Crimson Metals
Mount Gibson Gold Project
Assessment of Fauna Values

Western Stone Gecko (*Diplodactylus granariensis*). Photo: Wes Bancroft.

Prepared for: Tetris Environmental Pty Ltd
573 Canning Highway
ALFRED COVE WA 6154

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

5th March 2024

Executive Summary

Introduction

Crimson Metals Pty Ltd is proposing to recommence mining at the Mount Gibson Gold Project (MGGP), located in the midwest region of Western Australia, approximately 50 km north-east of Wubin and 70 km south-west of Paynes Find. The survey area comprises proposed mining operations area in the east, and a proposed upgraded airport/runway in the west.

Recent fauna studies (Biota 2022, 2023) included a Basic fauna assessment and targeted investigations that identified six species of conservation significant vertebrate fauna that are most likely to occur in the survey area: Gilled Slender Blue-tongue, Western Spiny-tailed Skink, Malleefowl, Western Rosella – inland, Peregrine Falcon and Central Long-eared Bat. One further species, the Southern Whiteface, has been listed (under the EPBC Act) since these studies and may also occur in the survey area. The Biota studies also investigation invertebrate fauna of conservation significance.

To support the previous studies, Bamford Consulting Ecologists (BCE) was commissioned by Tetris Environmental Pty Ltd (Tetris), on behalf of Crimson Metals, to conduct a detailed vertebrate fauna survey of the MGGP and also to undertake further targeted assessments for significant species, in particular the Malleefowl and Southern Whiteface. The survey was undertaken in accordance with the Environmental Protection Authority's (EPA) *Technical Guidance - terrestrial vertebrate fauna surveys for environmental impact assessment* (EPA 2020).

Background environmental information

While the survey area is within the Merredin (AVW01) Interim Biogeographic Regionalisation of Australia (IBRA) subregion of the Avon Wheatbelt bioregion, it shares very similar characteristics to the vegetation and soil types of the adjacent Yalgoo bioregion.

Four land systems occur within the survey area: Doney (alluvial plains; Eucalypt woodlands and halophytic understorey), Euchre (mesas, breakaways and stony plains; Acacia or eucalypt woodlands and halophytic shrublands), Joseph (sandplains; Acacia, mallees and heath), and Pindar (Wash plains; Eucalypt woodlands with non-halophytic understorey).

The dominant land uses within the subregion are cultivation – dry land agriculture and grazing), with lesser areas of UCL and Crown reserves, conservation, rural residential and mining. At the local scale, the survey area is surrounded by areas of continuous native vegetation.

There are no known Ramsar Sites, Important Wetlands, Bush Forever sites, Key Biodiversity Areas or Environmentally Sensitive Areas within the survey area. One Commonwealth listed Threatened Ecological Community (TEC) and State listed Priority Ecological Community (PEC) was found to occur within the survey area: Eucalypt Woodlands of the Western Australian Wheatbelt.

Methods

Although the 'basic'/'targeted' levels of survey conducted by Biota in 2021 and 2022 are considered appropriate for the project, the more comprehensive 'detailed' and 'targeted' level surveys have been

undertaken here, as requested by Tetris, in recognition of the value of additional data and as a precaution to ensure compliance with guidance.

The field investigations comprised 'detailed' surveys for terrestrial vertebrates (including pitfall and funnel trapping, bird censusing, motion-sensitive camera trapping and spotlighting) and targeted surveys the conservation significant Malleefowl and Southern Whiteface. These were undertaken between the 30th October and 7th November 2023. Specific methodologies are detailed within.

Fauna values

Vegetation and substrate associations (VSAs)

Eight major vegetation and substrate associations (VSAs) were identified in relation to fauna in the survey area:

- VSA 1. Acacia Shrubland.
- VSA 2. Allocasuarina Shrubland.
- VSA 3. Callitris Woodland.
- VSA 4. Eucalypt Woodland.
- VSA 5. Mallee Woodland.
- VSA 6. Mixed Shrubland.
- VSA 7. Rehabilitation.
- VSA 8. Cleared.

Field investigations

Forty-nine captures of 18 species were made by pitfall (420 pitfall trap-nights) and funnel trapping (210 funnel trap-nights) in the survey area. None was conservation significant. It was apparent that the *VSA 4 – Eucalypt Woodland* and *VSA 5 – Mallee Woodland* sites were the most biodiverse.

Thirty-eight bird species were recorded in the systematic sampling (a total of 42 transect surveys). None was conservation significant. The *VSA 3 – Callitris Woodland* and the *VSA4 – Eucalypt Woodland* sites were the most biodiverse, with the *VSA 1 – Acacia Shrubland* having the lowest bird species richness.

