 7. Vertebrate fauna expected to occur 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).

Bush Forever (Dell and Banyard 2000) status: HS = habitat specialists with a reduced distribution on the Swan Coastal Plain, LE = locally extinct, WR = wide ranging species with reduced populations on the Swan Coastal Plain.

LS = considered to be of local significance by Bamford Consulting Ecologists (see Appendix 1).

Int = introduced species.

Expected Occurrence categories:

See Section 2.3.4 for explanation of expected occurrence categories.

Source:

1 = Atlas of Living Australia (ALA 2022), 2 = NatureMap (DBCA 2022e), 3 = Protected Matters Search Tool (DAWE 2022g), 4 = general literature (see Table 4).

Recorded:

'+' = recorded directly, D = diggings, F = foraging signs, S = scats, T = tracks.

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	Status	Expected Occurrence	Source	Recorded
Hylidae (Tree frogs)				
Litoria adelaidensis w	Slender Tree Frog	Irregular visitor	1, 2	
Litoria moorei w	Motorbike Frog	Irregular visitor	1, 2	
Limnodynastidae (Burrowing frogs)				
Heleioporus eyrei w†	Moaning Frog	Resident	1, 2	
Limnodynastes dorsalis w†	Western Banjo Frog	Resident	1, 2	
Myobatrachidae (Ground frogs)				

Species		Status	Expected Occurrence	Source	Recorded
Crinia glauerti [w†]	Clicking Frog		Irregular visitor	1, 2	
Crinia insignifera [w†]	Squelching Froglet		Irregular visitor	1, 2	
Myobatrachus gouldii	Turtle Frog		Resident	1, 2	
Pseudophryne guentheri [w†]	Crawling Toadlet		Resident	1, 2	
Carphodactylidae (Carphodactylid geckos)					
Underwoodisaurus milii	Southern Barking Gecko		Resident	1, 2	
Diplodactylidae (Diplodactylid geckos)					
Crenadactylus ocellatus	South-western Clawless Gecko		Resident	1, 2	
Diplodactylus polyophthalmus	Spotted Sandplain Gecko		Resident	1, 2	
Lucasium alboguttatum			Resident	2	
Strophurus spinigerus spinigerus			Resident	1, 2	
Gekkonidae (Gekkonid geckos)					
Christinus marmoratus	Marbled Gecko		Resident	1, 2	
Pygopodidae (Legless lizards)					
Aprasia repens			Resident	1, 2	
Delma concinna concinna			Resident	2	
Delma fraseri			Resident	1, 2	
Delma grayii			Resident	1, 2	
Lialis burtonis	Burton's Legless-Lizard		Resident	1, 2	
Pletholax gracilis gracilis			Resident	1, 2	
Pygopus lepidopodus	Common Scaly Foot		Resident	1, 2	
Agamidae (Dragons)					
Ctenophorus adelaidensis	Western Heath Dragon		Resident	1, 2	

Species		Status	Expected Occurrence	Source	Recorded
Pogona minor minor	Western Bearded Dragon		Resident	1, 2	
Scincidae (Skinks)					
Acritoscincus trilineatus			Resident	1, 2	
Cryptoblepharus buchananii	Fence Skink		Resident	1, 2	
Ctenotus australis			Resident	1, 2	
Ctenotus fallens			Resident	2	
Ctenotus impar			Resident	1, 2	
Cyclodomorphus celatus			Resident	1, 2	
Egernia kingii	King's Skink		Resident	1, 2	
Egernia napoleonis			Resident	1, 2	
Hemiergis quadrilineata			Resident	1, 2	
Lerista elegans			Resident	1, 2	
Lerista lineopunctulata			Irregular visitor	1, 2	
Lerista praepedita			Resident	1, 2	
Menetia greyii			Resident	1, 2	
Morethia lineoocellata			Resident	1, 2	
Morethia obscura			Resident	1, 2	
Tiliqua occipitalis	Western Bluetongue		Resident	1, 2	
Tiliqua rugosa rugosa	Bobtail		Resident	1, 2	
Varanidae (Monitors and goannas)					
Varanus gouldii	Bungarra or Sand Goanna		Resident	1, 2	
Varanus tristis tristis	Tree Goanna		Resident	1, 2	
Typhlopidae (Blind snakes)					

Species		Status	Expected Occurrence	Source	Recorded
Anilios australis			Resident	1, 2	
Pythonidae (Pythons)					
Morelia spilota imbricata	Carpet Python (southwest)	CS3 (LS)	Regular visitor	1, 2	
Elapidae (Venomous land snakes)					
Brachyurophis fasciolatus fasciolatus			Resident (if present)	1, 2	
Brachyurophis semifasciatus			Resident	1, 2	
Demansia psammophis psammophis	Yellow-faced Whipsnake		Resident	1, 2	
Echiopsis curta	Bardick		Resident	1, 2	
Neelaps bimaculatus	Black-naped Snake		Resident	1, 2	
Neelaps calonotos	Black-striped Snake	CS2 (P3)	Resident (if present)	1, 2	
Pseudonaja affinis affinis	Dugite		Resident	1, 2	
Simoselaps bertholdi	Jan's Banded Snake		Resident	1, 2	
Suta gouldii	Gould's Hooded Snake		Resident	1, 2	
Suta nigriceps			Resident	2	
Casuariidae (Emus and Cassowaries)					
Dromaius novaehollandiae	Emu	CS3 (WR)	Regular visitor	1, 2	
Anatidae (Ducks, Geese and Swans)					
Tadorna tadornoides [w]	Australian Shelduck		Irregular visitor	1, 2	
Anas superciliosa [w]	Pacific Black Duck		Irregular visitor	1, 2	
Chenonetta jubata [w]	Australian Wood Duck		Irregular visitor	1, 2	
Phasianidae (Pheasants and Quail)					
Coturnix pectoralis	Stubble Quail		Vagrant	1, 2	

