Aurumin
Mount Dimer Project
Assessment of Fauna Values

Eucalypt woodland in the vicinity of the survey area. Photo: Wes Bancroft.

Prepared for: Aurumin Limited
Suite 2, Ground Floor
17 Ord Street
WEST PERTH WA 6005

Prepared by: Wes Bancroft and Mike Bamford
M.J. & A.R. BAMFORD CONSULTING ECOLOGISTS
23 Plover Way
KINGSLEY WA 6026

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1 Introduction

Aurumin Limited (Aurumin) is proposing to undertake remediation and safety upgrades within its Mount Dimer Gold Project, c. 100 km north-east of Southern Cross (hereafter "project area", see Section 2.1.1 and Figure 1). There are two areas in which these actions will be undertaken and to which the fauna assessment here is directed (the "survey areas", see Section 2.1.1 and Figure 1):

(i) Survey Area A (western). An inspection by environmental officers of Department of Mines, Industry Regulation and Safety (DMIRS) noted the presence of erosion gullies on the external batters of the Karli West Waste Rock Dump and requested remedial action be taken to stabilise the erosion and prevent sediment from entering the surrounding environment. The general location of Survey Area A is shown in Figure 1.

(ii) Survey Area B (eastern). Access to the operational Mount Dimer Airstrip is via a road that runs through the mining area (currently inactive). A safety review highlighted that if mining was to recommence then the interaction of airstrip traffic and mobile mining equipment may pose a safety risk. Therefore, it is proposed to construct a new access road to the airstrip that does not traverse the mining areas.

These actions will require the clearing of native vegetation and, as part of the process, Aurumin is required to apply for a Native Vegetation Clearing Permit (NVCP). The NVCP application necessitates that the actions are assessed in accordance with the ten clearing principles for native vegetation under Schedule 5 of the Western Australian *Environmental Protection Act 1986* (EP Act). The ten principles are discussed in detail by DER (2014) but are summarised in Table 1. While most of these principles may relate to fauna indirectly, Principle (b) specifically addresses this group:

> *Principle (b) – Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.*

Bamford Consulting Ecologists (BCE) was commissioned by Aurumin to assess the proposed remediation and road realignment works against this principle.

Table 1. Clearing principles for native vegetation under Schedule 5 of the *Environmental Protection Act 1986* (DER 2014).

Principle	Description
(a)	Native vegetation should not be cleared if it comprises a high level of biological diversity.
(b)	Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.
(c)	Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora.
(d)	Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of a threatened ecological community.

Principle	Description
(e)	Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared.
(f)	Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or wetland.
(g)	Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.
(h)	Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.
(i)	Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.
(j)	Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence or intensity of flooding.

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, including an assessment against relevant NVCP principles and Guidance 1.2 of the Department for Agriculture, Water and the Environment (DAWE).

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, survey area and background environmental information

1.2.1 Project area and survey areas

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 Mount Dimer Project is approximately 56 km north-north-east of Koolyanobbing and approximately 11 km east-south-east of the Helena and Aurora Ranges, and situated within the former Jaurdi Pastoral Station which is proposed to be a 5(1)(H) Reserve managed for the purposes of Conservation and Mining. There have previously been exploration and mining operations within the project area, with disturbed areas including tracks, drill pads, an airstrip, existing pits and waste rock piles.

The focus of the current investigations are the two 'survey areas' outlined in Section 1, and shown in Figure 1 (the site of the proposed Karli West Waste Rock Dump rehabilitation remediation works) and Figure 2 (the site of the proposed airport access road realignment). The 'development footprint' of the proposed works is not expected to take up the entirety of these survey areas.

The field investigations in this environmental impact assessment were focussed within the survey areas (although other work was conducted, concurrently, within the broader project area and, therefore, provides context).

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 (and, hence, survey areas) is within the Southern Cross (COO02) subregion of the Coolgardie bioregion, as mapped in Figure 3. This bioregion falls within

the Bioregion Group 2 (Eremaean Botanical Province) classification of EPA (2016c) where native vegetation is "is largely contiguous but used for commercial grazing".

The Southern Cross subregion was described by Cowan *et al.* (2001) and a summary of their work follows here. Southern Cross subregion has subdued relief, comprising gently undulating uplands dissected by broad valleys with bands of low greenstone hills. It lies on the 'Southern Cross Terrains' of the Yilgarn Craton. The granite strata of Yilgarn Craton are interrupted by parallel intrusions of Archaean Greenstone. Drainage is occluded. It has an arid to semi-arid Warm Mediterranean climate with 250-300 mm of mainly winter rainfall.

Valleys have Quaternary duplex and gradational soils and include chains of saline playa-lakes. Diverse *Eucalyptus* woodlands (*Eucalyptus salmonophloia*, *E. salubris*, *E transcontinentalis*, *E. longicornis*) rich in endemic eucalypts occur around these salt lakes, on the low greenstone hills, valley alluvials and broad plains of calcareous earths. The salt lake surfaces support dwarf shrublands of samphire. The granite basement outcrops at mid-levels in the landscape and supports swards of *Borya constricta*, with stands of *Acacia acuminata* and *Eucalyptus loxophleba*. Upper levels in the landscape are the eroded remnants of a lateritic duricrust yielding yellow sandplains, gravelly sandplains and laterite breakaways. Mallees (*Eucalyptus leptopoda*, *E. platycorys* and *E. scyphocalyx*) and scrub-heaths (*Allocasuarina corniculata*, *Callitris preissii*, *Melaleuca uncinata* and *Acacia beauverdiana*) occur on these uplands, as well as on sand lunettes associated with playas along the broad valley floors, and sand sheets around the granite outcrops. The scrubs are rich in endemic acacias and Myrtaceae.

1.2.3 Land systems and vegetation complexes

There appears to be limited information on the land systems in the vicinity of the survey areas. DPIRD (2022b) mapped the region as mapping unit 'My45': Undulating terrain with small gently sloping plains and some ranges on basic schists, gneisses, and allied rocks.

DPIRD (2022a) provide Beard's pre-European vegetation mapping for the region, and the survey areas sit within the 'Jackson' system, see Figure 4.

1.2.4 Land use and tenure

The dominant land uses within the Southern Cross (COO02) subregion are grazing – native pastures, UCL and Crown reserves, cultivation – dry land agriculture, and conservation reserves (Cowan *et al.* 2001). The survey areas lie in the central sector of the subregion. At the local scale, the survey areas are surrounded by mining operations/workings and native remnant vegetation.

1.2.5 Recognised sensitive sites

There are no known Ramsar Sites (DBCA 2022d), Important Wetlands (DBCA 2022b), Threatened Ecological Communities (DBCA 2022f, g), Bush Forever sites (Dell and Banyard 2000; DPLH 2022), Key Biodiversity Areas (KBA 2022) or Environmentally Sensitive Areas (DWER 2022a, b) within the survey areas.

1.2.6 Climate information

The project areas falls within the Köppen climate classification of 'Hot-summer Mediterranean climate (*Csa*)', which is characterised 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 Southern Cross (COO02) subregion, the climate is described as "arid to semi-arid Warm Mediterranean" with 250-300 mm of mainly winter rainfall (Cowan *et al.* 2001).

Climate averages (temperate, rainfall, sunshine) for the project area, as provided by BOM (2022b), are presented in Table 2.

Table 2. Climate averages for the project area.

Data from BOM (2022b) for:
Site name = SOUTHERN CROSS AIRFIELD
Site number = 012320

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years	
Temperature															
Mean maximum temperature (°C)	34.8	33.7	30.5	26.3	21.3	18.0	16.7	18.5	21.9	26.6	30.0	33.1	26.0	25	1996 2022
Mean minimum temperature (°C)	17.9	17.7	15.5	11.8	7.3	4.6	3.7	3.9	5.5	9.5	13.2	15.7	10.5	25	1996 2022
Rainfall															
Mean rainfall (mm)	27.9	27.5	36.1	22.0	27.9	26.7	35.2	30.1	19.2	18.0	17.4	14.9	301.3	23	1996 2022
Decile 5 (median) rainfall (mm)	17.8	20.4	27.6	18.4	18.2	19.4	35.4	24.2	18.2	7.6	16.2	11.4	303.6	25	1996 2022
Mean number of days of rain ≥ 1 mm	2.3	2.7	3.2	2.9	4.3	5.1	6.7	5.4	4.0	2.9	2.7	2.2	44.4	24	1996 2022

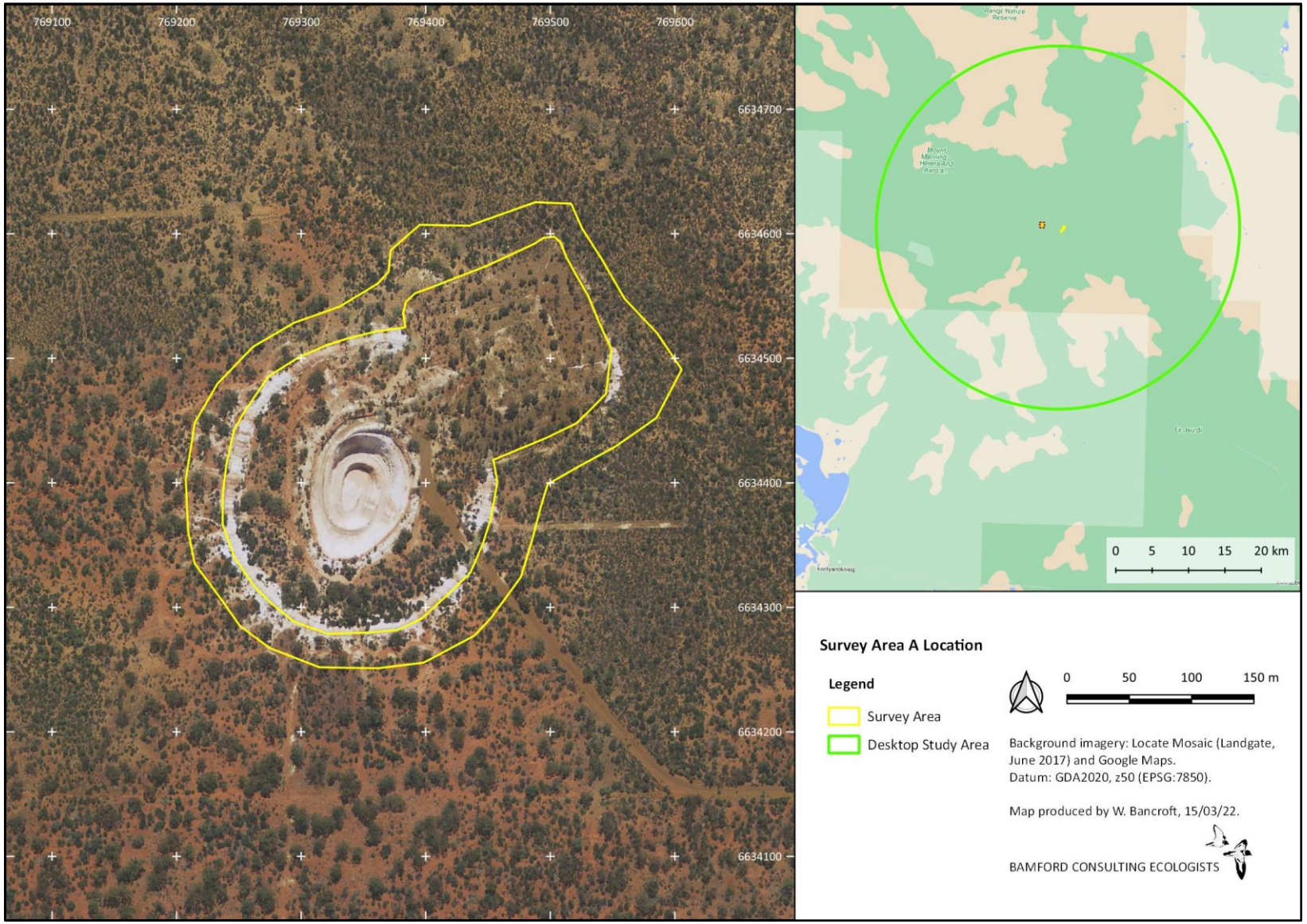

Figure 1. Location of the Survey Area A: the site of the proposed Karli West Waste Rock Dump remediation works.

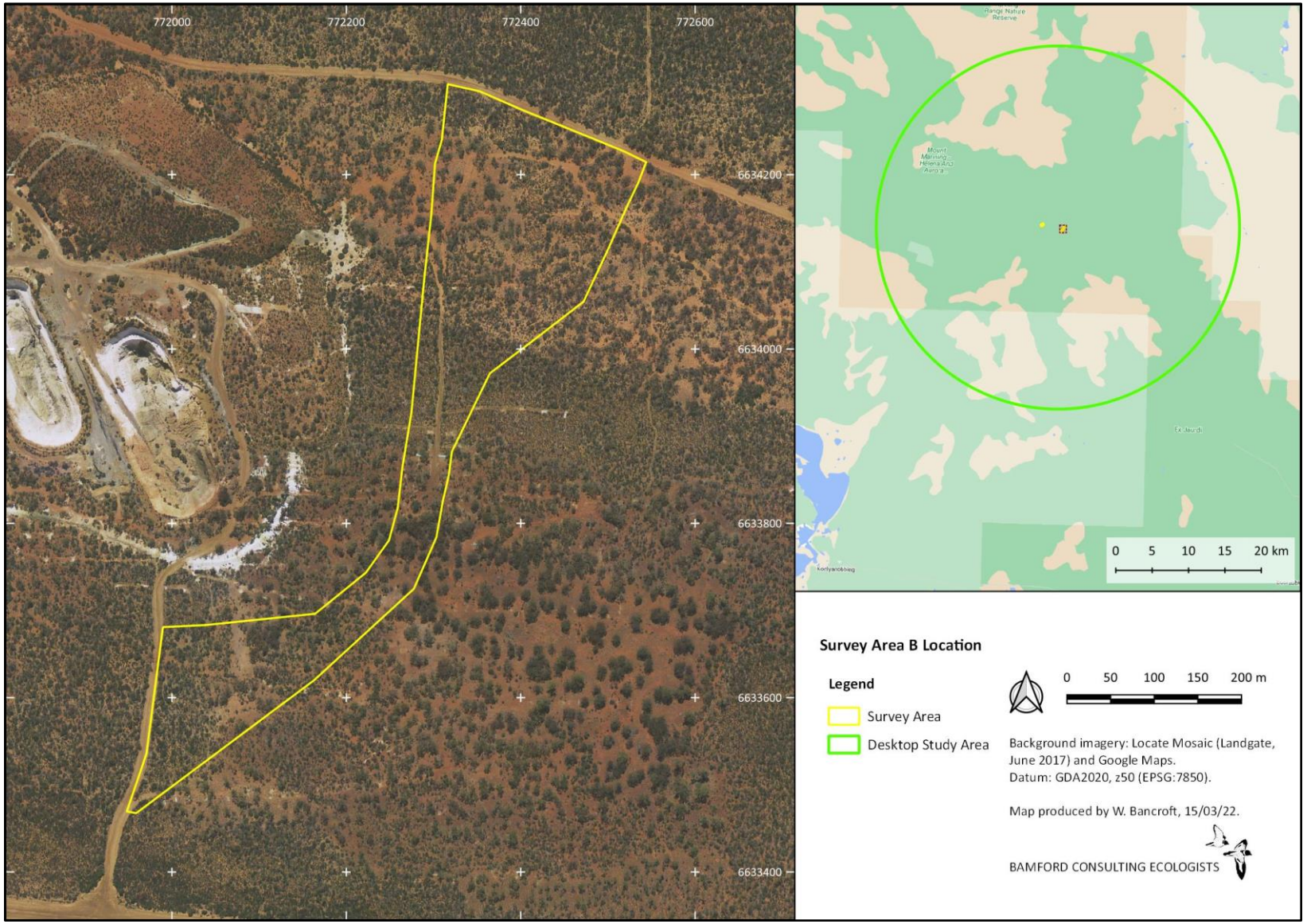

Figure 2. Location of the Survey Area B: the site of the proposed airport access road realignment.