Motion-sensitive cameras recorded 16 species including two native species not detected by other means (one lizard and one small mammal). One conservation significant species was recorded: Malleefowl.

Previous lidar surveys by Biota (2022, 2023) and other opportunistic observations suggested that there were 47 *potential* Malleefowl nest mound locations within the survey area (28 in the mine development envelope, 19 in the airport development). Only one of these mounds, in the very east of the mine development envelope, was found to be active in November 2023. Based on the age and activity status of mounds, it was determined that 11 locations in the proposed mine envelope and 17 locations in the proposed airport envelope should be the subject of subsequent visits.

A single Malleefowl was seen, opportunistically, crossing the main site entry road, and Malleefowl tracks were observed in almost all locations where field work was undertaken.

Surveys for Southern Whiteface failed to detect this species within the survey area. A flock of up to three birds were opportunistically observed on several occasions in the area surrounding the exploration camp (approximately 8 km to the north-west of the nearest survey area boundary).

A pair of Peregrine Falcons was seen, opportunistically, adjacent to an existing mine pit on two occasions.

At least 90 vertebrate species were recorded during the site inspection: no fish, no frogs, 24 reptiles, 59 birds and 7 mammals.

Patterns of biodiversity

Broadly speaking, areas of *VSA 4 – Eucalypt Woodland* had the highest species richness and abundance of vertebrate fauna. While the least biodiverse VSA, generally, was *VSA 1 – Acacia Shrubland*, it is this and *VSA 2 – Allocasuarina Shrubland* (in particular) that support the highest densities of Malleefowl nest mounds.

Ecological processes

Ecological processes that may presently be important for ecosystem function in the survey area include: local hydrology, fire, feral predators, and connectivity and landscape permeability.

Conservation significant vertebrate fauna synopsis

- *Cyclodomorphus branchialis* (Gilled Slender Blue-tongue). Listed as **Vulnerable** under both the EPBC Act and the WA BC Act. Not recorded in the survey area and unlikely to be present (if present it would most likely be restricted to rocky areas that are present regionally but not in the survey area). The proposed development is unlikely to have a significant impact on this species.
- *Egernia stokesii badia* (Western Spiny-tailed Skink). Listed as **Endangered** under the EPBC Act and **Vulnerable** under the WA BC Act. Not recorded in the survey area and unlikely to be present (at best occurring only as occasional dispersing animals). The proposed development is unlikely to have a significant impact on this species.
- *Leipoa ocellata* (Malleefowl). Listed as **Vulnerable** under both the EPBC Act and the WA BC Act. Known to occur in the survey area. Two VSAs appear to be strongly favoured for the construction of nest mounds: *VSA 1 - Acacia Shrubland* and *VSA 2 - Allocasuarina Shrubland* and these occur extensively within the region. While the proposed development is unlikely to have a significant impact on this species, at the species level, further management prior to the commencement of mining operations is likely to be required to minimise disruption to local individuals.
- *Platycercus icterotis xanthogenys* (Western Rosella – inland). Ranked as **Priority 4** by DBCA. Not recorded in the survey area and unlikely to be present (at best an irregular visitor or vagrant to the survey area). The proposed development is unlikely to have a significant impact on this species.
- *Falco peregrinus* (Peregrine Falcon). Listed as **Specially Protected** under the WA BC Act. Known to occur in the survey area. All sightings have been adjacent to existing mine pits which replicate the cliff-faces often preferred by this species. The proposed development is unlikely to have a significant impact on this species.

- *Aphelocephala leucopsis* (Southern Whiteface). Listed as **Vulnerable** under the EPBC Act. Not recorded in the survey area. The most-likely habitat within the survey area, *VSA 4 – Eucalypt Woodland* generally lacks the low shrub and herb stratum preferred by this species. Woodlands potentially supporting suitable habitat are extensive in the region. Opportunistically recorded within c. 8 km of the survey area. The proposed development is unlikely to have a significant impact on this species.
- *Nyctophilus major tor* (Central Long-eared Bat). Ranked as **Priority 3** by DBCA. Known to occur in the survey area. Day roost sites are likely to occur in *VSA 3 - Callitris Woodland* and *VSA 4 - Eucalypt Woodland*. While clearing will result in some loss of roosting habitat, it is extensive in the region and therefore the proposed development is unlikely to have a significant impact on this species.