Species		Status	Expected Occurrence	Source	Recorded
Synoicus ypsilophorus	Brown Quail		Resident	1, 2	
Columbidae (Pigeons and Doves)					
Columba livia	Rock Dove/Feral Pigeon	Int	Irregular visitor	1, 2	
Streptopelia chinensis	Spotted Dove	Int	Resident	1, 2	
Spilopelia senegalensis	Laughing Dove	Int	Resident	1, 2	
Phaps chalcoptera	Common Bronzewing	CS3 (HS)	Resident	1, 2	
Phaps elegans	Brush Bronzewing	CS3 (HS)	Irregular visitor	1, 2	
Ocyphaps lophotes	Crested Pigeon		Resident	1, 2	
Cuculidae (Cuckoos)					
Chalcites basalis	Horsfield's Bronze-Cuckoo		Regular migrant	1, 2	
Chalcites lucidus	Shining Bronze-Cuckoo		Regular migrant	1, 2	
Cacomantis flabelliformis	Fan-tailed Cuckoo		Regular migrant	1, 2	+
Heteroscenes pallidus	Pallid Cuckoo		Regular migrant	1, 2	
Podargidae (Frogmouths)					
Podargus strigoides	Tawny Frogmouth		Resident	1, 2	
Eurostopodidae (Eared Nightjars)					
Eurostopodus argus	Spotted Nightjar		Vagrant	1, 2	
Aegothelidae (Owlet-nightjars)					
Aegotheles cristatus	Australian Owlet-nightjar		Regular visitor	1, 2	
Apodidae (Swifts and Swiftlets)					
Apus pacificus	Fork-tailed Swift	CS1 (M,Mar,S5)	Vagrant	1, 2, 3	
Turnicidae (Button-quail)					
Turnix varius	Painted Button-quail	CS3 (WR)	Resident	1, 2	

Species		Status	Expected Occurrence	Source	Recorded
Turnix velox	Little Button-quail		Irregular visitor	1, 2	
Accipitridae (Eagles, Kites, Goshawks)					
Elanus axillaris	Black-shouldered Kite		Regular visitor	1, 2	
Lophoictinia isura	Square-tailed Kite	CS3 (WR)	Regular visitor	1, 2	
Aquila audax	Wedge-tailed Eagle	CS3 (WR)	Regular visitor	1, 2	
Hieraaetus morphnoides	Little Eagle	CS3 (WR)	Regular visitor	1, 2	
Circus assimilis	Spotted Harrier		Irregular visitor	1, 2	
Accipiter fasciatus	Brown Goshawk	CS3 (WR)	Regular visitor	1, 2	
Accipiter cirrocephalus	Collared Sparrowhawk	CS3 (WR)	Regular visitor	1, 2	
Haliastur sphenurus	Whistling Kite	CS3 (WR)	Regular visitor	1, 2	
Tytonidae (Masked Owls)					
Tyto alba	Barn Owl		Regular visitor	1, 2	
Strigidae (Hawk-Owls)					
Ninox novaeseelandiae	Southern Boobook		Regular visitor	1	
Meropidae (Bee-eaters)					
Merops ornatus	Rainbow Bee-eater		Regular migrant	1, 2, 3	
Alcedinidae (Kingfishers)					
Todiramphus sanctus	Sacred Kingfisher		Regular migrant	1, 2	
Dacelo novaeguineae	Laughing Kookaburra	Int	Resident	1, 2	
Falconidae (Falcons)					
Falco cenchroides	Nankeen Kestrel		Resident	1, 2	
Falco longipennis	Australian Hobby		Regular visitor	1, 2	
Falco berigora	Brown Falcon		Irregular visitor	1, 2	

Species		Status	Expected Occurrence	Source	Recorded
Falco peregrinus	Peregrine Falcon	CS1 (S7)	Regular visitor	1, 2	
Cacatuidae (Cockatoos and Corellas)					
Calyptorhynchus banksii naso	Forest Red-tailed Black-Cockatoo	CS1 (V,S3)	Irregular visitor	1, 2, 3	
Calyptorhynchus latirostris	Carnaby's Black-Cockatoo	CS1 (E,S2)	Regular migrant	1, 2, 3	F
Eolophus roseicapilla	Galah		Resident	1, 2	+
Cacatua tenuirostris	Long-billed Corella	Int	Regular visitor	1, 2	
Cacatua sanguinea	Little Corella		Regular visitor	1, 2	
Psittaculidae (Parrots, Lorikeets and Rosellas)					
Purpureicephalus spurius	Red-capped Parrot		Regular visitor	1, 2	+
Barnardius zonarius	Australian Ringneck		Resident	1, 2	+
Neophema elegans	Elegant Parrot		Resident	1, 2	
Trichoglossus haematodus	Rainbow Lorikeet	Int	Resident	1, 2	
Maluridae (Fairy-wrens, Emu-wrens and Grasswrens)					
Malurus assimilis	Purple-backed Fairy-wren	CS3 (HS)	Resident	1, 2	
Malurus splendens	Splendid Fairy-wren	CS3 (HS)	Resident	1, 2	+
Malurus leucopterus	White-winged Fairy-wren	CS3 (HS)	Irregular visitor	1, 2	+
Stipiturus malachurus	Southern Emu-wren	CS3 (HS)	Irregular visitor	4	
Meliphagidae (Honeyeaters and Chats)					
Lichmera indistincta	Brown Honeyeater		Resident	1, 2	
Phylidonyris novaehollandiae	New Holland Honeyeater	CS3 (WR)	Resident	1, 2	+
Phylidonyris niger	White-cheeked Honeyeater	CS3 (WR)	Resident	1, 2	+
Glyciphila melanops	Tawny-crowned Honeyeater	CS3 (WR)	Regular visitor	1, 2	
Acanthorhynchus superciliosus	Western Spinebill		Resident	1, 2	

Species		Status	Expected Occurrence	Source	Recorded
Epthianura albifrons	White-fronted Chat		Irregular visitor	1, 2	
Anthochaera lunulata	Western Wattlebird	CS3 (WR)	Regular visitor	1, 2	
Anthochaera carunculata	Red Wattlebird		Regular visitor	1, 2	
Gavicalis virescens	Singing Honeyeater		Resident	1, 2	
Manorina flavigula	Yellow-throated Miner	CS3 (WR)	Irregular visitor	1, 2	
Pardalotidae (Pardalotes)					
Pardalotus punctatus	Spotted Pardalote		Irregular visitor	1, 2	
Pardalotus striatus	Striated Pardalote		Resident	1, 2	
Acanthizidae (Thornbills and Gerygones)					
Gerygone fusca	Western Gerygone		Resident	1, 2	
Smicrornis brevirostris	Weebill	CS3 (HS)	Resident	1, 2	
Calamanthus campestris	Rufous Fieldwren		Irregular visitor	1	+
Sericornis frontalis	White-browed Scrubwren	CS3 (HS)	Resident	1, 2	+
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	CS3 (HS)	Resident	1, 2	
Acanthiza apicalis	Inland Thornbill	CS3 (HS)	Resident	1, 2	
Acanthiza inornata	Western Thornbill	CS3 (HS)	Irregular visitor	1, 2	
Neosittidae (Sittellas)					
Daphoenositta chrysoptera	Varied Sittella	CS3 (HS)	Irregular visitor	1, 2	
Campephagidae (Cuckoo-shrikes and Trillers)					
Coracina novaehollandiae	Black-faced Cuckoo-shrike		Regular visitor	1, 2	+
Lalage tricolor	White-winged Triller		Regular visitor	1, 2	
Pachycephalidae (Whistlers, Shrike-thrushes and allies)					
Pachycephala rufiventris	Rufous Whistler		Resident	1, 2	