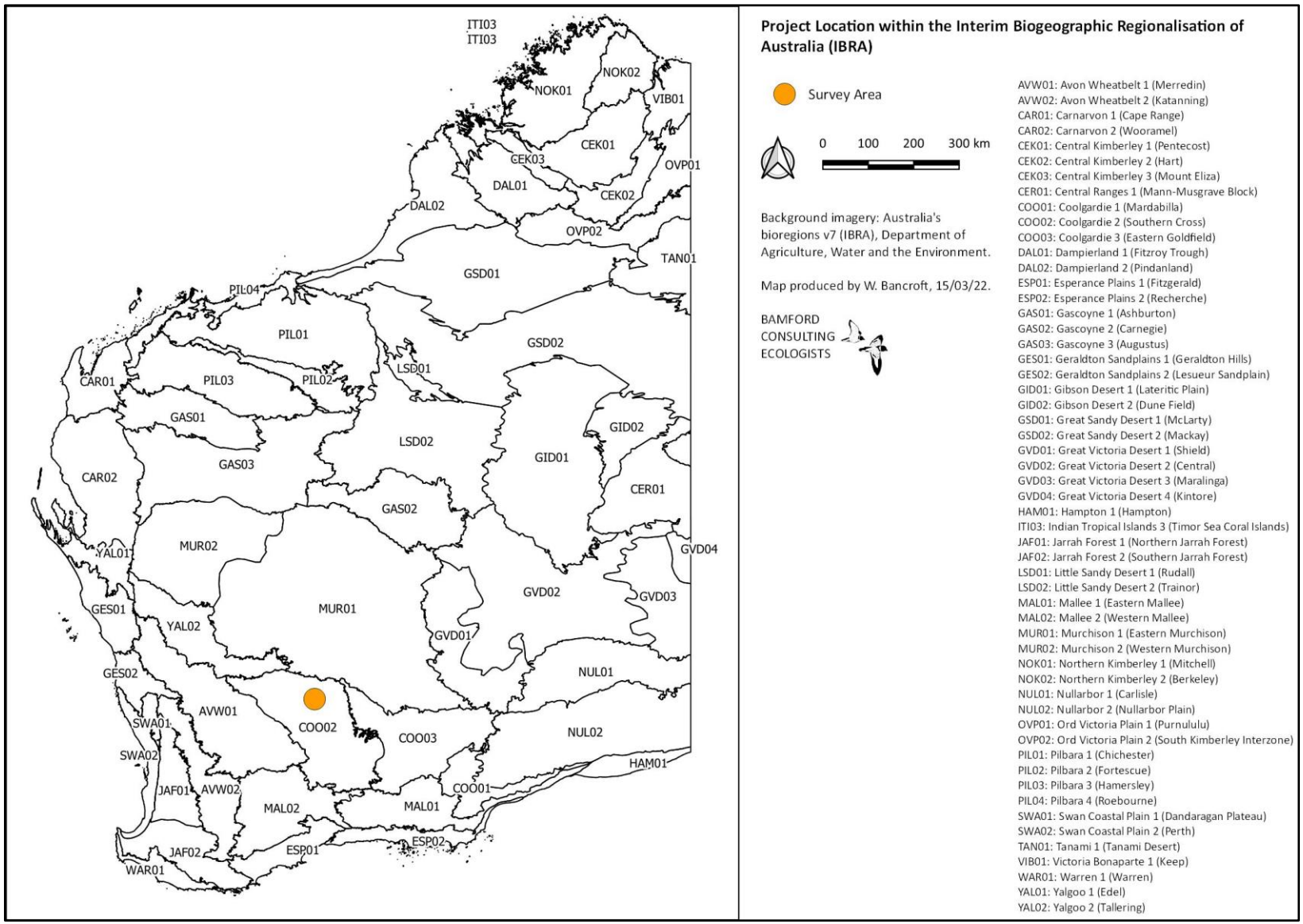

Figure 3. Project location within the Interim Biogeographic Regionalisation of Australia (IBRA).

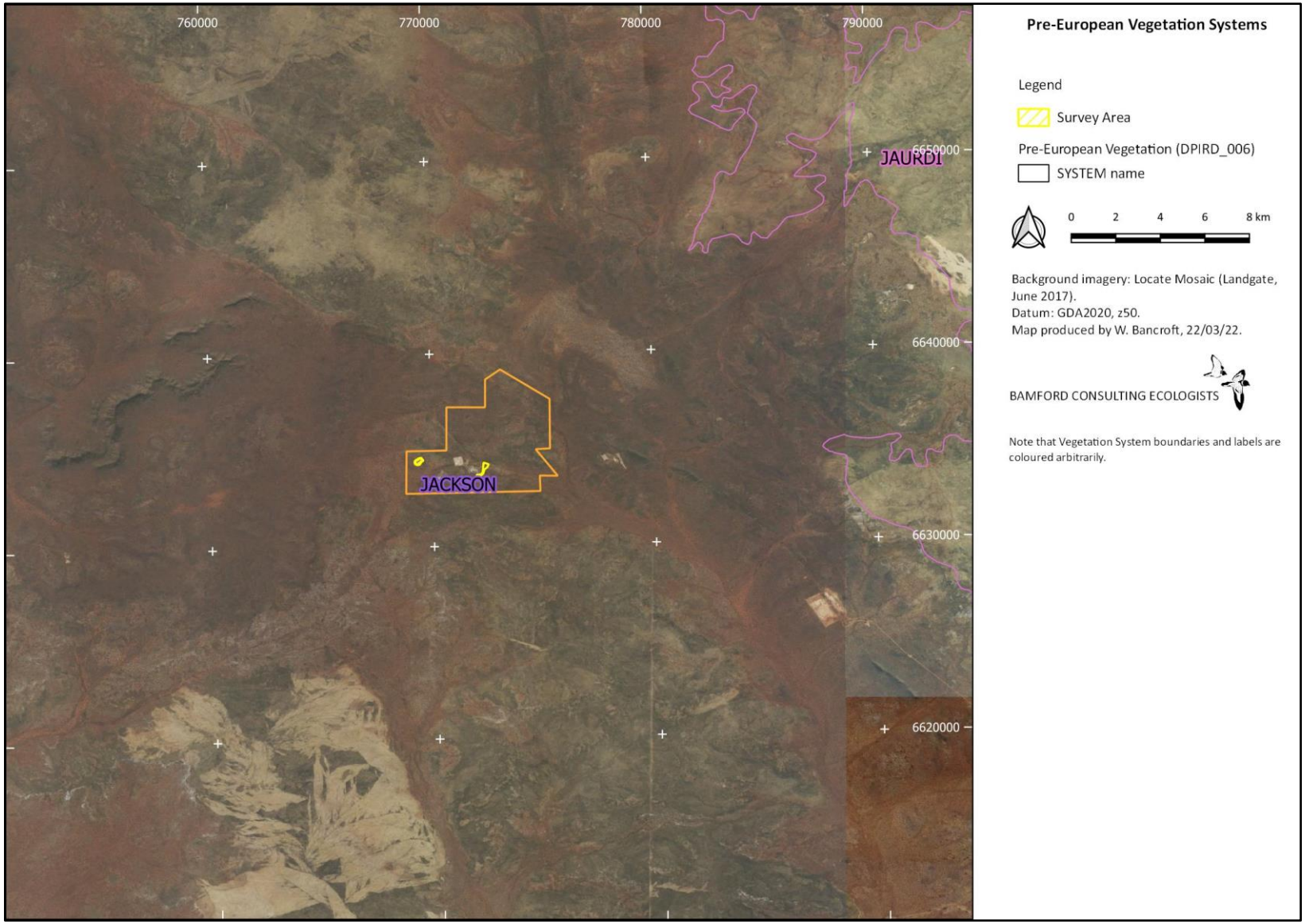

Figure 4. Beard's pre-European vegetation complexes (DPIRD 2022a) in the vicinity of the survey areas.

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, including review against the NVCP clearing principles and DAWE Guidance 1.2.

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 **Error! Reference source not found.**) 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 and Figure 2.

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 survey areas was drawn from a range of sources including databases (as listed in Table 3) and reports from other fauna surveys in the region (as listed in Table 4). Information from these sources was supplemented with species expected in the area based on general patterns of distribution. Sources of information used for these general patterns are listed in Table 5.

2.3.2 Previous fauna surveys

Bamford Consulting Ecologists has undertaken multiple previous fauna investigations in the region of the current study area (Table 4). 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 3. Databases searched for the desktop review; accessed January 2022.

Database	Type of records held in database	Area searched
BCE Database	Fauna recorded by BCE in the vicinity of the survey areas.	25 km buffer around the centroid of the survey areas (771550E, 6634064N; or 30.395° S, 119.826° 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 survey areas (771550E, 6634064N; or 30.395° S, 119.826° E).
NatureMap (DBCA 2022c)	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 survey areas (771550E, 6634064N; or 30.395° S, 119.826° E).
EPBC Protected Matters Search Tool (DAWE 2022e)	Records on MNES protected under the EPBC Act.	25 km buffer around the centroid of the survey areas (771550E, 6634064N; or 30.395° S, 119.826° 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 survey areas (771550E, 6634064N; or 30.395° S, 119.826° E).

Table 4. Literature sources for the desktop review.

Author	Title
Bamford and Turpin (2007)	Portman Iron Ore. Fauna assessment of the Koolyanobbing area.
Bamford and Basnett (2012)	Polaris Metals Pty Ltd Carina Iron Ore Fauna Assessment for Carina Extended, Carina North and Chamaeleon Project Areas.
Bamford (2016)	Tellus Holdings Limited Sandy Ridge Project Malleefowl Assessment, January 2016.
Metcalf *et al.* (2016)	Golden Iron Resources Ltd: Fauna Assessment of Mount Dimer Project Area.
Bamford Consulting Ecologists (2021a)	Malleefowl investigations for Aurumin in the Mt Dimer area (January 2021). Unpubl. Report to Aurumin by Bamford Consulting Ecologists, Kingsley.
Bamford Consulting Ecologists (2021b)	Malleefowl investigations for Aurumin in the Mt Dimer area (May 2021). Unpubl. Report to Aurumin by Bamford Consulting Ecologists, Kingsley.

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

Taxa	Sources
Fish	Morgan *et al.* (1998), Allen *et al.* (2003), Morgan *et al.* (2014), DoF (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 survey 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 survey areas. This involved looking around as much of the survey areas 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 survey areas were visited on the 20th and 21st February 2022.

2.4.3 Malleefowl survey

The entirety of each survey area was surveyed for Malleefowl nest mounds by foot, with the tracks of these surveys indicated in Figure 8 (Survey Area A) and Figure 9 (Survey Area B).

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)*	25 years	+	+
Dr Mike Bamford *BSc (Biology), Hons (Biology), PhD (Biology)*	40+ years		+
Mr Andy McCreery *BSc (Wildlife and Conservation Biology)*	15 years	+	
Mrs Sarah Smith *BSc (Biology)*	30 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 **Error! Reference source not found.**. 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 **Error! Reference source not found.**). 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 survey areas. 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 (**Error! Reference source not found.**). 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 (**Error! Reference source not found.**), 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 of 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 survey areas are a complex mosaic, largely reflecting soil types. A previous assessment of VSAs in the broader project area was made by (Metcalf *et al.* 2016). From this, and observations made during the field investigations here, four major vegetation and substrate associations (VSAs) were identified in relation to fauna in the survey areas:

VSA 1. Acacia shrublands. Open shrublands of Mulga (*Acacia spp.)* over a mixed understorey of shrubs, including *Acacia, Allocasuarina*, *Banksia*, *Eremophila*, *Grevillea* and a range of Myrtaceae, on gravel or gravel/loam. See Plate 1 and Plate 2.

VSA 2. Mallee woodlands on sands. A complex mosaic of open mallee eucalypt woodland over a mixed understorey of shrubs and/or spinifex on sands, or sandy loams. See Plate 3 and Plate 4.

VSA 3. Eucalypt woodlands on loams. Woodland of Salmon Gum (*Eucalyptus salmonophloia*) and Gimlet (*E. salubris*) with sparse shrubs on loams. See Plate 5.

VSA 4. Disturbed or cleared areas. Cleared or largely disturbed areas (e.g. roads, or where mining or exploration has taken place). See Plate 6.

The extent of the VSAs in the survey areas are mapped in Figure 5 (for the Survey Area A) and Figure 6 (for the Survey Area B).

Plate 1. VSA 1: Acacia shrublands. Survey Area A.

Plate 2. VSA 1: Acacia shrublands. Survey Area B.

Plate 3. VSA 2: Mallee woodlands on sands. Survey Area A.

Plate 4. VSA 2: Mallee woodlands on sands. Survey Area B.

Plate 5. VSA 3: Eucalypt woodlands on loams. Survey Area B.

Plate 6. VSA 4: Disturbed or cleared areas. Survey Area B.

Figure 5. The distribution of VSAs in Survey Area A: the site of the proposed Karli West Waste Rock Dump remediation works.