Short range endemic (SRE) invertebrates

Comprehensive surveys were undertaken by Biota (2022). One species of conservation significant invertebrate species has been confirmed present (*Idiosoma kopejtkaorum*, Lake Goorly Shield-backed Trapdoor Spider – Endangered under the WA BC Act) and two could occur (but have not yet been confirmed) within the survey area and surrounds: *Idiosoma formosum* (Ornate Shield-backed Trapdoor Spider) – Endangered under the WA BC Act; and *Aganippe castellum* (Tree-stem Trapdoor Spider) – ranked as Priority 4 by DBCA.

Impact assessment

Overall, the effects of impacting processes are considered to be Minor or Negligible; this is mainly due to targeted management actions (towards species of greatest conservation significance and/or risk), and the continuous, extensive and fairly uniform environment in which the proposed development envelope sits. Potentially minor impacts that may need to be addressed are:

- Mortality of fauna during construction.
- Ongoing mortality.
- Disturbance by dust, noise or light.

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1 Introduction

Crimson Metals Pty Ltd (a subsidiary of Capricorn Metals Ltd) is proposing to recommence mining at the Mount Gibson Gold Project (MGGP), located in the midwest region of Western Australia, approximately 50 km north-east of Wubin and 70 km south-west of Paynes Find (the 'survey area', see Figure 1). The survey area comprises a mining operations area in the east, and a proposed upgraded airport/runway in the west, as shown in Figure 1.

The project was previously operational between 1986 and 1999, and to progress the recommissioning, Crimson Metals requires updated environmental impact assessments of the proposed development areas. Recent assessments of the area include:

- Biota (2022) – a basic and targeted vertebrate and Short-range Endemic (SRE) fauna survey
- Biota (2023) – an addendum to Biota (2022) subsequent an expansion of the study area
- FVC (2023a, 2023b) – detailed flora and vegetation assessments.

The recent fauna studies (Biota 2022, 2023) identified six species of conservation significant vertebrate fauna that are most likely to occur in the survey area:

- *Egernia stokesii badia* (Western Spiny-tailed Skink) – listed as Endangered under the Federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and also as Vulnerable under the Western Australian *Biodiversity Conservation Act 2016* (WA BC Act, see 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* (WA BC Act). In addition, the Western Australian Department of

Biodiversity, Conservation and Attractions (DBCA) recognises priority levels, while local populations of some species may be significant even if the species as a whole has no formal recognition. Therefore, three broad levels of conservation significance can be recognised and are used for the purposes of this report, and are outlined below. A full description of the conservation significance categories, schedules and priority levels mentioned below is provided in Appendix 2.

Conservation Significance (CS) 1: Species listed under State or Commonwealth Acts.
Species listed under the EPBC Act are assigned to categories recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN 2012), or are listed as migratory. Migratory species are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA), the Republic of South Korea Australia Migratory Bird Agreement (ROKAMBA), and/or the Convention on the Conservation of Migratory Species of Wild Animals (CMS; also referred to as the Bonn Convention). The *Wildlife Conservation Act 1950* uses a series of seven Schedules to classify conservation status that largely reflect the IUCN categories (IUCN 2012).

Conservation Significance (CS) 2: Species listed as Priority by DBCA but not listed under State or Commonwealth Acts.
In Western Australia, DBCA has produced a supplementary list of Priority Fauna, being species that are not considered threatened under the *Biodiversity Conservation Act 2016* 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 2024b). The EEZ extends to 200 nautical miles (approximately 350 kilometres) from the coast (DAWE 2024b). 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 2024c) 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 survey 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).
- *Cyclodomorphus branchialis* (Gilled Slender Blue-tongue) – Vulnerable under both acts.
- *Leipoa ocellata* (Malleefowl) – Vulnerable under both acts.
- *Falco peregrinus* (Peregrine Falcon) – Specially Protected under the WA BC Act.
- *Nyctophilus major tor* (Central Long-eared Bat) – ranked as Priority 3 by the Department of Biodiversity, Conservation and Attractions (DBCA).
- *Platycercus icterotis xanthogenys* (Western Rosella – inland) – Priority 4.

In addition, one further species, *Aphelocephala leucopsis* (Southern Whiteface), has been very recently listed under the EPBC Act (as Vulnerable) and may also occur in the survey area.