Species		Status	Expected Occurrence	Source	Recorded
Colluricincla harmonica	Grey Shrike-thrush	CS3 (HS)	Resident	1, 2	+
Oreoicidae (Australo-Papuan Bellbirds)					
Oreoica gutturalis	Crested Bellbird		Vagrant	1	
Artamidae (Woodswallows, Currawongs, Butcherbirds and Magpie)					
Strepera versicolor	Grey Currawong	CS3 (WR)	Irregular visitor	1, 2	
Gymnorhina tibicen	Australian Magpie		Resident	1, 2	+
Cracticus torquatus	Grey Butcherbird		Resident	1, 2	
Artamus personatus	Masked Woodswallow	CS3 (WR)	Vagrant	1, 2	
Artamus cyanopterus	Dusky Woodswallow	CS3 (WR)	Regular visitor	1, 2	
Artamus cinereus	Black-faced Woodswallow		Resident	1, 2	+
Rhipiduridae (Fantails)					
Rhipidura leucophrys	Willie Wagtail		Resident	1, 2	
Rhipidura albiscapa	Grey Fantail		Resident	1, 2	+
Corvidae (Crows and Ravens)					
Corvus coronoides	Australian Raven		Resident	1, 2	+
Monarchidae (Monarch and Flycatchers)					
Grallina cyanoleuca	Magpie-lark		Resident	1, 2	+
Petroicidae (Australian Robins)					
Petroica boodang	Scarlet Robin	CS3 (HS)	Regular visitor	1, 2	
Petroica goodenovii	Red-capped Robin		Irregular visitor	1, 2	
Quoyornis georgianus	White-breasted Robin	CS3 (HS)	Irregular visitor	1, 2	
Melanodryas cucullata	Hooded Robin		Irregular visitor	1	
Dicaeidae (Flowerpeckers)					

Species		Status	Expected Occurrence	Source	Recorded
Dicaeum hirundinaceum	Mistletoebird		Regular visitor	1, 2	
Motacillidae (Pipits and Wagtails)					
Anthus novaeseelandiae	Australasian Pipit		Resident	1, 2	
Locustellidae (Grassbirds)					
Cincloramphus cruralis	Brown Songlark		Regular visitor	1	
Cincloramphus mathewsi	Rufous Songlark		Regular visitor	1	
Hirundinidae (Swallows and Martins)					
Cheramoeca leucosterna	White-backed Swallow		Regular visitor	1, 2	
Petrochelidon ariel	Fairy Martin		Irregular visitor	1, 2	
Petrochelidon nigricans	Tree Martin		Resident	1, 2	
Hirundo neoxena	Welcome Swallow		Resident	1, 2	+
Zosteropidae (White-eyes)					
Zosterops lateralis	Silvereye		Resident	1, 2	+
Tachyglossidae (Echidnas)					
Tachyglossus aculeatus acanthion	Short-beaked Echidna		Resident	1, 2	
Dasyuridae (Dasyurids)					
Dasyurus geoffroii fortis	Chuditch	CS1 (V,S3)	Vagrant	1, 2, 3	
Peramelidae (Bandicoots)					
Isoodon fusciventer	Quenda	CS2 (P4)	Resident	1, 2	D
Tarsipedidae (Honey Possum)					
Tarsipes rostratus	Honey Possum, Noolbenger	CS3 (LS)	Resident	1, 2	
Phalangeridae (Brushtail possums)					
Trichosurus vulpecula hypoleucus	Brushtail Possum		Resident	1, 2	

Species		Status	Expected Occurrence	Source	Recorded
Macropodidae (Kangaroos)					
Macropus fuliginosus melanops	Western Grey Kangaroo		Resident	1, 2	S,T
Notamacropus irma	Brush Wallaby	CS2 (P4)	Regular visitor	1, 2	
Muridae (Rats and mice)					
Mus musculus	House Mouse	Int	Resident	1, 2	
Rattus fuscipes fuscipes	Western Bush Rat, Moodit	CS3 (LS)	Resident	1, 2	
Rattus rattus	Black Rat	Int	Resident	1, 2	
Leporidae (Rabbits and hares)					
Oryctolagus cuniculus	Rabbit	Int	Resident	1, 2	D,S
Molossidae (Freetail bats)					
Austronomus australis	White-striped Free-tailed Bat		Regular migrant	1	
Vespertilionidae (Vespertillionid bats)					
Chalinolobus gouldii	Gould's Wattled Bat		Regular visitor	1, 2	
Chalinolobus morio	Chocolate Wattled Bat		Regular visitor	1, 2	
Nyctophilus geoffroyi geoffroyi	Lesser Long-eared Bat		Regular visitor	1, 2	
Nyctophilus holtorum (formerly gouldi)	Holt's Long-eared Bat		Regular visitor	1, 2	
Vespadelus regulus	Southern Forest Bat		Regular visitor	1, 2	
Canidae (Dogs)					
Vulpes vulpes	Red Fox	Int	Resident	1, 2	
Felidae (Cats)					
Felis catus	Cat	Int	Resident	1, 2	

Appendix 8. Species recorded in the field investigations.

Species	Annotations
Cacomantis flabelliformis (Fan-tailed Cuckoo)	Heard from site.
Calyptorhynchus latirostris (Carnaby's Black-Cockatoo)	Extensive foraging evidence throughout site.
Eolophus roseicapilla (Galah)	One or two birds seen.
Purpureicephalus spurius (Red-capped Parrot)	Heard from site.
Barnardius zonarius (Australian Ringneck)	Heard from site.
Malurus splendens (Splendid Fairy-wren)	Heard from site.
Malurus leucopterus (White-winged Fairy-wren)	Heard from site.
Phylidonyris novaehollandiae (New Holland Honeyeater)	Several birds throughout site.
Phylidonyris niger (White-cheeked Honeyeater)	Heard from site.
Calamanthus campestris (Rufous Fieldwren)	Heard from site.
Sericornis frontalis (White-browed Scrubwren)	Heard from site.
Coracina novaehollandiae (Black-faced Cuckoo-shrike)	One or two birds seen.
Colluricincla harmonica (Grey Shrike-thrush)	Heard from site.
Gymnorhina tibicen (Australian Magpie)	Heard from site.
Artamus cinereus (Black-faced Woodswallow)	Several birds passing overhead.
Rhipidura albiscapa (Grey Fantail)	Heard from site.
Corvus coronoides (Australian Raven)	Heard from site.
Grallina cyanoleuca (Magpie-lark)	Heard from site.
Hirundo neoxena (Welcome Swallow)	Several birds passing overhead.
Zosterops lateralis (Silvereye)	Heard from site.
Isoodon fusciventer (Quenda)	Several diggings noted.
Macropus fuliginosus melanops (Western Grey Kangaroo)	Tracks and scats seen throughout site.