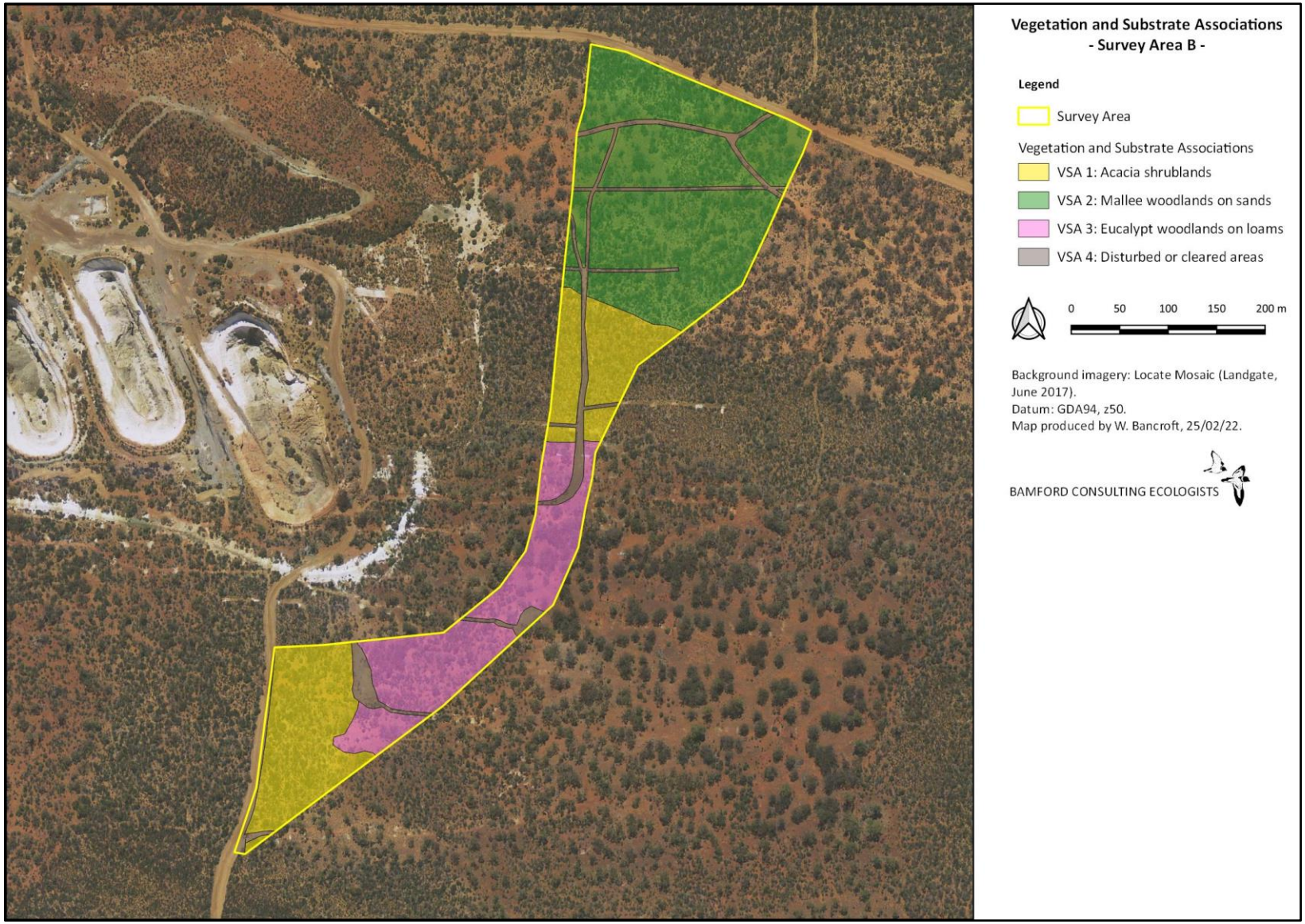

Figure 6. The distribution of VSAs in Survey Area B: the site of the proposed airport access road realignment.

3.1.1 Regional development

The survey areas are located within an almost completely natural landscape with some minor developments for mining. Figure 7 illustrates the existing extent of vegetation and development in a 15 km buffer around the survey areas. Existing developments (c. 129 ha) impact c. 0.2% of the total land area within this buffer (c. 70,686 ha).

The proposed Survey Area A (Karli West Waste Rock Dump remediation) has a total area of c. 3.51 ha, of which at c. 0.09 ha has been cleared (VSA 4, see above). Therefore, up to an additional 3.42 ha may be impacted and this would, at most, contribute 0.005% to the land clearing within the region, taking the total developments in the region to c. 0.205% of the area. It should be noted that the development footprint (see Section 2.1.1) within Survey Area A may be less than this figure.

The proposed Survey Area B (airport access road realignment) has a total area of c. 10.33 ha, of which at c. 0.84 ha has been cleared (VSA 4, see above). Therefore, up to an additional 9.49 ha may be impacted and this would, at most, contribute 0.01% to the land clearing within the region, taking the total developments in the region to c. 0.21% of the area. It should be noted that the development footprint (see Section 2.1.1) within Survey Area A is likely to be less than this figure.

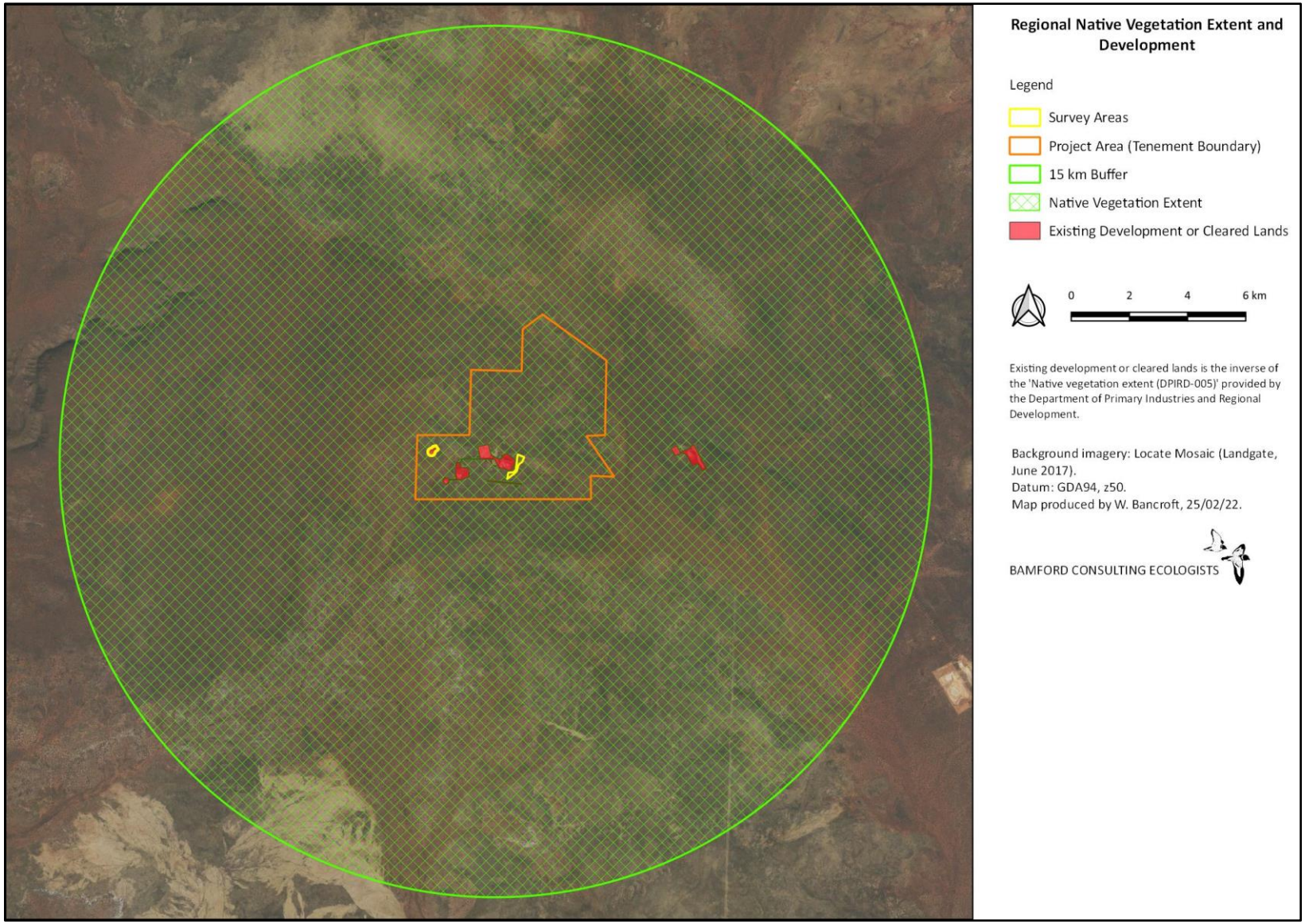

Figure 7. Estimated existing native vegetation and development within the region (15 km).

3.2 Fauna assemblage

3.2.1 Overview of vertebrate fauna assemblage

The desktop study identified 255 vertebrate fauna species as potentially occurring in one or both of the survey areas: no fish, four frogs, 75 reptiles, 143 birds and 33 mammals. These species are listed in Appendix 5. The presence of at least 43 species (two reptiles, 36 birds and five mammals) was confirmed during the 2022 site inspection (as presented in Appendix 6, but also indicated in Appendix 5). Note that Metcalf *et al.* (2016) listed 13 mammal species as extinct in the region; because of their status these are not considered in this report.

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

Table 9. Composition of vertebrate fauna assemblage of the survey areas.

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

Taxon	Expected Species	Recorded Species (2022)	Number of species in each status category			
			Resident	Migrant or regular visitor	Irregular visitor	Vagrant
Fish	0	0	0	0	0	0
Frogs	4	0	4	0	0	0
Reptiles	75	2	75	0	0	0
Birds	143 (1)	36	73	26	34	10
Mammals	33 (7)	5	29	2	2	0
Total	**255 (8)**	**43**	**181**	**28**	**36**	**10**

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 four frog species are all considered to be residents in the vicinity of the survey areas. These species spend much, or all, of their life cycle away from wetlands/damplands and may be wide-ranging through woodlands. These species are typically able to aestivate through dry periods, emerging when seasonal rains fall to breed. There are no introduced species of frog expected.

The 75 reptile species are all considered to be residents in the region. There are no introduced species of reptiles expected.

About half (74 of 143 species) of the bird assemblage are expected to be resident in the vicinity of the survey areas, with a further 26 expected to be regular visitors or migrants. Many of these non-resident species will pass through the area, and even reside temporarily, when suitable seasonal conditions prevail (e.g. rainfall or flowering events). A further 32 are expected to be irregular visitors and there are five vagrant species. There is one introduced species of bird expected to occur within the survey areas (Laughing Kookaburra). The expected bird assemblage lacks a number of wetland- or dampland-dependent species (due to the absence of these habitats within the immediate area).

Almost all of the 33 mammal species are considered to be residents (29), with two (the Dog and Dingo) expected to be irregular visitors to the area. A large proportion of the original indigenous local mammal fauna has become extinct. There are seven introduced species of mammal expected to occur within the survey areas including three feral predators, and the House Mouse, Rabbit and Camel.

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

- **Uniqueness:** The fauna assemblage is probably typical of the eucalypt woodlands and Acacia shrublands of the wider region. This assemblage is very well-represented due to considerable and continuous native vegetation in the region. The survey sites are located in the north west of the 16 million hectare Great Western Woodlands that extends from the Western Australian Wheatbelt to the Nullarbor. It is also in a biogeographic interzone between the temperate south-west and the arid interior, resulting in a number of different habitat types converging in the one area. Therefore, the fauna assemblage has elements of both zones. In addition, the survey areas lie in a land system of rocky hills and clay to loam soils that support eucalypt woodlands and mixed shrublands, whereas 10 km to the east lie the heaths and scrub-heaths of the Boorabin sandplains. There is, thus, potential for some fauna species more typical of the sandplain environment to be present in the vicinity of the survey areas.
- **Completeness:** The assemblage is likely to be substantially complete except for waterbirds (due to the absence of suitable habitat) and the mammal component, which is depauperate in both medium-sized and small ("critical weight range") species.
- **Richness:** The assemblage can be described as only moderately rich in a regional sense. This is partly because of the loss of some mammal species, but in addition the nearby sandplain heaths are likely to be richer in reptiles and possibly small mammals, although possibly less so for birds.

3.2.3 Invertebrate fauna of conservation significance

The survey areas sit within DBCA's Goldfields management region (DBCA 2022a). DBCA (2022e) listed 11 threatened or priority invertebrate fauna in this region, as outlined in Appendix 7. At least eight of these species can be immediately ruled out from occurring within the survey areas and the reasons for exclusion are presented in Appendix 7. (e.g. wholly or locally extinct, absence of suitable habitat in the survey areas, distance from known populations). To help ascertain the status of the remaining three species, relevant literature, databases (e.g. ALA 2022; WAM 2022) and previous reports (e.g. Metcalf *et al.* 2016) from the area were consulted and interpreted in light of the field investigations conducted as part of this assessment.

One priority invertebrate species is known from within the survey areas:

(i) Tree-Stem Trapdoor Spider (*Idiosoma castellum*[1]) – listed as Priority 4 by DBCA, the Tree-stem Trapdoor Spider occurs in the southern mid-west, northern and central wheatbelt and south-western goldfields regions of Western Australia. Based on Bamford Consulting records, the Mt Dimer area is the eastern extent of its range. It builds a palisade burrow against the stems of bushes and small trees (hence its common name of Tree-stem Trapdoor Spider), with a radiating 'moustache' of twig-lines around the entrance (Main 1986; Rix *et al.* 2017). Previously recorded in the project area by Metcalf *et al.* (2016), active burrows of this species were recorded during the February 2022 site inspection in the Survey Area B and an inactive (old) burrow was recorded in Survey Area A.

An assessment of the expected occurrence of the remaining two species follows:

(ii) Coolgardie Shield-backed Trapdoor Spider (*Idiosoma intermedium*) – listed as Priority 4 by DBCA, the Coolgardie Shield-backed Trapdoor Spider has a relatively widespread albeit poorly defined distribution in the eastern Wheatbelt and north-western Coolgardie bioregions of south-western Western Australia (Rix *et al.* 2018). Rix *et al.* (2018) state that its known range extends from "Bodallin north to Billiburning Rock in the eastern Wheatbelt, and east to near the Helena-Aurora Range, Mount Manning, and Koolyanobbing in the Coolgardie bioregion". Little is known of this species' ecology (Rix *et al.* 2018). It is probable that the Coolgardie Shield-backed Trapdoor Spider occurs in the vicinity of the survey areas.

(iii) Arid Bronze Azure Butterfly (*Ogyris subterrestris petrina*) – listed as critically endangered under the Commonwealth EPBC Act and as Schedule 1 (critically endangered) under the Western Australian BC Act, the Arid Bronze Azure Butterfly has a severely fragmented distribution with only two extant subpopulations (DBCA 2020b). These subpopulations are at Barbalin Nature Reserve, between the towns of Bencubbin and Mukinbudin in the Western Australia Wheatbelt, and also and at a second site c. 100km from Barbalin (the precise location is withheld for conservation reasons). A third subpopulation (the first discovered, in the 1980s) occurred near Lake Douglas, 12 km SW of Kalgoorlie, but is now locally extinct (DBCA 2020b). The Arid Bronze Azure Butterfly has an obligate association with a sugar ant *Camponotus* sp. nr. *Terebrans*, with the butterfly larvae living entirely within the ant's nest during their development (DBCA 2020b). The most critical factor for habitat occupancy by the butterfly is the presence of large colonies of the host ant (DBCA 2020b). While the survey areas fall within the areas mapped as 'potential habitat' by DBCA (2020b), no *Camponotus* ant colonies were noted during the site inspection. It is, therefore, uncertain as to the presence

[1] Previously known as *Aganippe casteullum*, the taxonomy of this species was revised by Rix *et al*. (2017).

of this species in the survey areas but it is considered likely to be absent. Should it be required, further information and survey methodology for this species are provided by DBCA (2020a, b).