Species	Annotations
Oryctolagus cuniculus (Rabbit)	Diggings and scats seen throughout site.

Appendix 9. 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.

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).

Bush Forever (Dell and Banyard 2000) status: HS = habitat specialists with a reduced distribution on the Swan Coastal Plain, LE = locally extinct, WR = wide ranging species with reduced populations on the Swan Coastal Plain.

LS = considered to be of local significance by Bamford Consulting Ecologists (see Appendix 1).

Int = introduced species.

Exclusion categories:

Locally extinct =species is locally extinct in the vicinity of the project area, Habitat = insufficient suitable habitat for the species occurs within the project area, Range = project area falls outside the known range of the species.

Source:

1 = Atlas of Living Australia (ALA 2022), 2 = NatureMap (DBCA 2022e), 3 = Protected Matters Search Tool (DAWE 2022g).

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		Status	Expected Occurrence	Source
Galaxiidae (Galaxiids)				
Galaxias occidentalis ~	Western Minnow		Habitat	1, 2
Galaxiella munda ~	Western Mud Minnow	CS1 (S3)	Habitat	1, 2
Galaxiella nigrostriata ~	Black-stripe Minnow	CS1 (S2)	Habitat	3
Gobiidae (Gobies)				
Pseudogobius olorum ~	Blue-spot Goby		Habitat	1, 2

Species		Status	Expected Occurrence	Source
Cyprinidae (Cyprinids)				
Carassius auratus [~]	Goldfish	Int	Habitat	2
Poeciliidae (Livebearers)				
Gambusia holbrooki [~]	Eastern Mosquitofish	Int	Habitat	1
Hylidae (Tree frogs)				
Litoria rothii [w]	Northern Laughing Tree Frog		Range	1
Limnodynastidae (Burrowing frogs)				
Heleioporus albopunctatus [w†]	Western Spotted Frog		Range	1, 2
Heleioporus barycragus [w†]	Hooting Frog		Range	1, 2
Heleioporus inornatus [w†]	Whooping Frog		Range	1, 2
Heleioporus psammophilus [w†]	Sand Frog		Range	2
Neobatrachus pelobatoides [w†]	Humming Frog		Range	1, 2
Myobatrachidae (Ground frogs)				
Crinia bilingua [w†]	Bilingual Froglet		Range	2
Crinia georgiana [w†]	Quacking Frog		Habitat	1, 2
Geocrinia leai [w†]	Ticking Frog		Habitat	1
Cheloniidae (Hard-shelled sea turtles)				
Caretta caretta [o]	Loggerhead Turtle	CS1 (E,Mar,S2)	Habitat	1, 2
Chelonia mydas [o]	Green Turtle	CS1 (V,Mar,S3)	Habitat	2
Natator depressus [o]	Flatback Turtle	CS1 (V,Mar,S3)	Habitat	1, 2
Dermochelyidae (Leathery Sea Turtle)				
Dermochelys coriacea [o]	Leatherback Turtle	CS1 (E,Mar,S3)	Habitat	1, 2
Chelidae (Side-necked freshwater turtles)				

Species		Status	Expected Occurrence	Source
Chelodina oblonga [w]	Oblong Tortoise		Habitat	1, 2
Pseudemydura umbrina [w]	Western Swamp Tortoise	CS1 (C,S1)	Habitat	1, 2
Diplodactylidae (Diplodactylid geckos)				
Diplodactylus granariensis granariensis			Range	2
Strophurus michaelseni			Range	2
Gekkonidae (Gekkonid geckos)				
Hemidactylus frenatus	Asian House Gecko	Int	Range	1
Agamidae (Dragons)				
Chlamydosaurus kingii	Frill-necked Lizard		Range	1
Ctenophorus ornatus	Ornate Crevice Dragon		Range	1
Scincidae (Skinks)				
Cryptoblepharus plagiocephalus			Range	2
Ctenotus gemmula		CS2 (P3)	Range	1, 2
Ctenotus inornatus			Range	1
Cyclodomorphus melanops melanops			Range	1
Hemiergis initialis initialis			Range	2
Hemiergis peronii peronii			Range	1, 2
Lerista christinae			Range	1, 2
Lerista distinguenda			Range	2
Varanidae (Monitors and goannas)				
Varanus rosenbergi	Heath Goanna		Range	2
Typhlopidae (Blind snakes)				

Species		Status	Expected Occurrence	Source
Anilios [w] aitii			Range	1
Pythonidae (Pythons)				
Antaresia childreni	Children's Python		Range	2
Elapidae (Venomous land snakes)				
Elapognathus coronatus	Crowned Snake		Range	1, 2
Notechis scutatus	Tiger Snake		Habitat	1, 2
Pseudechis australis	Mulga Snake		Range	1, 2
Pseudonaja mengdeni	Gwardar; Western Brown Snake		Range	1, 2
Simoselaps littoralis	West Coast Banded Snake		Range	1
Aipysurus pooleorum [o]			Habitat	1
Hydrophis elegans [o]			Habitat	1
Hydrophis platurus platurus [o]	Yellow-bellied Sea-snake		Habitat	1, 2
Anatidae (Ducks, Geese and Swans)				
Dendrocygna eytoni [w]	Plumed Whistling-Duck		Range	1, 2
Dendrocygna arcuata [w]	Wandering Whistling-Duck		Range	1
Oxyura australis [w]	Blue-billed Duck	CS2 (P4)	Habitat	1, 2
Malacorhynchus membranaceus [w]	Pink-eared Duck		Habitat	1, 2
Cygnus atratus [w]	Black Swan		Habitat	1, 2
Cygnus olor [w]	Mute Swan	Int	Range	1
Aythya australis [w]	Hardhead		Habitat	1, 2
Spatula rhynchotis [w]	Australasian Shoveler		Habitat	1, 2
Anas platyrhynchos [w]	Northern Mallard		Range	1, 2
Anas gracilis [w]	Grey Teal		Habitat	1, 2