Therefore, it is considered that two known invertebrate species of conservation significance are known, or most likely to occur, in the vicinity of the survey areas:

- Tree-Stem Trapdoor Spider – CS2 (P4)
- Coolgardie Shield-backed Trapdoor Spider – CS2 (P4)

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

3.2.4 Vertebrate fauna of conservation significance

Of the 255 species of vertebrate fauna that are expected to occur in the survey areas (Section 3.2.1 above), 27 are considered to be of conservation significance (nine CS1, four CS2 and 14 CS3; see Appendix 1 for descriptions of these CS (conservation significance) levels). A summary of the numbers in each vertebrate class is presented in **Error! Reference source not found.**. These species of conservation significance are indicated in the complete species list (Appendix 5) but are also listed with details of their conservation significance in Table 11. More than half of conservation significant species are expected as residents or regular visitors/migrants visitors (16 species), with some irregular visitors (nine species) or vagrants (two 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	0	1	**1**
Birds	8	2	13	**23**
Mammals	1	2	0	**3**
Total	**9**	**4**	**14**	**27**

Table 11. Conservation significant fauna species expected to occur within the survey areas.

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
Leipoa ocellata	Malleefowl	CS1 (V,S3)	Resident
Apus pacificus	Fork-tailed Swift	CS1 (M,Mar,S5)	Irregular visitor
Burhinus grallarius	Bush Stone-curlew	CS3 (LS)	Irregular visitor
Ardeotis australis	Australian Bustard	CS3 (LS)	Vagrant
Thinornis rubricollis	Hooded Plover	CS2 (Mar,P4)	Irregular visitor

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE
Calidris acuminata	Sharp-tailed Sandpiper	CS1 (M,Mar,S5)	Irregular visitor
Callidris ferruginea	Curlew Sandpiper	CS1 (C,M,Mar,S3,S5)	Irregular visitor
Calidris melanotus	Pectoral Sandpiper	CS1 (M,Mar,S5)	Irregular visitor
Actitis hypoleucos	Common Sandpiper	CS1 (M,Mar,S5)	Irregular visitor
Lophoictinia isura	Square-tailed Kite	CS3 (LS)	Regular migrant
Falco hypoleucos	Grey Falcon	CS1 (S3)	Vagrant
Falco peregrinus	Peregrine Falcon	CS1 (S7)	Regular visitor
Cacatua leadbeateri	Major Mitchell's Cockatoo	CS3 (LS)	Regular visitor
Platycercus icterotis xanthogenys	Western Rosella (inland)	CS2 (P4)	Resident
Climacteris rufus	Rufous Treecreeper	CS3 (LS)	Resident
Malurus pulcherrimus	Blue-breasted Fairy-wren	CS3 (LS)	Resident
Calamanthus cautus	Shy Heathwren	CS3 (LS)	Irregular visitor
Pyrrholaemus brunneus	Redthroat	CS3 (LS)	Resident
Pomatostomus superciliosus	White-browed Babbler	CS3 (LS)	Resident
Oreoica gutturalis	Crested Bellbird	CS3 (LS)	Resident
Pachycephala inornata	Gilbert's Whistler	CS3 (LS)	Irregular visitor
Eopsaltria griseogularis	Western Yellow Robin	CS3 (LS)	Resident
Drymodes brunneopygia	Southern Scrub-robin	CS3 (LS)	Resident
Dasyurus geoffroii	Chuditch	CS1 (V,S3)	Regular visitor
Pseudomys occidentalis	Western Mouse	CS2 (P4)	Regular visitor
Nyctophilus major tor	Central Long-eared Bat	CS2 (P4)	Resident
Idiosoma castellum	Tree-stem Trapdoor Spider	CS2 (P4)	Resident
Idiosoma intermedium	Coolgardie Shield-backed Trapdoor Spider	CS2 (P4)	Resident (if present)

3.2.5 Conservation significant species accounts

A list of all conservation significant species expected within the survey areas is provided in Table 11; these comprise two invertebrates (see also Section 3.2.3) and 27 vertebrates (see also Section 3.2.4). Information on the conservation status, distribution and habitat, salient ecology and expected occurrence within the survey areas is provided for each of these species is below (and, for invertebrates, in Section **Error! Reference source not found.**).

3.2.5.1 Conservation Significance 1

Malleefowl (*Leipoa ocellata*) CS1 (V,S3)

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

Distribution and habitat: The Malleefowl lives within scrubland and woodland dominated by mallee eucalypts and wattle species (Burbidge 2004; DotE 2019; DAWE 2022d). The species is distributed throughout the southern third of Australia in suitable, predominantly inland, semi-arid habitats (Menkhorst *et al.* 2017).

Ecology: A diurnal, ground-foraging and usually solitary omnivore, the Malleefowl has a preference for long-unburnt sites (Benshemesh 2007). Although not flightless, this species spends the vast majority of its time on the ground. In the breeding season, males construct large nest mounds out of soil and vegetation into which their female mates lay eggs (DAWE 2022d). The males tend the nests during the incubation period, where they adjust mound height and composition to control the internal temperature and, hence, egg development (Benshemesh 2007; DAWE 2022d). No parental care is provided to emergent fledgelings. Major threatening processes for this species include habitat loss, fragmentation, grazing, fire and predation by Foxes (Burbidge 2004; Benshemesh 2007).

Expected occurrence: Resident. Malleefowl have been previously recorded in the vicinity and there is a number of known nest mounds nearby, although none were located in the survey areas during the site inspection.

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: Irregular visitor. Likely to be present, unpredictably, within the region and to pass over the survey areas on an occasional basis.

Migratory waders (4 species; see Table 11) CS1 (M, S5 [C, S3])

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

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

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

Expected occurrence: Irregular visitors. These species may occur sporadically in the region in areas of suitable habitat (wetlands) that may be ephemeral. They will make use of temporary pools and water bodies such as tailings dams.

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

Conservation status: Schedule 3 under the BC Act.

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

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

Expected occurrence: Vagrant. The project area is outside the accepted range of the species (Garnett and Baker 2021).

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 survey areas on a regular basis. The project may be within the foraging range of a breeding pair.

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 2022c).

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: Regular visitor. Wide-ranging and likely to be present near to and within the survey areas.

3.2.5.2 Conservation Significance 2

Hooded Plover (*Thinornis cucullatus*) CS2 (P4)

Conservation status: Listed as Priority 4 by DBCA.

Distribution and habitat: Coastal and near-coastal areas of the southern states of Australia, although extends well inland in Western Australia to salt lakes through the Wheatbelt and southern Goldfields (Johnstone and Storr 1998; Singor 2009; Menkhorst *et al.* 2017). In south-west Western Australian, the Hooded Plover inhabits beaches, and the margins of estuaries and salt lakes from Kalbarri to Eyre, and inland to the vicinity of Paynes Find, Kambalda, and Norseman (Johnstone and Storr 1998; TSSC 2014).

Ecology: Forages diurnally for aquatic invertebrates from wetland substrates (Johnstone and Storr 1998). Occurs singly, in pairs, family groups or flocks. Nomadic and forms flocks of hundreds on inland lakes in the early breeding season and may form very large non-breeding flocks on near-coastal salt-lakes, dependent on rainfall and wetland availability (TSSC 2014). It appears to move towards the coast in summer (TSSC 2014). Human disturbance to nesting (especially on beaches) and nest predation by invasive species such as cats, foxes, dogs and rats (TSSC 2014).

Expected occurrence: Irregular visitor. Hooded plover may utilise salt lakes within the broader region but it highly unlikely that they will occur within the survey areas. A slight potential birds would visit tailings dams or similar shallow water bodies created during mining.

Western Rosella (inland) (*Platycercus icterotis xanthogenys*) CS2 (P4)

Conservation status: Listed as Priority 4 by DBCA.

Distribution and habitat: Occurs in drier woodland with heath understory in the Wheatbelt region of Western Australia (Johnstone and Storr 1998; Cork 2020). The Western Rosella (inland) was formerly widely distributed throughout the wheatbelt region but now, because of clearing for agriculture, only occurs where natural ecosystems are heavily fragmented, disturbed and, generally, in very poor condition (EA 2000).

Ecology: A diurnal ground and tree-foraging granivore, this species generally occurs singly, in pairs or small parties (Johnstone and Storr 1998; Menkhorst *et al.* 2017).

Expected occurrence: Irregular visitor. If present, this species would be at the very north-eastern limit of its range; the distribution map of Johnstone and Storr (1998) shows its occurrence north to about Southern Cross.

Western Mouse (*Pseudomys occidentalis)* CS2 (P4)

Conservation status: Listed as Priority 4 by DBCA.

Distribution and habitat: Occurs in a number of semi-isolated Wheatbelt conservation reserves, with a preference for long unburnt sites with dense vegetation on sandy clay loam or sandy loam (Lee 1995; Van Dyck and Strahan 2008). Quandong (*Santalum acuminatum*) and sedge species are thought to be important habitat requirements in the northern part of the mouse's range.

Ecology: A nocturnal, semi-arboreal omnivore, with a diet including plant material, flowers, seeds and invertebrates (Van Dyck and Strahan 2008). Lives communally and shelters in burrow systems during the day (Van Dyck and Strahan 2008).

Expected occurrence: Regular visitor. If present, this species would be at the very northern limit of its range.

Central Long-eared Bat (*Nyctophilus major tor*) CS2 (P4)

Conservation status: Listed as Priority 4 by DBCA.

Distribution and habitat: Throughout southern Western Australia, east to the Eyre Peninsula in South Australia, with the exception of the south-western corner of Western Australia, where this subspecies is replaced by *N. m. major* (Parnaby 2009). Possibly occurs as far north the Hammersley Ranges . This species probably also does not extend into the Nullarbor Plain (Churchill 2009). Occurs in 'desert habitats' (Churchill 2009), including shrublands, grassland and eucalypt woodlands.

Ecology: A nocturnal, aerial insectivore (Churchill 2009; Parnaby 2009). Shelters during the day in tree cavities, under bark and within foliage (Churchill 2009).

Expected occurrence: Resident. The echolocation call of a *Nyctophilus* species was recorded in June 2016 (Metcalf *et al.* 2016), however it could only be identified to genus level.

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 2022e). 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: Resident. Seen in 2012 during the Carina survey only a few kilometres east of Mt Dimer (Bamford and Basnett 2012).

Bush Stone-curlew (*Burhinus grallarius*) and Australian Bustard (*Ardeotis australis*) CS3 (LS)

Conservation status: Both species have experienced historic declines across southern Australia, associated with habitat loss and impacts from introduced species (e.g. predation from foxes and feral cats).

Distribution and habitat: The Bush Stone-curlew occurs throughout Australia, with the exception of the central desert areas (Menkhorst *et al.* 2017). The Australian Bustard occurs throughout Australia, west of the Great Dividing Range (Menkhorst *et al.* 2017). The stone-curlew occurs in grassy woodlands and open forests, and the bustard generally prefers more open country, including grasslands, sandplains and open woodland (Johnstone and Storr 1998; Menkhorst *et al.* 2017).

Ecology: Both species are ground-dwelling, with the stone-curlew predominantly nocturnal and the bustard diurnal (Johnstone and Storr 1998; Menkhorst *et al.* 2017). The stone-curlew is largely an insectivore, with the bustard omnivorous and foraging on small animals, seeds, leaves and fruits (Johnstone and Storr 1998; Menkhorst *et al.* 2017).

Expected occurrence: Irregular visitor or vagrant.

Square-tailed Kite (*Lophoictinia isura*), Rufous Treecreeper (*Climacteris rufus*), Blue-breasted Fairy-wren (*Malurus pulcherrimus*), Shy Heathwren (*Calamanthus cautus*), Redthroat (*Pyrrholaemus brunneus*), White-browed Babbler (*Pomatostomus superciliosus*), Crested Bellbird (*Oreoica gutturalis*), Gilbert's Whistler (*Pachycephala inornata*), Western Yellow Robin (*Eopsaltria griseogularis*) and Southern Scrub-robin (*Drymodes brunneopygia*). CS3 (LS)

Conservation status: All ten of these CS3 species have experienced declines in their south-western populations. Their declines vary in rate and extent, but all are associated with a loss of habitat associated with broad-scale clearing for agriculture in the wheatbelt.

Distribution and habitat: Generally, semi-arid woodlands, shrublands and heathlands in south-western Australia.

Ecology: Most species are insectivorous.

Expected occurrence: Residents or regular visitors.

Major Mitchell's Cockatoo (*Cacatua leadbeateri mollis*) CS3 (LS)

Conservation status: Considered locally significant even though not listed as it has declined across the Wheatbelt. The western sub-species (*C. leadbeateri mollis)* would appear to be subject to the same threats as the eastern sub-species (*C. leadbeateri leadbeateri*) which is listed as Endangered by Garnett and Baker (2021).

Distribution and habitat: Uncommon and patchily distributed throughout inland Australia (Menkhorst *et al.* 2017). In Western Australia it occurs in a number of disjunct populations including: southern Kimberley area; around Warburton; southern Great Victoria Desert; southern coast from Eyre to Eucla; in the vicinity of the Murchison River; and the north-eastern Wheatbelt/western Goldfields area (Johnstone and Storr 1998). It prefers arid and semi-arid woodlands (Johnstone and Storr 1998; Menkhorst *et al.* 2017).

Ecology: A diurnal granivore, it feeds on the ground and in trees (Johnstone and Storr 1998; Menkhorst *et al.* 2017). Breeds in eucalypt tree hollows, with (Johnstone and Storr 1998) suggesting a preference for River Red Gums (*Eucalyptus camaldulensis*) and salmon gums (*E. salmonophloia*).

Expected occurrence: Regular visitor. This species is regularly seen in the Koolyanobbing area and around Bullfinch to the west (BCE records), and was recorded at Carina by Ninox (2009). It was recorded along the Mount Walton Road during the February 2022 site inspection.

3.3 Field investigations

The survey areas were inspected in February 2022 to check for the presences, evidence or suitable habitat of significant fauna. Particular focus was targeted to assessing the presence of Malleefowl and Tree-stem Trapdoor Spiders in the survey areas.

No Malleefowl mounds, or evidence of Malleefowl, were detected in either survey area. A map of survey effort (tracks) is provided for Survey Area A in Figure 8, and for Survey Area B in Figure 9.

Several trapdoor spider burrows were located within, or near to, the survey areas, as shown in Figure 8 (Survey Area A) and Figure 9 (Survey Area B). This included two active Tree-stem Trapdoor Spider burrows in Survey Area B. Burrow locations are provided in Appendix 8. Example photographs of Tree-stem Trapdoor Spider burrows are provided in Plate 7 and Plate 8, and of an unidentified *Idiosoma* species in Plate 9.