Species		Status	Expected Occurrence	Source
Anas castanea [w]	Chestnut Teal		Habitat	1, 2
Stictonetta naevosa [w]	Freckled Duck		Habitat	1, 2
Biziura lobata [w]	Musk Duck		Habitat	1, 2
Nettapus pulchellus [w]	Green Pygmy-goose		Range	1
Megapodiidae (Megapodes)				
Leipoa ocellata	Malleefowl	CS1 (V,S3)	Range	3
Phasianidae (Pheasants and Quail)				
Pavo cristatus	Indian Peafowl	Int	Range	1
Podicipedidae (Grebes)				
Tachybaptus novaehollandiae [w]	Australasian Grebe		Habitat	1, 2
Poliocephalus poliocephalus [w]	Hoary-headed Grebe		Habitat	1, 2
Podiceps cristatus [w]	Great Crested Grebe		Habitat	1, 2
Columbidae (Pigeons and Doves)				
Geopelia cuneata	Diamond Dove		Range	1
Cuculidae (Cuckoos)				
Eudynamys orientalis	Eastern Koel		Range	1
Chalcites osculans	Black-eared Cuckoo		Range	1
Otididae (Bustards)				
Ardeotis australis	Australian Bustard		Range	1
Rallidae (Crakes, Rails and Swamphens)				
Hypotaenidia philippensis [w]	Buff-banded Rail		Habitat	1, 2
Porzana fluminea [w]	Australian Spotted Crake		Habitat	1, 2
Zapornia pusilla [w]	Baillon's Crake		Habitat	1, 2

Species		Status	Expected Occurrence	Source
Zapornia tabuensis [w]	Spotless Crake		Habitat	1, 2
Porphyrio porphyrio [w]	Purple Swamphen		Habitat	1, 2
Gallinula tenebrosa [w]	Dusky Moorhen		Habitat	1, 2
Tribonyx ventralis [w]	Black-tailed Native-hen		Habitat	1, 2
Fulica atra [w]	Eurasian Coot		Habitat	1, 2
Burhinidae (Stone-curlews)				
Burhinus grallarius	Bush Stone-curlew		Locally extinct	1, 2
Haematopodidae (Oystercatchers)				
Haematopus longirostris [w]	Australian Pied Oystercatcher		Habitat	1, 2
Haematopus fuliginosus [o]	Sooty Oystercatcher		Habitat	1, 2
Recurvirostridae (Stilts and Avocets)				
Cladorhynchus leucocephalus [w]	Banded Stilt		Habitat	1, 2
Recurvirostra novaehollandiae [w]	Red-necked Avocet		Habitat	1, 2, 3
Himantopus leucocephalus [w]	Pied Stilt		Habitat	1, 2, 3
Charadriidae (Plovers, Dotterel and Lapwings)				
Pluvialis squatarola [w]	Grey Plover	CS1 (M,Mar,S5)	Habitat	1, 2
Pluvialis fulva [w]	Pacific Golden Plover	CS1 (M,Mar,S5)	Habitat	1, 2
Charadrius ruficapillus [w]	Red-capped Plover		Habitat	1, 2, 3
Charadrius bicinctus [w]	Double-banded Plover	CS1 (M,Mar,S5)	Habitat	1
Charadrius leschenaultii [w]	Greater Sand Plover	CS1 (M,Mar,S3, S5)	Habitat	1, 2
Thinornis cucullatus [w]	Hooded Plover	CS2 (Mar,P4)	Habitat	1
Elseyornis melanops [w]	Black-fronted Dotterel		Habitat	1, 2
Vanellus tricolor	Banded Lapwing		Habitat	1, 2

Species		Status	Expected Occurrence	Source
Vanellus miles	Masked Lapwing		Habitat	1, 2
Erythrogonys cinctus [w]	Red-kneed Dotterel		Habitat	1, 2
Rostratulidae (Painted Snipe)				
Rostratula australis [w]	Australian Painted-snipe	CS1 (E,Mar,S2)	Habitat	2, 3
Scolopacidae (Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes)				
Numenius phaeopus [w]	Whimbrel	CS1 (M,Mar,S5)	Habitat	1
Numenius madagascariensis [w]	Eastern Curlew	CS1 (C,M,Mar,S3,S5)	Habitat	1, 3
Limosa lapponica [w]	Bar-tailed Godwit	CS1 (M,Mar,S5)	Habitat	1, 2, 3
Limosa limosa [w]	Black-tailed Godwit	CS1 (M,Mar,S5)	Habitat	1, 2
Arenaria interpres [w]	Ruddy Turnstone	CS1 (M,Mar,S5)	Habitat	1, 2
Calidris tenuirostris [w]	Great Knot	CS1 (M,Mar,S3,S5)	Habitat	2
Calidris canutus [w]	Red Knot	CS1 (M,Mar,S5)	Habitat	2, 3
Calidris acuminata [w]	Sharp-tailed Sandpiper	CS1 (M,Mar,S5)	Habitat	1, 2, 3
Calidris ferruginea [w]	Curlew Sandpiper	CS1 (C,M,Mar,S3,S5)	Habitat	1, 2, 3
Calidris subminuta [w]	Long-toed Stint	CS1 (M,Mar,S5)	Habitat	1, 2, 3
Calidris ruficollis [w]	Red-necked Stint	CS1 (M,Mar,S5)	Habitat	1, 2, 3
Calidris alba [w]	Sanderling	CS1 (M,Mar,S5)	Habitat	1, 2
Calidris melanotos [w]	Pectoral Sandpiper	CS1 (M,Mar,S5)	Habitat	1, 2, 3
Xenus cinereus [w]	Terek Sandpiper	CS1 (M,Mar,S5)	Habitat	1, 2
Actitis hypoleucos [w]	Common Sandpiper	CS1 (M,Mar,S5)	Habitat	1, 2, 3
Tringa brevipes [w]	Grey-tailed Tattler	CS1 (M,Mar,S5,P4)	Habitat	1, 2
Tringa nebularia [w]	Common Greenshank	CS1 (M,Mar,S5)	Habitat	1, 2, 3

Species		Status	Expected Occurrence	Source
Tringa glareola [w]	Wood Sandpiper	CS1 (M,Mar,S5)	Habitat	1, 2, 3
Tringa stagnatilis [w]	Marsh Sandpiper	CS1 (M,Mar,S5)	Habitat	1, 2
Glareolidae (Pratincoles)				
Glareola maldivarum	Oriental Pratincole	CS1 (M,Mar,S5)	Habitat	1
Stercorariidae (Skuas and Jaegers)				
Stercorarius parasiticus [o]	Arctic Jaeger	CS1 (M,Mar,S5)	Habitat	1
Stercorarius pomarinus [o]	Pomarine Jaeger	CS1 (M,Mar,S5)	Habitat	1
Catharacta antarcticus [o]	Brown Skua		Habitat	1
Laridae (Gulls, Terns and Noddies)				
Anous stolidus [o]	Common Noddy	CS1 (M,Mar,S5)	Habitat	3
Anous tenuirostris [o]	Lesser Noddy	CS1 (V,Mar,S2)	Habitat	1, 2, 3
Chroicocephalus novaehollandiae	Silver Gull		Habitat	1, 2, 3
Larus pacificus [w]	Pacific Gull		Habitat	1, 2, 3
Onychoprion fuscatus [o]	Sooty Tern		Habitat	1, 2
Onychoprion anaethetus [o]	Bridled Tern	CS1 (M,Mar,S5)	Habitat	1, 2, 3
Sternula albifrons [w]	Little Tern	CS1 (M,Mar,S5)	Habitat	1
Sternula nereis [w]	Fairy Tern	CS1 (V,Mar,S3)	Habitat	1, 2, 3
Gelochelidon nilotica [w]	Common Gull-billed Tern	CS1 (M,Mar,S5)	Habitat	1
Hydroprogne caspia [w]	Caspian Tern	CS1 (M,Mar,S5)	Habitat	1, 2, 3
Chlidonias hybrida [w]	Whiskered Tern		Habitat	1, 2
Chlidonias leucopterus [w]	White-winged Black Tern	CS1 (M,Mar,S5)	Habitat	1, 2
Chlidonias niger [o]	Black Tern		Habitat	1
Sterna dougallii [o]	Roseate Tern	CS1 (M,Mar,S5)	Habitat	1, 2, 3

Species		Status	Expected Occurrence	Source
Sterna paradisaea [o]	Arctic Tern		Habitat	1, 2
Thalasseus bergii [w]	Crested Tern		Habitat	1, 2
Spheniscidae (Penguins)				
Eudyptula minor [o]	Little Penguin		Habitat	1, 2
Oceanitidae (Southern Storm-Petrels)				
Oceanites oceanicus [o]	Wilson's Storm-Petrel	CS1 (M,Mar,S5)	Habitat	1, 2
Pelagodroma marina [o]	White-faced Storm-Petrel		Habitat	1
Diomedeidae (Albatrosses)				
Thalassarche chrysostoma [o]	Grey-headed Albatross	CS1 (E,M,Mar,S3,S5)	Habitat	1
Thalassarche melanophris [o]	Black-browed Albatross		Habitat	1
Thalassarche cauta [o]	Shy Albatross	CS1 (V,M,Mar,S3,S5)	Habitat	1, 2
Procellariidae (Petrels and Shearwaters)				
Macronectes giganteus [o]	Southern Giant-Petrel	CS1 (E,M,Mar,S5)	Habitat	1, 2
Daption capense [o]	Cape Petrel		Habitat	1, 2
Halobaena caerulea [o]	Blue Petrel	CS1 (V,Mar)	Habitat	1, 2
Pachyptila salvini [o]	Salvin's Prion		Habitat	1
Pachyptila desolata [o]	Antarctic Prion		Habitat	1, 2
Pachyptila belcheri [o]	Slender-billed Prion		Habitat	1, 2
Pachyptila turtur [o]	Fairy Prion		Habitat	1, 2
Pterodroma mollis [o]	Soft-plumaged Petrel	CS1 (V,Mar)	Habitat	1
Pterodroma lessonii [o]	White-headed Petrel		Habitat	1, 2
Pterodroma macroptera [o]	Great-winged Petrel		Habitat	1, 2

Species		Status	Expected Occurrence	Source
Procellaria aequinoctialis [o]	White-chinned Petrel	CS1 (M,Mar,S3,S5)	Habitat	2
Ardenna pacifica [o]	Wedge-tailed Shearwater	CS1 (M,Mar,S5)	Habitat	1
Ardenna carneipes [o]	Flesh-footed Shearwater	CS1 (M,Mar,S3,S5)	Habitat	1
Puffinus huttoni [o]	Hutton's Shearwater	CS1 (Mar,S2)	Habitat	1
Puffinus assimilis [o]	Little Shearwater		Habitat	1, 2
Pelicanidae (Pelican)				
Pelecanus conspicillatus [w]	Australian Pelican		Habitat	1, 2
Ardeidae (Herons, Egrets and Bitterns)				
Botaurus poiciloptilus [w]	Australasian Bittern	CS1 (E,S2)	Habitat	1, 2, 3
Ixobrychus dubius [w]	Australian Little Bittern	CS2 (P4)	Habitat	1, 2
Nycticorax caledonicus [w]	Nankeen Night-Heron		Habitat	1, 2
Bubulcus coromandus	Eastern Cattle Egret		Habitat	1, 2, 3
Ardea pacifica [w]	White-necked Heron		Habitat	1, 2
Ardea alba [w]	Great Egret		Habitat	1, 2
Ardea intermedia [w]	Intermediate Egret		Habitat	1, 2
Egretta novaehollandiae [w]	White-faced Heron		Habitat	1, 2
Egretta garzetta [w]	Little Egret		Habitat	1, 2
Egretta sacra [o]	Eastern Reef Egret		Habitat	1
Threskiornithidae (Ibis and Spoonbills)				
Threskiornis moluccus	Australian White Ibis		Habitat	1
Threskiornis spinicollis	Straw-necked Ibis		Habitat	1, 2
Platalea flavipes [w]	Yellow-billed Spoonbill		Habitat	1, 2
Platalea regia [w]	Royal Spoonbill		Habitat	1, 2