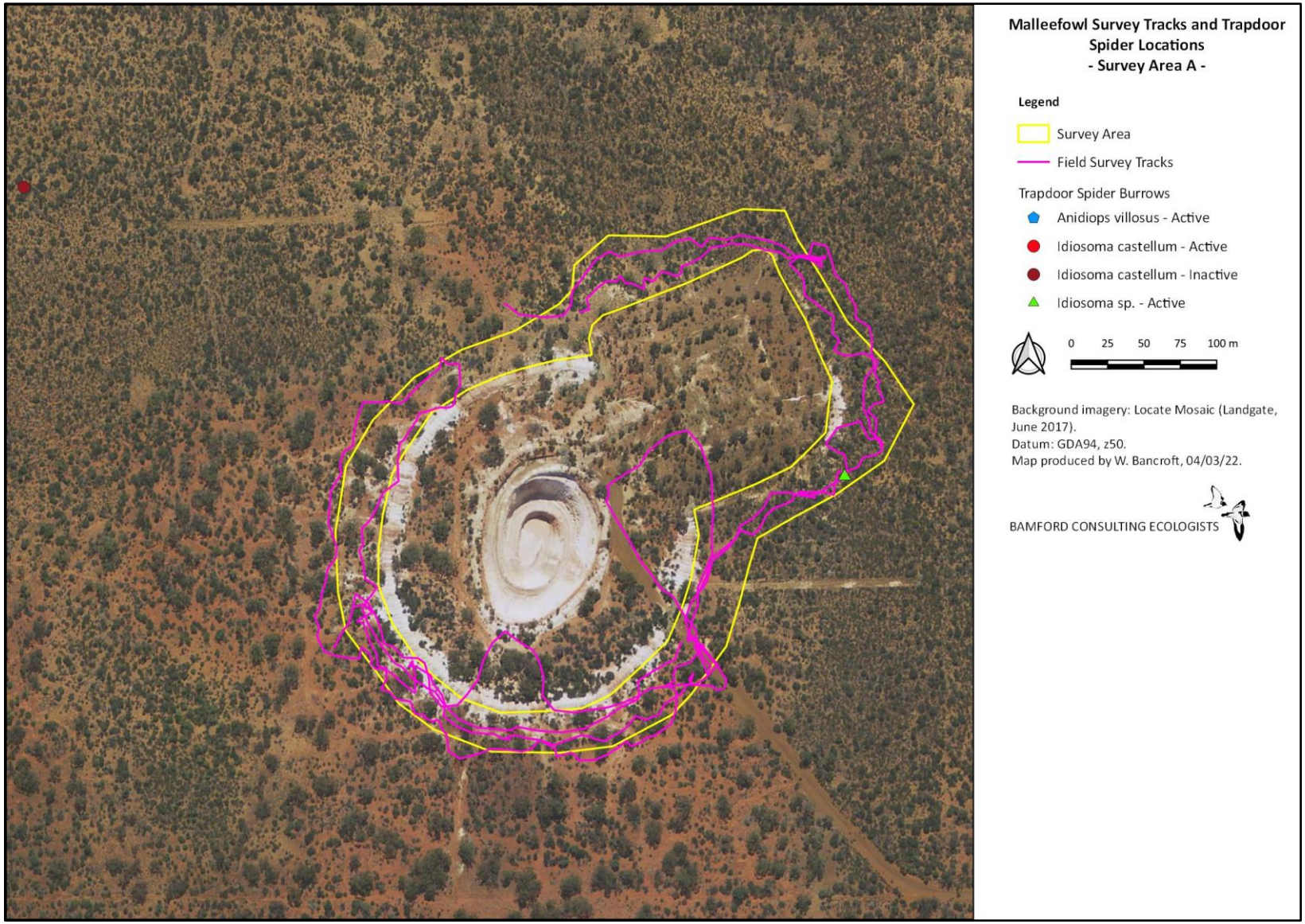

Figure 8. Location of Malleefowl survey tracks and trapdoor spiders within Survey Area A (Karli West Waste Rock Dump remediation).

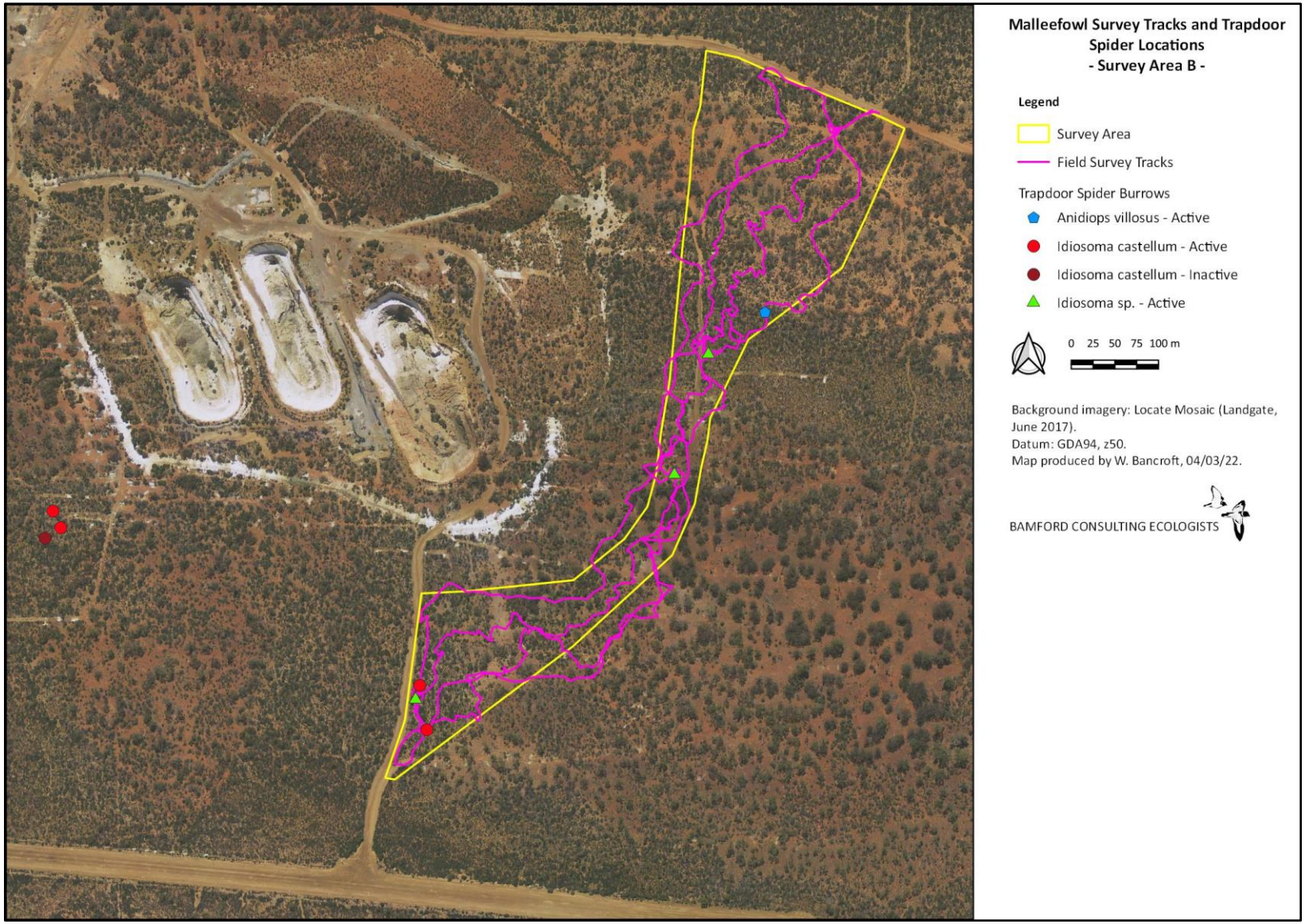

Figure 9. Location of Malleefowl survey tracks and trapdoor spiders within Survey Area B (airport access road realignment).

Plate 7. An example of a Tree-stem Trapdoor Spider burrow.

Left - door closed, Right – door open. Burrow lumen c. 15 mm.

Plate 8. An example of a Tree-stem Trapdoor Spider burrow.

Left - door closed, Right – door open. Burrow lumen c. 25 mm.

Plate 9. An example of an unidentified *Idiosoma* burrow.

Left - door closed, Right – door open. Burrow lumen c. 20 mm.

3.4 Patterns of biodiversity

Investigating patterns of biodiversity can be complex and are often beyond the scope even of detailed or targeted investigations, but it is possible to draw some general conclusions based upon the different landscapes in the survey areas. The three intact native VSAs (VSA 1 – Acacia shrublands; VSA 2 – Mallee woodlands on sands; and VSA 3 – Eucalypt woodlands on loams) can be expected to be much richer in species than the disturbed or cleared areas (VSA 4).

Differences in the fauna assemblage between the two woodland VSAs might be slight, as they contain many of the same plant species and have broadly similar substrates. It is probable that species dependent upon large eucalypts, such as birds that forage in the canopy and species that shelter in large hollows, may be more abundant in VSA 3 than VSA 2. Understorey plant species were less dense in VSA 3 than VSA 2 so this may reduce the occurrence of cover-dependent species in VSA 3 (e.g. wrens, some reptiles).

The contrasting substrate (gravel, in place of sand and/or loam) and vegetation structure (lower overstorey, more dense understorey) of VSA 1 may drive difference in fauna identity but not necessarily overall diversity. It was noted during the field investigations that potential SRE trapdoor spiders (e.g. Tree-stem Trapdoor Spider and *Idiosoma* sp.) were more commonly encountered in VSA1.

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.

Local hydrology. Interruptions of hydro-ecological processes can have massive effects because they underpin primary production in ecosystems and there are specific, generally rare habitats that are hydrology-dependent. A range of drainage types occur throughout the survey areas; some of the VSA 3 (Eucalypt woodlands on loams) areas appear to be drained by sheetflow, which is easily disturbed by earthworks. Roads and mining may alter both surface and sub-surface hydrology.

Fire. There was no evidence of fire affecting native vegetation at the time of the survey. Fire is however recognised as a factor in the dynamics of fauna populations in the south-west of Western Australia (Bamford and Roberts 2003); 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). There are a number of areas with thick vegetation which would be particularly prone to fire. 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.

Feral predators and interactions with over-abundant native species. Feral predators are a major factor in the decline and local extinction of some mammal and bird species (Burbidge and McKenzie 1989), and there is growing evidence that over-abundant native species can adversely affect biodiversity (e.g. Harrington 2002). The increase in the abundance of Galahs and Corellas across the Wheatbelt may

have contributed to the decline of some other cockatoo species (Saunders and Ingram 1995). The fauna assemblage of the survey areas has already been impacted by feral species (loss of a major component of the mammal fauna), and several feral species are present.

Habitat degradation due to weed invasion. Native vegetation is largely intact with very low levels of weed invasion in the survey areas.

Connectivity and landscape permeability. The survey areas lie within an undisturbed landscape and has no obvious restrictions to landscape permeability.

3.6 Summary of fauna values

The desktop study identified 255 vertebrate fauna species as potentially occurring in one or both of the survey areas: no fish, four frogs, 75 reptiles, 143 birds and 33 mammals. The presence of at least 43 species (two reptiles, 36 birds and five mammals) was confirmed during the 2022 site inspection.

Fauna assemblage. Moderately rich and substantially intact except for the loss of a suite of medium-size mammal species and the absence of waterbirds (because of an absence of suitable habitat). Distinctive in that it contains elements from both Eremean (arid) and Bassian (Mediterranean) regions, including species that have declined or disappeared from the adjacent Wheatbelt. Assemblage may contain some elements of the sandplain fauna assemblage, but generally appears typical of fauna associated with woodlands and shrublands on loam and is probably less rich, at least for reptiles and small mammals, than the assemblage of the nearby sandplains.

Species of conservation significance. The majority of the 29 conservation significant species (including one reptile, 23 birds, three mammals and two invertebrates) expected in the survey areas are likely to be residents or regular visitors/migrants. Only nine of the expected conservation species are listed under WA State and/or Commonwealth legislation (category CS1; eight birds and one mammal), with six listed as Priority by DBCA (category CS2; two birds, two mammals and two invertebrates) and the remaining 14 considered locally significant (category CS3; one reptile and 13 birds). Of most concern are the Malleefowl (CS1, known to be a resident in the broader area but with no evidence of breeding within the survey areas), and the Tree-Stem Trapdoor Spider (CS2, known to occur within the survey areas).

Vegetation and Substrate Associations (VSAs). The survey areas encompass four VSAs which reflect landscape position and soil type: Acacia shrublands (VSA 1), Mallee woodlands on sands (VSA 2), Eucalypt woodlands on loams (VSA 3), and Disturbed or cleared areas (VSA 4). 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 much richer in species than the disturbed or cleared areas. Differences in the fauna assemblage between the two woodland VSAs might be slight, as they contain many of the same plant species and have broadly similar substrates. It is probable that species dependent upon large eucalypts may be more abundant in VSA 3 than VSA 2, and that cover-dependent species are more abundant in VSA 2 than VSA 3. The

contrasting substrate and vegetation structure of VSA 1 may drive difference in fauna identity but not necessarily overall diversity in these areas.

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

4 Impact assessment

Aurumin is proposing to undertake remediation and safety upgrades within its Mount Dimer Gold Project and, as part of the process, is applying for a native vegetation clearing permit (NVCP). The following sections examine possible impacts upon fauna values described in Section 3 with reference specifically to the survey area.

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 in Section 4.1. Landscape context is important, as the survey areas contain areas of previously cleared or disturbed lands and are in a local, and regional, landscape that is relatively continuous and intact. Impact categories are defined in Table 8.

An assessment against the NVCP principles is also presented in Section 4.2.

4.1 Review of threatening processes

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

The areas in which clearing is proposed to be undertaken are small and already partly disturbed. The c. 3.42 ha of native vegetation within Survey Area A (Karli West Waste Rock Dump remediation) represents 0.005% of native vegetation within the region (15 km radius) and would bring the total regional clearing to c. 0.205%. The development footprint within Survey Area A may be less than this figure. The c. 9.49 ha of native vegetation within Survey Area B (airport access road realignment) represents 0.01% of native vegetation within the region (15 km radius) and would bring the total regional clearing to c. 0.21%. The development footprint within Survey Area B is highly likely to be considerably less than this figure. No Malleefowl mounds are likely to be impacted. Population decline due to habitat loss is, therefore, likely to be negligible to minor in impact.

Habitat loss leading to population fragmentation. *Negligible*

The development footprints are expected to be compact and expand on existing developed areas, with native vegetation surrounding. For Survey Area A, the proposed clearing will marginally increase the boundary of an 'island' of disturbed land within the surrounding, continuous native vegetation and is not expected to pose any change to the landscape permeability for fauna. Linear infrastructure (such as roads, rail, pipelines etc.) as proposed for Survey Area B have the potential to pose a barrier to fauna movement but, given the scale of the proposal, and the vast areas of surrounding native vegetation, this is expected to have negligible impact on terrestrial fauna. An access road already exists, in this case, and traffic levels are not anticipated to increase; no net change in the impact to fauna is expected.

Degradation of habitat due to weed invasion. *Negligible to Minor*

Within the survey areas, the level of weed invasion was low in the native vegetation, but some weeds were present in disturbed 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. The extent of impact depends largely upon management and can be considered to be Negligible or Minor if management is adequate.

Mortality during construction. *Negligible to Minor*

This is a concern mostly on animal welfare grounds, as the development footprints are 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.

Ongoing mortality. *Negligible*

This results mainly from roadkill due to vehicle movements close to native vegetation, fauna striking infrastructure and the effects of lighting. There is presently no permanent infrastructure or lighting within either survey area, and none is proposed as part of the planned remediation and/or road realignment. Also, it is expected there will not be any ongoing increase in road traffic.

Species interactions. *Negligible to Minor*

Feral species are already present on the site, but feral species may be temporarily attracted to work-sites and increase in abundance. It is not expected that this will be a sustained effect. Impacts to native fauna can be kept to Negligible or Minor through standard practices such as not feeding wildlife and managing food waste.

Hydrological change. *Negligible*

There is no surface water and activities are not expected 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 survey areas is tolerant of and to some extent dependent on fire, but the fire regime is important. The proposed developments are unlikely to lead to increased fire frequency.

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

The level of dust, noise and light during the proposed works has the potential to result in some impacts, but there are standard management procedures to minimise these. There is not expected to be any long-term increase to these factors, post-construction.

Overall, the effects of impacting processes are considered to be Minor or Negligible; this is mainly due to the small scale of impact, continuous, extensive and fairly uniform environment, and low hydrological sensitivity. Potentially minor impacts that may need to be addressed are:

- Mortality of fauna during construction.
- Weed invasion.
- Possibility of temporary disturbance by dust, noise or light.

4.2 Review of the proposed project against NVCP Principle (b)

Under Schedule 5 of the *Environmental Protection Act (WA) 1986* (EP Act), it is an offence to clear native vegetation unless the clearing is done in accordance with a clearing permit, or an exemption applies (DER 2014). Clearing is not generally permitted where the biodiversity values, land conservation and water protection roles of native vegetation would be significantly adversely impacted. If a clearing permit is required under the EP Act and the proposed clearing will have or is likely to have an impact on a matter of national environmental significance (matter of NES) identified under the EPBC Act, the clearing application may be assessed under the assessment bilateral agreement under the EPBC Act.

As part of the application process for a Native Vegetation Clearing Permit (NVCP), vegetation clearing within the survey areas is required to be assessed in accordance with the ten clearing principles for native vegetation under Schedule 5 of the EP Act (summarised in Table 1). While most of these principles may relate to fauna indirectly, Principle (b) specifically addresses this group. The likely impact of the Aurumin proposal on fauna is discussed below, with regard to Principle (b) as listed in Schedule 5 of the EP Act.

Principle (b) – Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.

Of the 255 vertebrate species expected to occur in the vicinity of the survey areas (see Section 3.2.1), 27 are of conservation significance (see Section 3.2.4). At least two species of conservation significant invertebrate may also occur in the vicinity (see Section 3.2.3). Out of these 29 conservation significant species, 17 are expected to occur regularly within the survey areas (see Section 3.2.4), with the Malleefowl and the Tree-stem Trapdoor Spider expected to be of most concern. The remaining species, if or when present, are likely to occur in very low numbers or density within the survey areas or may only use the areas inconsistently/unpredictably. All regularly expected conservation significant species use habitat that is extensive in the region and well-represented outside of the survey areas.

A Malleefowl survey was conducted in February 2022 and no nest mounds (active or inactive) were located within the survey areas (see Section 3.3). Potential impacts to the Malleefowl were assessed against federal significant impact guidelines (DotE 2013), as shown in Table 12, with the conclusion that no significant impacts are likely to occur.

A survey for Tree-stem Trapdoor Spiders was also conducted in February 2022, with a number of active and inactive burrows located within the survey areas (see Section 3.3). Potential impacts to the Tree-stem Trapdoor Spider were assessed against federal significant impact guidelines (DotE 2013), as shown in Table 13, with the conclusion that no significant impacts are likely to occur.

Therefore, the clearing of vegetation within the two survey areas at Mount Dimer is not likely to impact a significant habitat for fauna indigenous to Western Australia.

Summary: **The proposal is unlikely to be at variance with this Principle.**

Table 12. Malleefowl assessed as per Guidelines 1.1.

Significance Criteria under Guidelines 1.1	Likelihood and rationale
	Malleefowl
Lead to a long-term decrease in the size of a population[2] (or an important population[3]).	**Unlikely to occur.** Malleefowl are known to occur in the broader region but there is no evidence to support breeding within, or regular use of, the survey areas. Clearing within the survey areas is at unlikely to affect individuals, let alone populations. No long-term change is expected.
Reduce the area of occupancy of the species (or an important population).	**Unlikely to occur.** Area of loss of habitat will be negligible relative to the available habitat in the region. The species will still be able to move through the area.
Fragment an existing population (or important population) into two or more populations.	**Unlikely to occur.** This is a mobile species and clearing within the survey areas is not likely to affect its ability to move through the landscape.
Adversely affect habitat critical to the survival of a species[4].	**Unlikely to occur.** No nest mounds (either active or inactive) were located in the survey areas and no other habitat critical to the survival of the species was identified.
Disrupt the breeding cycle of a population (or important population).	**Unlikely to occur.** No loss of active nest mounds (or inactive mounds). It is not expected that any individuals will be affected.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	**Unlikely to occur.** Negligible and localised loss of general habitat. No loss of active breeding habitat (nest mounds).

[2] A 'population of a species' is defined under the EPBC Act as an occurrence of the species in a particular area (includes a geographically distinct regional population, or collection of local populations, or a population, or collection of local populations, that occurs within a particular bioregion). Pertains to endangered and vulnerable species.

[3] An 'important population' is a population that is necessary for a species' long-term survival and recovery (includes populations identified as such in recovery plans, and/or key source populations either for breeding or dispersal, populations that are necessary for maintaining genetic diversity, and/or populations that are near the limit of the species range). Pertains to vulnerable species.

[4] 'Habitat critical to the survival of a species' refers to areas that are necessary: for activities such as foraging, breeding, roosting, or dispersal; for the long-term maintenance of the species; to maintain genetic diversity and long term evolutionary development; or for the reintroduction of populations or recovery of the species or ecological community. Pertains to endangered and vulnerable species.

Significance Criteria under Guidelines 1.1	Likelihood and rationale
	Malleefowl
Result in invasive species that are harmful to a threatened species becoming established in the threatened species' habitat.	**Unlikely to occur.** Feral predators (e.g. cats and foxes) are likely to be present in the region already and the development is unlikely to affect their abundance to a degree that will adversely impact Malleefowl.
Introduce disease that may cause the species to decline.	**Unlikely to occur.** Hygiene management plan will be implemented.
Interfere with the recovery of the species.	**Unlikely to occur.** At most, highly localised impacts. Broad-scale threatening processes (i.e. habitat fragmentation, feral predators) are of greatest concern for the species. No active, direct recovery measures are currently undertaken in the survey areas.

Table 13. Tree-stem Trapdoor Spider assessed as per Guidelines 1.1.

Significance Criteria under Guidelines 1.1	Likelihood and rationale
	Tree-stem Trapdoor Spider
Lead to a long-term decrease in the size of a population[5] (or an important population[6]).	**Unlikely to occur.** The Tree-stem Trapdoor Spider is known to occur in, and adjacent to, the survey areas but also regionally. Clearing within the survey areas is at most likely to affect a small number of individuals. No long-term change is expected.
Reduce the area of occupancy of the species (or an important population).	**Unlikely to occur.** Area of loss of habitat will be small relative to the available habitat in the region. The species moves on a very short, local scale and the development will not affect the area of occupancy for the population.
Fragment an existing population (or important population) into two or more populations.	**Unlikely to occur.** This is a highly sedentary species and clearing within the survey areas is not likely to alter its ability to interconnect.
Adversely affect habitat critical to the survival of a species[7].	**Unlikely to occur.** Habitat within the survey areas is well represented regionally and clearing will not adversely impact or effectively reduce the availability of critical habitat.
Disrupt the breeding cycle of a population (or important population).	**Unlikely to occur.** There may be some loss of individuals and a highly localised impairment of breeding individuals, but this will not have an impact on the population.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	**Unlikely to occur.** Very small and localised loss of general habitat.
Result in invasive species that are harmful to a	**Unlikely to occur.**

[5] A 'population of a species' is defined under the EPBC Act as an occurrence of the species in a particular area (includes a geographically distinct regional population, or collection of local populations, or a population, or collection of local populations, that occurs within a particular bioregion). Pertains to endangered and vulnerable species.

[6] An 'important population' is a population that is necessary for a species' long-term survival and recovery (includes populations identified as such in recovery plans, and/or key source populations either for breeding or dispersal, populations that are necessary for maintaining genetic diversity, and/or populations that are near the limit of the species range). Pertains to vulnerable species.

[7] 'Habitat critical to the survival of a species' refers to areas that are necessary: for activities such as foraging, breeding, roosting, or dispersal; for the long-term maintenance of the species; to maintain genetic diversity and long term evolutionary development; or for the reintroduction of populations or recovery of the species or ecological community. Pertains to endangered and vulnerable species.

Significance Criteria under Guidelines 1.1	Likelihood and rationale
	Tree-stem Trapdoor Spider
threatened species becoming established in the threatened species' habitat.	Feral predators (e.g. cats and foxes) are unlikely to present a major threat to this species, generally. Some predation of Tree-stem Trapdoor Spiders by native goannas has been noted in other areas in the region (e.g. Koolyanobbing area) but it is not expected that the abundance of these species, or the incidence of predation, will be in any way affected by the proposal.
Introduce disease that may cause the species to decline.	**Unlikely to occur.** Hygiene management plan will be implemented.
Interfere with the recovery of the species.	**Unlikely to occur.** No active, direct recovery measures are currently being undertaken.

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

Loss of habitat affecting population survival

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

Loss of habitat leading to population fragmentation

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

Degradation of habitat due to weed invasion leading to population decline

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

Increased mortality

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

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

Species interactions, including predation and competition

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

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

Hydroecology

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

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

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

Fire

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

Dust, light, noise and vibration

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

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

Appendix 4. Ecological and threatening processes identified under legislation and in the literature.

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

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

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

Threatening processes (EPBC Act)

Under the EPBC Act, a key threatening process is an ecological interaction that threatens or may threaten the survival, abundance or evolutionary development of a threatened species or ecological community. There are currently 20 key threatening processes listed by the federal Department of the Environment (DotE 2014b):

- Competition and land degradation by rabbits.
- Competition and land degradation by unmanaged goats.
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*).
- Incidental catch (bycatch) of Sea Turtle during coastal otter-trawling operations within Australian waters north of 28 degrees South.
- Incidental catch (or bycatch) of seabirds during oceanic longline fishing operations.
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis.
- Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris.
- Invasion of northern Australia by Gamba Grass and other introduced grasses.
- Land clearance.
- Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants.
- Loss of biodiversity and ecosystem integrity following invasion by the Yellow Crazy Ant (*Anoplolepis gracilipes*) on Christmas Island, Indian Ocean.
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases.
- Novel biota and their impact on biodiversity.
- Predation by European red fox.
- Predation by exotic rats on Australian offshore islands of less than 1000 km^2 (100,000 ha).
- Predation by feral cats.
- Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs.
- Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species.
- The biological effects, including lethal toxic ingestion, caused by Cane Toads (*Bufo marinus*).
- The reduction in the biodiversity of Australian native fauna and flora due to the red imported fire ant, *Solenopsis invicta* (fire ant).

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

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

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

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

Appendix 5. Vertebrate fauna expected to occur in the survey areas.

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 **Error! Reference source not found.** for explanation of expected occurrence categories.

Source:

1 = Atlas of Living Australia (ALA 2022), 2 = NatureMap (DBCA 2022c), 3 = Protected Matters Search Tool (DAWE 2022e), 4 = BirdLife Australia Birdata database (BA 2022), 5 = Bamford and Basnett (2012), 6 = Bamford (2016), 7 = Metcalf *et al.* (2016) and/or Bamford 2022a, b), 8 = general literature

Recorded (in the February 2022 field investigations):

'+' = 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
Myobatrachidae (Ground frogs)					
Neobatrachus kunapalari ^{w†}	Kunapalari Frog		Resident	1, 2, 5, 6	
Neobatrachus pelobatoides ^{w†}	Humming Frog		Resident	8	
Neobatrachus sutor ^{w†}	Shoemaker Frog		Resident	1, 2, 6, 7	
Pseudophryne occidentalis ^{w†}	Western Toadlet		Resident	1, 2, 5, 6, 7	
Carphodactylidae (Carphodactylid geckos)					

Species		Status	Expected Occurrence	Source	Recorded
Nephrurus stellatus	Stellate Knob-tail		Resident	1, 2	
Underwoodisaurus milii	Thick-tailed Gecko		Resident	1, 2, 5	
Diplodactylidae (Diplodactylid geckos)					
Diplodactylus granariensis	Western Stone Gecko		Resident	1, 2, 5, 6	
Diplodactylus pulcher	Fine-faced Gecko		Resident	1, 2, 5, 6	
Lucasium bungabinna	Southern Sandplain Gecko		Resident	1, 2	
Lucasium maini	Main's Ground Gecko		Resident	1, 2, 5, 6	
Gekkonidae (Gekkonid geckos)					
Crenadactylus ocellatus	South-western Clawless Gecko		Resident	1, 2, 5	
Gehyra purpurascens	Purplish Dtella		Resident	1, 2, 6	
Gehyra variegata	Tree Dtella		Resident	1, 2, 5, 6, 7	
Hesperoedura reticulata	Reticulated Velvet Gecko		Resident	1, 2, 5, 6	
Heteronotia binoei	Bynoe's Gecko		Resident	1, 2, 5, 7	
Rhynchoedura ornata	Western Beaked Gecko		Resident	1, 2	
Strophurus assimilis	Goldfields Spiny-tailed Gecko		Resident	1, 2	
Strophurus elderi	Jewelled Gecko		Resident	1, 2	
Pygopodidae (Legless lizards)					
Aprasia repens	Sedgelands Worm-lizard		Resident	1, 2	
Delma australis	Marble-faced Delma		Resident	1, 2, 5, 7	
Delma butleri	Unbanded Delma		Resident	1, 2	
Delma fraseri	Fraser's Legless Lizard		Resident	2	
Lialis burtonis	Burton's Snake-lizard		Resident	1, 2	
Pygopus lepidopodus	Common Scaly Foot		Resident	2	

Species		Status	Expected Occurrence	Source	Recorded
Pygopus nigriceps	Western Hooded Scaly-foot		Resident	2	
Agamidae (Dragons)					
Ctenophorus cristatus	Crested Dragon		Resident	1, 2, 5, 6	
Ctenophorus fordi	Mallee Military Dragon		Resident	1, 2, 6	
Ctenophorus isolepis	Central Military Dragon		Resident	1, 2, 6	
Ctenophorus maculatus	Spotted Military Dragon		Resident	8	+
Ctenophorus reticulatus	Western Netted Dragon		Resident	1, 2, 5	
Ctenophorus scutulatus	Lozenge-marked Dragon		Resident	1, 2, 5, 6	
Moloch horridus	Thorny Devil		Resident	1, 2, 5, 6	
Pogona minor	Dwarf Bearded Dragon		Resident	1, 2, 5, 6	
Tympanocryptis pseudopsephos	Goldfields Pebble-mimic Dragon		Resident	1	
Scincidae (Skinks)					
Cryptoblepharus australis	Inland Snake-eyed Skink		Resident	1, 2, 7	
Cryptoblepharus buchananii	Buchanan’s Snake-eyed Skink		Resident	1, 2, 5	
Cryptoblepharus plagiocephalus	Peron's Snake-eyed Skink		Resident	1, 2, 5	
Ctenotus atlas	Southern Mallee Ctenotus		Resident	1, 2	
Ctenotus brooksi	Brooks Ctenotus		Resident	1, 2	
Ctenotus leonhardii	Leonhardi's Ctenotus		Resident	1, 2	
Ctenotus mimetes	Checker-sided Ctenotus		Resident	2	
Ctenotus pantherinus	Leopard Ctenotus		Resident	1, 2	
Ctenotus schomburgkii	Barred Wedgesnout Ctenotus		Resident	1, 2, 6	
Ctenotus uber	Rich Ctenotus		Resident	1, 2, 5	
Ctenotus xenopleura	Wide-striped Ctenotus		Resident	1, 2, 6	