Species		Status	Expected Occurrence	Source
Plegadis falcinellus [w]	Glossy Ibis	CS1 (M,Mar,S5)	Habitat	1, 2
Sulidae (Gannets and Boobies)				
Morus serrator [o]	Australasian Gannet		Habitat	1, 2
Phalacrocoracidae (Cormorants and Shags)				
Microcarbo melanoleucos [w]	Little Pied Cormorant		Habitat	1, 2
Phalacrocorax carbo [w]	Great Cormorant		Habitat	1, 2
Phalacrocorax sulcirostris [w]	Little Black Cormorant		Habitat	1, 2
Phalacrocorax varius [w]	Pied Cormorant		Habitat	1, 2
Anhingidae (Darter)				
Anhinga novaehollandiae [w]	Australasian Darter		Habitat	1, 2
Pandionidae (Osprey)				
Pandion cristatus [w]	Eastern Osprey	CS1 (M,Mar,S5)	Habitat	1, 2, 3
Accipitridae (Eagles, Kites, Goshawks)				
Circus approximans [w]	Swamp Harrier		Habitat	1, 2
Haliaeetus leucogaster [w]	White-bellied Sea-Eagle		Habitat	1, 2, 3
Milvus migrans	Black Kite		Range	1
Tytonidae (Masked Owls)				
Tyto novaehollandiae	Masked Owl		Locally extinct	1, 2
Strigidae (Hawk-Owls)				
Ninox connivens	Barking Owl		Locally extinct	1, 2
Cacatuidae (Cockatoos and Corellas)				
Nymphicus hollandicus	Cockatiel		Range	2
Calyptorhynchus baudinii	Baudin's Black-Cockatoo	CS1 (V,S2)	Range	1, 2

Species		Status	Expected Occurrence	Source
Cacatua leadbeateri	Major Mitchell's Cockatoo		Range	1
Cacatua pastinator	Western Corella		Range	1, 2
Cacatua galerita	Sulphur-crested Cockatoo	Int	Range	1, 2
Psittaculidae (Parrots, Lorikeets and Rosellas)				
Polytelis anthopeplus	Regent Parrot		Range	1, 2
Platycercus icterotis	Western Rosella		Habitat	1, 2
Neophema petrophila	Rock Parrot		Habitat	1
Glossopsitta porphyrocephala	Purple-crowned Lorikeet		Habitat	1
Melopsittacus undulatus	Budgerigar		Range	1
Climacteridae (Treecreepers)				
Climacteris rufus	Rufous Treecreeper		Range	1
Maluridae (Fairy-wrens, Emu-wrens and Grasswrens)				
Malurus elegans	Red-winged Fairy-wren		Range	1, 2
Malurus pulcherrimus	Blue-breasted Fairy-wren		Range	1, 2
Meliphagidae (Honeyeaters and Chats)				
Nesoptilotis leucotis	White-eared Honeyeater		Range	1, 2
Melithreptus brevirostris	Brown-headed Honeyeater		Range	1, 2
Melithreptus chloropsis	Gilbert's Honeyeater		Range	1
Acanthagenys rufogularis	Spiny-cheeked Honeyeater		Range	1, 2
Ptilotula ornata	Yellow-plumed Honeyeater		Range	1
Ptilotula penicillata	White-plumed Honeyeater		Range	1
Purnella albifrons	White-fronted Honeyeater		Range	1
Falcunculidae (Shriketits)				

Species		Status	Expected Occurrence	Source
Falcunculus frontatus leucogaster	Crested Shrike-tit (race leucogaster)		Range	1, 2
Psophodidae (Whipbirds and Wedgebills)				
Psophodes nigrogularis	Western Whipbird	CS1	Locally extinct	1
Artamidae (Woodswallows, Currawongs, Butcherbirds and Magpie)				
Cracticus nigrogularis	Pied Butcherbird		Range	1, 2
Corvidae (Crows and Ravens)				
Corvus bennetti	Little Crow		Range	1, 2
Monarchidae (Monarch and Flycatchers)				
Myiagra inquieta	Restless Flycatcher		Range	1, 2
Petroicidae (Australian Robins)				
Microeca fascinans	Jacky Winter		Range	1, 2
Eopsaltria griseogularis	Western Yellow Robin		Range	1, 2
Estrildidae (Weaver Finches)				
Lonchura castaneothorax	Chestnut-breasted Mannikin		Range	1, 2
Stagonopleura oculata	Red-eared Firetail		Range	1, 2
Taeniopygia guttata	Zebra Finch		Range	1
Passeridae (Weaver Finches)				
Passer domesticus	House Sparrow	Int	Range	1, 2
Passer montanus	Eurasian Tree Sparrow	Int	Range	1, 2
Motacillidae (Pipits and Wagtails)				
Motacilla cinerea	Grey Wagtail	CS1 (M,Mar,S5)	Range	3
Motacilla alba	White Wagtail		Range	1

Species		Status	Expected Occurrence	Source
Fringillidae (Old World Finches)				
Carduelis carduelis	European Goldfinch	Int	Range	1
Locustellidae (Grassbirds)				
Poodytes gramineus [w]	Little Grassbird		Habitat	1, 2
Acrocephalidae (Reed-Warblers)				
Acrocephalus australis [w]	Australian Reed-Warbler		Habitat	1, 2
Turdidae (Thrushes)				
Turdus merula	Common Blackbird		Range	1
Dasyuridae (Dasyurids)				
Phascogale calura	Red-tailed Phascogale	CS1 (E,S6)	Range	1
Phascogale tapoatafa [w] *ambenger*	Brush-tailed Phascogale, Wambenger	CS1 (S6)	Locally extinct	1
Sminthopsis crassicaudata	Fat-tailed Dunnart		Locally extinct	1, 2
Sminthopsis fuliginosus fuliginosus	Grey-bellied Dunnart	CS3 (LS)	Locally extinct	2
Sminthopsis gilberti	Gilbert's Dunnart		Range	2
Burramyidae (Pygmy possums)				
Cercartetus concinnus	Western Pygmy-possum, Mundarda	CS3 (LS)	Locally extinct	1, 2
Pseudocheiridae (Ringtail possums)				
Pseudocheirus occidentalis	Western Ringtail Possum	CS1 (V,S1)	Locally extinct	3
Potoroidae (Potoroos and bettongs)				
Bettongia lesueur graii	Burrowing Bettong, Boodie	CS1 (Ex,S4)	Locally extinct	2
Bettongia penicillata ogilbyi	Brush-tailed Bettong, Woylie	CS1 (E,S1)	Locally extinct	2, 3
Macropodidae (Kangaroos)				

Species		Status	Expected Occurrence	Source
Osphranter rufus	Red Kangaroo, Marlu		Range	1
Muridae (Rats and mice)				
Hydromys chrysogaster [w]	Water-rat, Rakali	CS2 (P4)	Habitat	1, 2
Pseudomys albocinereus albocinereus	Ash-grey Mouse, Noodji	CS3 (LS)	Locally extinct	1, 2
Otariidae (Eared seals)				
Neophoca cinerea [o]	Australian Sea Lion	CS1 (V,Mar,S3)	Habitat	1, 2
Phocidae (True' seals)				
Hydrurga leptonyx [o]	Leopard Seal		Habitat	1, 2
Mirounga leonina [o]	Southern Elephant Seal	CS1 (V,Mar)	Habitat	1, 2
Canidae (Dogs)				
Canis familiaris dingo	Dingo		Locally extinct	1, 2
Mustelidae (Ferrets)				
Mustela putorius	European Polecat, Ferret	Int	Range	2
Equidae (Horses)				
Equus asinus	Donkey	Int	Range	1
Camelidae (Camels)				
Camelus dromedarius	Dromedary, Camel	Int	Range	2
Bovidae (Horned ruminants)				
Bos taurus	European Cattle	Int	Range	1, 2
Ovis aries	Sheep	Int	Range	1, 2
Balaenidae (Right whales)				
Eubalaena australis [o]	Southern Right Whale	CS1 (E,S3)	Habitat	1, 2

Species		Status	Expected Occurrence	Source
Balaenopteridae (Rorquals)				
Balaenoptera acutorostrata [o]	Dwarf Minke Whale		Habitat	1, 2
Physeteridae (Sperm Whale)				
Physeter macrocephalus [o]	Sperm Whale	CS1 (S3)	Habitat	2
Kogiidae (Pygmy sperm whales)				
Kogia breviceps [o]	Pygmy Sperm Whale		Habitat	1, 2
Ziphiidae (Beaked whales)				
Mesoplodon bowdoini [o]	Andrew's Beaked Whale		Habitat	2
Mesoplodon densirostris [o]	Blainville's Beaked Whale		Habitat	1
Deliphinidae (Dolphins, pilot whales and Killer Whale)				
Tursiops aduncus [o]	Indo-Pacific Bottlenose Dolphin		Habitat	1

Appendix 10. Conservation significant invertebrate fauna species expected to occur in the Swan management region (as per DBCA 2022b, g), 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).

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
Australotomurus morbidus	Cemetery Springtail, Guildford Springtail	CS2 (P3)	Probably absent. The Cemetery Springtail is known from four urban remnants within the Perth region, where it occurs in Banksia heath (Greenslade and Jordana 2014).
Austroconops mcmillani	McMillan's Biting Midge (Swan Coastal Plain)	CS2 (P2)	Probably absent. Known from only a small number of very localised populations between Yanchep and Darkan where it appears to be associated with areas of damp soil or open water (Borkent and Craig 2004).
Austrosaga spinifer	Spiny Katydid (Swan Coastal Plain)	CS2 (P2)	Possibly present.
Euoplos inornatus	Inornate Trapdoor Spider (northern Jarrah Forest)	CS2 (P3)	Absent. Restricted to the western Darling Range east of Perth, with two outlying populations on the Swan Coastal Plain at Kings Park (Mt Eliza) and on the Mount Henry Peninsula (Rix *et al.* 2017), where it prefers "consolidated banks". Project area more than 30 km outside of the species' known range.
Glacidorbis occidentalis	Jarrah Forest Freshwater Snail	CS2 (P3)	Absent. No wetland habitat.

Species	Common Name	Status	Expected Occurrence
Glossurocolletes bilobatus	a short-tongued bee (southwest)	CS2 (P2)	Absent. Survey area more than 40 km outside of species known range that is described by Houston (2018) as "the Perth region east to York". Museum records on the Swan Coastal Plain are all south of the Swan River.
Hesperocolletes douglasi	Douglas's Broad-headed Bee	CS1 (S1)	Uncertain; probably absent.
Hurleya sp. (WAM C23193)	Crystal Cave Crangonyctoid, cave shrimp	CS1 (S1)	Absent. Known only from cave systems in the Yanchep National Park where "critical habitat for … the Crystal Cave Crangonyctoid is composed of the seven individual caves, the seven cave steams, the trees that have roots in each of the caves, and the catchments for the streams that flow through the caves" (English *et al.* 2003; Horwitz *et al.* 2009), none of which occur within the survey area.
Hylaeus globuliferus	Woollybush Bee	CS2 (P3)	Probably absent.
Idiosoma dandaragan	Dandaragan Plateau Shield-backed Trapdoor Spider	CS2 (P2)	Absent. Survey area more than 100 km outside of species known range, and preferred habitat (Rix *et al.* 2018) not within the survey area.
Idiosoma mcclementsorum	Julimar Shield-backed Trapdoor Spider	CS2 (P2)	Absent. Survey area more than 40 km outside of species known range, and preferred habitat (Rix *et al.* 2018) not within the survey area.
Idiosoma nigrum	Shield-backed Trapdoor Spider	CS1 (S2, V)	Absent. Survey area more than 80 km outside of species known range, and preferred habitat (Rix *et al.* 2018) not within the survey area.

Species	Common Name	Status	Expected Occurrence
Idiosoma sigillatum	Swan Coastal Plain Shield-backed Trapdoor Spider	CS2 (P3)	Present.
Kawaniphila pachomai	Grey Vernal Katydid (southwest)	CS2 (P1)	Absent. Known only from only two records, near Witchcliffe and Armadale, where it is thought to occur in moist, shaded uncleared forests and gullies (Harewood 2017; Moulds 2019).
Leioproctus contrarius	a short-tongued bee	CS2 (P3)	Possibly present.
Leioproctus douglasiellus	a short-tongued bee	CS1 (S2, C)	Absent. Survey area more than 50 km outside of species known range. Known only from three locations within the Perth metropolitan area ranging from Cannington to Forrestdale, where it has been found in association with the yellow flowers of *Goodenia pulchella* within clay plans (DSEWPaC 2013b; CoA 2017).
Neopasiphae simplicior	a short-tongued bee	CS1 (S2, C)	Absent. Survey area more than 40 km outside of species known range. Known only from a single location in Forrestdale Lake Nature Reserve where it has been associated with the flowers of *Goodenia filiformis*, *Lobelia tenulor*, *Angianthus preissianus* and *Velleia* sp (Houston 2000; DEWHA 2008).
Synemon gratiosa	Graceful Sun-Moth	CS2 (P4)	Possibly present.
Throscodectes xederoides	Mogumber Bush Cricket, Northern Throsco	CS2 (P3)	Absent. Survey area more than 70 km outside of species known range.
Throscodectes xiphos	Stylet Bush Cricket, stylet Throsco (Jandakot)	CS2 (P1)	Absent. Survey area more than 40 km outside of species known range. Known only from the Jandakot

Species	Common Name	Status	Expected Occurrence
			area on the Swan Coastal Plain, it is associated with *Xanthorrhoea preissei* grass trees (Moulds 2019).
Westralunio carteri	Carter's Freshwater Mussel	CS1 (S3, V)	Absent. No wetland habitat.

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