Species		Status	Expected Occurrence	Source	Recorded
Cyclodomorphus melanops	Eastern Slender Blue-tongue		Resident	1, 2	
Egernia formosa	Goldfields Crevice-skink		Resident	1, 2	
Eremiascincus richardsonii	Broad-banded Sand-swimmer		Resident	1, 2, 5	
Hemiergis initialis			Resident	1, 2, 5	
Lerista gerrardii	Bold-striped Robust Slider		Resident	1, 2, 5	
Lerista kingi	King's Three-toed Slider		Resident	1, 2, 7	
Lerista macropisthopus	Unpatterned Robust Slider		Resident	1, 2	
Lerista timida	Timid Slider		Resident	1, 2, 5	
Liopholis inornata	Desert Skink		Resident	1, 2, 6	
Liopholis multiscutata	Bull Skink		Resident	2, 7	
Menetia greyii	Common Dwarf Skink		Resident	1, 2, 5, 6	
Morethia butleri	Woodland Morethia Skink		Resident	1, 2	
Morethia obscura	Shrubland Morethia Skink		Resident	1, 2	
Tiliqua occipitalis	Western Blue-tongue		Resident	1, 2, 6	
Varanidae (Monitors and goannas)					
Varanus giganteus	Perentie		Resident	2	
Varanus gouldii	Gould's Goanna		Resident	1, 2, 5, 6	D
Varanus tristis	Black-headed Monitor		Resident	1, 2, 5, 6	
Typhlopidae (Blind snakes)					
Anilios australis	Southern Blind Snake		Resident	1, 2, 4, 5, 6	
Anilios bicolor	Dark-spined Blind Snake		Resident	1	
Anilios bituberculatus	Prong-snouted Blind Snake		Resident	1, 5	
Anilios hamatus	Pale-headed Blind Snake		Resident	1	

Species		Status	Expected Occurrence	Source	Recorded
Pythonidae (Pythons)					
Morelia spilota	Carpet Python	CS3 (LS)	Resident	2, 5	
Elapidae (Venomous land snakes)					
Brachyurophis fasciolatus	Narrow-banded Shovel-nosed Snakesubsp. fasciolatus		Resident	2	
Brachyurophis semifasciatus	Southern Shovel-nosed Snake		Resident	1, 2, 5, 6	
Demansia psammophis	Yellow-faced Whipsnake		Resident	2	
Furina ornata	Orange-naped Snake		Resident	1, 2	
Pseudechis australis	King Brown Snake		Resident	1, 2	
Pseudonaja mengdeni	Western Brown Snake		Resident	1, 2	
Pseudonaja modesta	Ringed Brown Snake		Resident	2	
Simoselaps anomalus	Desert Banded Snake		Resident	2	
Simoselaps bertholdi	Jan's Banded Snake		Resident	1, 2, 5	
Suta fasciata	Rosen's Snake		Resident	1, 2, 7	
Suta gouldii	Gould's Hooded Snake		Resident	2	
Suta monachus	Monk Snake		Resident	2	
Casuariidae (Emus and Cassowaries)					
Dromaius novaehollandiae	Emu		Resident	1, 2, 4, 7	ST
Anatidae (Ducks, Geese and Swans)					
Tadorna tadornoides [w]	Australian Shelduck		Irregular visitor	1, 4	
Chenonetta jubata [w]	Australian Wood Duck, Maned Duck		Irregular visitor	1, 4	
Anas superciliosa [w]	Pacific Black Duck		Irregular visitor	1, 2, 4	
Anas gracilis [w]	Grey teal		Irregular visitor	1, 4	

Species		Status	Expected Occurrence	Source	Recorded
Megapodiidae (Megapodes)					
Leipoa ocellata	Malleefowl	CS1 (V,S3)	Resident	1, 2, 3, 4	
Podicipedidae (Grebes)					
Tachybaptus novaehollandiae [w]	Australasian Grebe		Irregular visitor	4	
Podargidae (Frogmouths)					
Podargus strigoides	Tawny Frogmouth		Resident	1, 2, 4	
Eurostopodidae (Eared Nightjars)					
Eurostopodus argus	Spotted Nightjar		Resident	1, 2, 4	
Aegothelidae (Owlet-nightjars)					
Aegotheles cristatus	Australian Owlet-nightjar		Resident	1, 2, 4, 7	+
Apodidae (Swifts and Swiftlets)					
Apus pacificus	Fork-tailed Swift	CS1 (M,Mar,S5)	Irregular visitor	3	
Cuculidae (Cuckoos)					
Chalcites basalis	Horsfield's Bronze-Cuckoo		Regular migrant	1, 2, 4	
Chalcites osculans	Black-eared Cuckoo		Regular migrant	1, 2, 3, 4	
Chalcites lucidus	Shining Bronze-Cuckoo		Regular migrant	4	
Heteroscenes pallidus	Pallid Cuckoo		Regular migrant	1, 2, 4	
Cacomantis flabelliformis	Fan-tailed Cuckoo		Regular migrant	1, 2, 4	
Burhinidae (Stone-curlews)					
Burhinus grallarius	Bush Stone-curlew	CS3 (LS)	Irregular visitor	8	
Otididae (Bustards)					
Ardeotis australis	Australian Bustard	CS3 (LS)	Vagrant	4	
Columbidae (Pigeons and Doves)					

Species		Status	Expected Occurrence	Source	Recorded
Phaps chalcoptera	Common Bronzewing		Resident	1, 2, 4, 7	+
Phaps elegans	Brush Bronzewing		Irregular visitor	8	
Ocyphaps lophotes	Crested Pigeon		Irregular visitor	1, 2, 4	
Turnicidae (Button-quail)					
Turnix varius	Painted Button-quail		Resident	1, 2, 4	
Turnix velox	Little Button-quail		Irregular visitor	1, 4	
Charadriidae (Plovers, Dotterel and Lapwings)					
Thinornis rubricollis [w]	Hooded Plover	CS2 (Mar,P4)	Irregular visitor	2, 3	
Vanellus tricolor	Banded Lapwing		Irregular visitor	4	
Scolopacidae (Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes)					
Calidris acuminata [w]	Sharp-tailed Sandpiper	CS1 (M,Mar,S5)	Irregular visitor	3	
Callidris ferruginea [w]	Curlew Sandpiper	CS1 (C,M,Mar,S3,S5)	Irregular visitor	3	
Calidris melanotus [w]	Pectoral Sandpiper	CS1 (M,Mar,S5)	Irregular visitor	3	
Actitis hypoleucos [w]	Common Sandpiper	CS1 (M,Mar,S5)	Irregular visitor	3	
Ardeidae (Herons, Egrets and Bitterns)					
Ardea pacifica [w]	White-necked Heron		Irregular visitor	1, 4	
Egretta novaehollandiae [w]	White-faced Heron		Irregular visitor	4	
Ardea ibis	Cattle Egret		Vagrant	3	
Accipitridae (Eagles, Kites, Goshawks)					
Lophoictinia isura	Square-tailed Kite	CS3 (LS)	Regular migrant	1, 2, 4	
Hamirostra melanosternon	Black-breasted Buzzard		Regular visitor	1, 2, 4	
Hieraaetus morphnoides	Little Eagle		Resident	1, 2, 4	

Species		Status	Expected Occurrence	Source	Recorded
Aquila audax	Wedge-tailed Eagle		Resident	1, 2, 4	
Accipiter fasciatus	Brown Goshawk		Resident	1, 2, 4	
Accipiter cirrocephalus	Collared Sparrowhawk		Resident	1, 2, 4	+
Haliastur sphenurus	Whistling Kite		Resident	1, 2, 4	
Tytonidae (Masked Owls)					
Tyto alba	Barn Owl		Regular visitor	4	
Strigidae (Hawk-Owls)					
Ninox boobook	Southern Boobook		Resident	1, 4	
Alcedinidae (Kingfishers)					
Dacelo novaeguineae	Laughing Kookaburra	Int	Irregular visitor	1, 2, 4	
Todiramphus sanctus	Sacred Kingfisher		Regular migrant	1, 2, 4	
Todiramphus pyrrhopygius	Red-backed Kingfisher		Regular visitor	1, 2, 4	
Meropidae (Bee-eaters)					
Merops ornatus	Rainbow Bee-eater		Regular migrant	1, 2, 3, 4	+
Falconidae (Falcons)					
Falco cenchroides	Nankeen Kestrel		Resident	1, 2, 4	
Falco longipennis	Australian Hobby		Resident	1, 2, 4	
Falco berigora	Brown Falcon		Resident	1, 2, 4	
Falco hypoleucos	Grey Falcon	CS1 (S3)	Vagrant	3	
Falco peregrinus	Peregrine Falcon	CS1 (S7)	Regular visitor	1, 2, 4	
Cacatuidae (Cockatoos and Corellas)					
Nymphicus hollandicus	Cockatiel		Irregular visitor	1, 4	
Calyptorhynchus banksii	Red-tailed Black Cockatoo		Regular visitor	1, 4	

Species		Status	Expected Occurrence	Source	Recorded
Eolophus roseicapilla	Galah		Resident	1, 2, 4	
Cacatua leadbeateri	Major Mitchell's Cockatoo	CS3 (LS)	Regular visitor	1, 2, 4	
Psittaculidae (Parrots, Lorikeets and Rosellas)					
Polytelis anthopeplus	Regent Parrot		Resident	1, 2, 4	
Psephotus varius	Mulga Parrot		Regular visitor	1, 4	
Purpureicephalus spurius	Red-capped Parrot		Vagrant	4	
Platycercus icterotis xanthogenys	Western Rosella (inland)	CS2 (P4)	Irregular visitor	1, 2, 4	
Barnardius zonarius	Australian Ringneck		Resident	1, 2, 7	+
Neophema splendida	Scarlet-chested Parrot		Vagrant	1, 2, 4	
Parvipsitta porphyrocephala	Purple-crowned Lorikeet		Regular visitor	1, 4, 7	
Melopsittacus undulatus	Budgerigar		Irregular visitor	1, 2, 4	
Ptilonorhynchidae (Bowerbirds and Catbirds)					
Ptilonorhynchus guttatus	Western Bowerbird		Vagrant	4	
Climacteridae (Treecreepers)					
Climacteris affinis	White-browed Treecreeper		Vagrant	4	
Climacteris rufus	Rufous Treecreeper	CS3 (LS)	Resident	1, 4, 7	+
Maluridae (Fairy-wrens, Emu-wrens and Grasswrens)					
Malurus pulcherrimus	Blue-breasted Fairy-wren	CS3 (LS)	Resident (if present)	1, 2, 4, 7	
Malurus splendens	Splendid Fairy-wren		Resident	1, 2, 4	+
Malurus assimilis	Purple-backed Fairy-wren		Resident	2, 4	+
Malurus leucopterus	White-winged Fairy-wren		Resident	1, 2, 4	
Meliphagidae (Honeyeaters and Chats)					
Epthianura tricolor	Crimson Chat		Regular visitor	1, 2, 4	

Species		Status	Expected Occurrence	Source	Recorded
Epthianura albifrons	White-fronted Chat		Vagrant	1, 2, 4	
Gliciphila melanops	Tawny-crowned Honeyeater		Regular visitor	1, 2, 4	
Certhionyx variegatus	Pied Honeyeater		Irregular visitor	1, 2, 4	
Sugomel niger	Black Honeyeater		Irregular visitor	1, 4	
Phylidonyris novaehollandiae	New Holland Honeyeater		Irregular visitor	1, 2	
Phylidonyris niger	White-cheeked Honeyeater		Regular visitor	1, 2, 4	
Lichmera indistincta	Brown Honeyeater		Resident	1, 2, 4, 7	+
Nesoptilotis leucotis	White-eared Honeyeater		Resident	1, 2, 4, 7	+
Melithreptus brevirostris	Brown-headed Honeyeater		Resident	1, 2, 4, 7	
Purnella albifrons	White-fronted Honeyeater		Regular visitor	1, 2, 4, 7	+
Lichenostomus cratitius	Purple-gaped Honeyeater		Irregular visitor	2	
Gavicalis virescens	Singing Honeyeater		Resident	1, 4, 7	+
Ptilotula plumula	Grey-fronted Honeyeater		Vagrant	1, 4	
Ptilotula penicillata	White-plumed Honeyeater		Vagrant	4	
Ptilotula ornata	Yellow-plumed Honeyeater		Resident	1, 4, 7	+
Anthochaera carunculata	Red wattlebird		Regular visitor	1, 2, 4, 7	
Acanthagenys rufogularis	Spiny-cheeked Honeyeater		Resident	1, 2, 4, 7	+
Manorina flavigula	Yellow-throated Miner		Resident	1, 2, 4, 7	+
Pardalotidae (Pardalotes)					
Pardalotus punctatus	Spotted Pardalote		Regular visitor	1, 2, 4	
Pardalotus striatus	Striated Pardalote		Resident	1, 2, 4, 7	+
Acanthizidae (Thornbills and Gerygones)					
Smicrornis brevirostris	Weebill		Resident	1, 2, 4, 7	+

Species		Status	Expected Occurrence	Source	Recorded
Calamanthus campestris	Rufous Fieldwren		Irregular visitor	1, 2, 4	
Calamanthus cautus	Shy Heathwren	CS3 (LS)	Irregular visitor	1, 4	
Pyrrholaemus brunneus	Redthroat	CS3 (LS)	Resident	1, 2, 4,7	
Sericornis frontalis	White-browed Scrubwren		Resident	1, 2, 4	
Gerygone fusca	Western Gerygone		Resident	1, 2, 4	
Acanthiza apicalis	Inland Thornbill		Resident	1, 2, 4	+
Acanthiza uropygialis	Chestnut-rumped Thornbill		Resident	1, 2, 4,7	+
Acanthiza chrysorrhoa	Yellow-rumped Thornbill		Resident	1, 2, 4	
Acanthiza robustirostris	Slaty-backed Thornbill		Resident	1, 2, 4	
Aphelocephala leucopsis	Southern Whiteface		Resident	1, 2, 4	
Pomatostomidae (Australian Babblers)					
Pomatostomus superciliosus	White-browed Babbler	CS3 (LS)	Resident	1, 2, 4, 7	+
Cinclosomatidae (Quail-thrush)					
Cinclosoma clarum	Copper-backed Quail-thrush		Resident	1, 7	+
Cinclosoma castaneothorax	Chestnut-breasted Quail-thrush		Resident	1, 2, 4	
Artamidae (Woodswallows, Currawongs, Butcherbirds and Magpie)					
Artamus personatus	Masked Woodswallow		Irregular visitor	1, 2, 4	
Artamus cinereus	Black-faced Woodswallow		Resident	1, 2, 4, 7	
Artamus cyanopterus	Dusky Woodswallow		Resident	1, 2, 4, 7	+
Artamus minor	Little Woodswallow		Resident	1, 2, 4	+
Gymnorhina tibicen	Australian Magpie		Resident	1, 2, 4	+
Cracticus torquatus	Grey Butcherbird		Resident	1, 2, 4, 7	+
Cracticus nigrogularis	Pied Butcherbird		Resident	1, 2, 4	

Species		Status	Expected Occurrence	Source	Recorded
Strepera versicolor	Grey Currawong		Resident	1, 2, 4, 7	+
Campephagidae (Cuckoo-shrikes and Trillers)					
Coracina maxima	Ground Cuckoo-shrike		Irregular visitor	1, 2, 4	
Coracina novaehollandiae	Black-faced Cuckoo-shrike		Resident	1, 2, 4, 7	+
Lalage tricolor	White-winged Triller		Regular visitor	1, 2, 4	
Neosittidae (Sittellas)					
Daphoenositta chrysoptera	Varied Sittella		Resident	1, 2, 4, 7	
Oreoicidae (Australo-Papuan Bellbirds)					
Oreoica gutturalis	Crested Bellbird	CS3 (LS)	Resident	1, 2, 4, 7	
Falcunculidae (Shriketits)					
Falcunculus frontatus	Crested Shrike-tit		Irregular visitor	1, 2, 4	
Pachycephalidae (Whistlers, Shrike-thrushes and allies)					
Pachycephala inornata	Gilbert's Whistler	CS3 (LS)	Irregular visitor	1, 2, 4	
Pachycephala occidentalis	Western Whistler		Resident	1, 4	
Pachycephala rufiventris	Rufous Whistler		Resident	1, 2, 4	+
Colluricincla harmonica	Grey Shrike-thrush		Resident	1, 2, 4, 7	+
Rhipiduridae (Fantails)					
Rhipidura leucophrys	Willie Wagtail		Resident	1, 2, 4, 7	+
Rhipidura albiscapa	Grey Fantail		Resident	1, 2, 4	
Monarchidae (Monarch and Flycatchers)					
Grallina cyanoleuca	Magpie-lark		Resident	1, 2, 4	
Myiagra inquieta	Restless Flycatcher		Resident	2, 4	
Corvidae (Crows and Ravens)					

Species		Status	Expected Occurrence	Source	Recorded
Corvus orru	Torresian Crow		Resident	1, 2, 4, 7	
Corvus bennetti	Little Crow		Irregular visitor	1, 2, 4	
Corvus coronoides	Australian Raven		Resident	1, 2, 4, 7	
Petroicidae (Australian Robins)					
Eopsaltria griseogularis	Western Yellow Robin	CS3 (LS)	Resident	1, 4	+
Melanodryas cucullata	Hooded Robin		Resident	1, 2, 4	
Drymodes brunneopygia	Southern Scrub-robin	CS3 (LS)	Resident	1, 2, 4	
Microeca fascinans	Jacky Winter		Resident	1, 2, 4	+
Petroica goodenovii	Red-capped Robin		Resident	1, 2, 4	+
Hirundinidae (Swallows and Martins)					
Cheramoeca leucosterna	White-backed Swallow		Resident	1, 2, 4	
Hirundo neoxena	Welcome Swallow		Resident	1, 2, 4	
Petrochelidon ariel	Fairy Martin		Irregular visitor	1, 4	
Petrochelidon nigricans	Tree Martin		Resident	1, 2, 4	+
Locustellidae (Grassbirds)					
Cincloramphus cruralis	Brown Songlark		Regular visitor	1, 4	
Cincloramphus mathewsi	Rufous Songlark		Regular visitor	1, 4	
Dicaeidae (Flowerpeckers)					
Dicaeum hirundinaceum	Mistletoebird		Resident	1, 2, 4	
Estrildidae (Weaver Finches)					
Taeniopygia guttata	Zebra Finch		Regular visitor	1, 2, 4	
Motacillidae (Pipits and Wagtails)					
Anthus novaeseelandiae	Australian Pipit		Resident	1, 4	+

Species		Status	Expected Occurrence	Source	Recorded
Tachyglossidae (Echidnas)					
Tachyglossus aculeatus	Short-beaked Echidna		Resident	5, 6	
Dasyuridae (Dasyurids)					
Dasyurus geoffroii	Chuditch	CS1 (V,S3)	Regular visitor	3	
Ningaui ridei	Wongai Ningaui		Resident	1, 2	
Ningaui yvonneae	Southern Ningaui		Resident	1, 2	
Pseudantechinus woolleyae	Woolley's Pseudantechinus		Resident	1, 2	
Sminthopsis crassicaudata	Fat-tailed Dunnart		Resident	1	
Sminthopsis dolichura	Little Long-tailed Dunnart		Resident	1, 2, 5	
Sminthopsis hirtipes	Hairy-footed Dunnart		Resident	1, 2	
Burramyidae (Pygmy possums)					
Cercartetus concinnus	Western Pygmy-possum, Mundarda		Resident	1, 2, 5	
Macropodidae (Kangaroos)					
Macropus fuliginosus	Western Grey Kangaroo		Resident	2, 6, 7	ST
Osphranter robustus	Euro, Biggada		Resident	2, 5, 7	
Muridae (Rats and mice)					
Mus musculus	House Mouse	Int	Resident	1, 2, 5	
Notomys mitchellii	Mitchell's Hopping Mouse		Resident	1, 2, 5, 7	
Pseudomys albocinereus	Ash-grey Mouse		Resident	1, 2, 5	
Pseudomys hermannsburgensis	Sandy Inland Mouse		Resident	1, 2, 5	
Pseudomys occidentalis	Western Mouse	CS2 (P4)	Regular visitor	2	
Leporidae (Rabbits and hares)					

Species		Status	Expected Occurrence	Source	Recorded
Oryctolagus cuniculus	Rabbit	Int	Resident	2, 5, 6, 7	S
Molossidae (Freetail bats)					
Austronomus australis	White-striped Freetail-Bat		Resident	1, 5, 6, 7	
Ozimops kitcheneri	South-western Freetail-Bat		Resident	1	
Ozimops petersi	Inland Freetail-Bat		Resident	1	
Vespertilionidae (Vespertillionid bats)					
Chalinolobus gouldii	Gould's Wattled Bat		Resident	1, 2, 5, 6, 7	
Chalinolobus morio	Chocolate Wattled Bat		Resident	1, 2, 5	
Nyctophilus geoffroyi	Lesser Long-eared Bat		Resident	1, 2, 7	
Nyctophilus major tor	Central Long-eared Bat	CS2 (P4)	Resident	1, 2, 7	
Scotorepens balstoni	Inland Broad-nosed Bat		Resident	1, 2	
Vespadelus baverstocki	Inland Forest Bat		Resident	7	
Vespadelus regulus	Southern Forest Bat		Resident	1, 2	
Canidae (Dogs)					
Canis lupus dingo	Dingo		Irregular visitor	5, 6	
Canis lupus familiaris	Dog	Int	Irregular visitor	5, 6	
Vulpes vulpes	Red Fox	Int	Resident	2, 5, 7	T
Felidae (Cats)					
Felis catus	Cat	Int	Resident	2, 5, 7	T
Camelidae (Camels)					
Camelus dromedarius	Dromedary, Camel	Int	Resident	2, 5, 6, 7	+
Bovidae (Horned ruminants)					
Bos taurus	European Cattle	Int	Resident	2	

Appendix 6. Species recorded in the field investigations, February 2022.

Species	Annotations
Ctenophorus maculatus	Seen in Acacia shrubland.
Varanus gouldii (Gould's Goanna)	Few diggings throughout.
Dromaius novaehollandiae (Emu)	Scats and tracks. Uncommon.
Leipoa ocellata (Malleefowl)	Inactive mounds.
Aegotheles cristatus (Australian Owlet-nightjar)	One or two heard during day, and one flushed from tree hollow.
Phaps chalcoptera (Common Bronzewing)	One seen in Western search area.
Accipiter cirrocephalus (Collared Sparrowhawk)	One seen in eucalypt woodland.
Haliastur sphenurus (Whistling Kite)	One over Mount Walton road on departure from site.
Merops ornatus (Rainbow Bee-eater)	Several heard near Western survey area.
Cacatua leadbeateri (Major Mitchell's Cockatoo)	Twelve over Mount Walton road on departure from site.
Barnardius zonarius (Australian Ringneck)	Several in Salmon Gum woodlands.
Climacteris rufus (Rufous Treecreeper)	Common in eucalypt woodlands.
Malurus splendens (Splendid Fairy-wren)	Few parties throughout.
Malurus lamberti (Variegated Fairy-wren)	One group in Eastern survey area.
Lichmera indistincta (Brown Honeyeater)	Few birds throughout. Not common.
Nesoptilotis leucotis (White-eared Honeyeater)	Single birds seen throughout, reasonably common.
Purnella albifrons (White-fronted Honeyeater)	Possibly heard on one or two occasions.
Gavicalis virescens (Singing Honeyeater)	Single birds seen or heard occasionally throughout.
Ptilotula ornata (Yellow-plumed Honeyeater)	Several birds near core sorting area, in eucalypts.
Acanthagenys rufogularis (Spiny-cheeked Honeyeater)	One or two birds throughout.
Manorina flavigula (Yellow-throated Miner)	Small parties throughout but especially in woodland areas.

Species	Annotations
Pardalotus striatus (Striated Pardalote)	One bird heard once in Salmon Gum woodland.
Smicrornis brevirostris (Weebill)	Common throughout.
Acanthiza apicalis (Inland Thornbill)	Few birds throughout, often in mixed flocks with Chestnut-rumped Thornbills.
Acanthiza uropygialis (Chestnut-rumped Thornbill)	Common throughout.
Pomatostomus superciliosus (White-browed Babbler)	One or two small groups.
Cinclosoma clarum (Copper-backed Quail-thrush)	Singles or pairs throughout; not uncommon.
Artamus cinereus (Black-faced Woodswallow)	Pair seen along Mount Walton road on departure from site.
Artamus cyanopterus (Dusky Woodswallow)	Few birds in Salmon Gum woodland.
Artamus minor (Little Woodswallow)	Up six birds in several areas, usually very close to mining pits.
Gymnorhina tibicen (Australian Magpie)	Uncommon, seen in near Western survey area. Heard around camp.
Cracticus torquatus (Grey Butcherbird)	Single birds heard throughout.
Cracticus nigrogularis (Pied Butcherbird)	Heard near camp.
Strepera versicolor (Grey Currawong)	Two birds seen in woodland.
Coracina novaehollandiae (Black-faced cuckoo-shrike)	One bird seen over eucalypt woodland.
Pachycephala rufiventris (Rufous Whistler)	One heard in Acacia woodland.
Colluricincla harmonica (Grey Shrike-thrush)	Reasonably common throughout.
Rhipidura leucophrys (Willie Wagtail)	One or two birds throughout.
Grallina cyanoleuca (Magpie-lark)	Heard near camp.
Corvus orru (Torresian Crow)	At camp.
Corvus coronoides (Australian Raven)	One possibly heard at camp.
Eopsaltria griseogularis (Western Yellow Robin)	Heard throughout.
Microeca fascinans (Jacky Winter)	One heard near Western survey area.

Species	Annotations
Petroica goodenovii (Red-capped Robin)	One seen in Eastern survey area.
Petrochelidon nigricans (Tree Martin)	Several at the airstrip.
Anthus novaeseelandiae (Australian Pipit)	One seen at the airstrip.
Macropus fuliginosus (Western Grey Kangaroo)	Scattered tracks and scats but not common.
Mus musculus (House Mouse)	Several at camp.
Oryctolagus cuniculus (Rabbit)	Scats in occasional places.
Austronomus australis (White-striped Freetail-bat)	Heard around camp. Abundant.
Chalinolobus gouldii (Gould's Wattled Bat)	Probably. Seen in number around camp.
Vulpes vulpes (Red Fox)	Scats and tracks throughout.
Felis catus (Cat)	Tracks occasionally.
Camelus dromedarius (Dromedary, Camel)	Two seen on main mine access road, with tracks and scats common throughout.

Appendix 7. Conservation significant invertebrate fauna species expected to occur in the Goldfields management region (as per DBCA 2022a, e), 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
Aganippe castellum	tree-stem trapdoor spider	CS2 (P4)	Present. Known from the survey areas.
Branchinella apophysata	a fairy shrimp (Laverton)	CS2 (P1)	Absent. No wetland habitat.
Branchinella denticulata	a fairy shrimp (Carnarvon to Kalgoorlie)	CS2 (P3)	Absent. No wetland habitat.
Branchinella simplex	a fairy shrimp (inland WA)	CS2 (P1)	Absent. No wetland habitat.
Idiosoma intermedium	Coolgardie shield-backed trapdoor spider	CS2 (P3)	Possibly present. Survey area within expected distribution (Rix *et al.* 2017; Rix *et al.* 2018).
Idiosoma nigrum	shield-backed trapdoor spider	CS1 (V, S2)	Absent. Survey areas well outside known range (Rix *et al.* 2017; Rix *et al.* 2018).
Jalmenus aridus	inland hairstreak, desert blue butterfly	CS2 (P1)	Absent. Only known from one location near Kalgoorlie (Graham and Moulds 1988; Geyle *et al.* 2021).
Kwonkan moriartii	Moriarty's trapdoor spider	CS2 (P2)	Absent. Only known from one location on Kathleen Valley Station, north of Leinster (Main 1983).

Species	Common Name	Status	Expected Occurrence
Ogyris subterrestris petrina	arid bronze azure butterfly	CS1 (C, S1)	Uncertain, but probably absent.
Paraplatyarthrus subterraneus	Poseidon slater	CS2 (P1)	Absent. Only known from calcrete aquifer near Laverton (Javidkar *et al.* 2015).
Troglodiplura lowryi	Nullarbor cave trapdoor spider	CS1 (V)	Absent. No suitable habitat and well outside known range.

Appendix 8. Location details of mygalomorph spider burrows recorded in and around the survey areas during the February 2022 site inspection.

Highlighted rows indicate spiders located within the survey areas (see Figure 1 and Figure 2).
Datum: GDA2020, Zone 50J.

ID	Date	Easting	Northing	Taxon	Comments
Mygal01	20/02/2022	769557	6634440	*Idiosoma sp.*	
Mygal02	20/02/2022	768992	6634639	*Idiosoma castellum*	Old, disused.
Mygal03	20/02/2022	770854	6633281	*Idiosoma sp.*	
Mygal04	20/02/2022	771566	6633774	*Idiosoma castellum*	2 burrows.
Mygal05	20/02/2022	771575	6633755	*Idiosoma castellum*	
Mygal06	20/02/2022	771557	6633743	*Idiosoma castellum*	Old, mud-filled, disused.
Mygal07	20/02/2022	773644	6634635	*Idiosoma castellum*	Old, lidless.
Mygal08	20/02/2022	773669	6634650	*Idiosoma castellum*	
Mygal09	21/02/2022	772383	6634002	*Anidiops villosus*	
Mygal10	21/02/2022	772318	6633954	*Idiosoma sp.*	
Mygal11	21/02/2022	772279	6633816	*Idiosoma sp.*	
Mygal12	21/02/2022	771995	6633523	*Idiosoma castellum*	
Mygal13	21/02/2022	771982	6633558	*Idiosoma sp.*	
Mygal14	21/02/2022	771987	6633574	*Idiosoma castellum*	
Mygal15	21/02/2022	773074	6635939	*Idiosoma castellum*	Old, lidless.
Mygal16	21/02/2022	773191	6636015	*Idiosoma castellum*	
Mygal17	21/02/2022	773223	6636052	*Idiosoma castellum*	Old, lidless.

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