To support the previous studies, Bamford Consulting Ecologists (BCE) was commissioned by Tetris Environmental Pty Ltd (Tetris), on behalf of Crimson Metals, to conduct a detailed vertebrate fauna survey of the MGGP and also to undertake further targeted assessments for species of conservation significance, in particular the Malleefowl and Southern Whiteface. The survey was undertaken in accordance with the Environmental Protection Authority's (EPA) *Technical Guidance - terrestrial vertebrate fauna surveys for environmental impact assessment* (EPA 2020). This report provides the results of those surveys and assesses the likely impacts to fauna as a result of the proposed development.

It should be noted that Biota (2022, 2023) conducted a comprehensive assessment of the short-range endemic invertebrate fauna of the survey area and, as such, only a brief synopsis of their work is provided here.

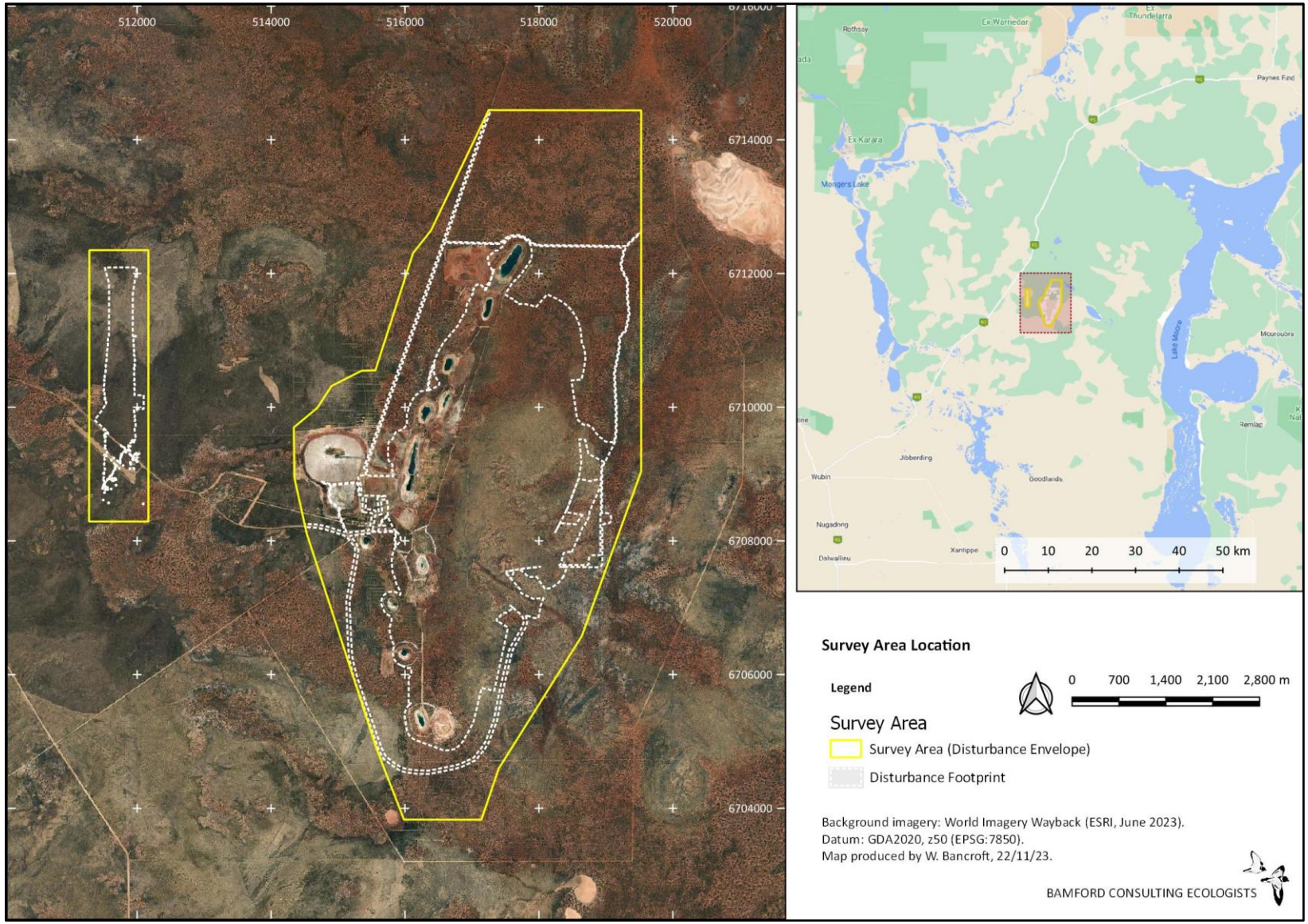

Figure 1. Location of the survey area.

1.1 General approach to fauna impact assessment

The approach to BCE investigations outlined below have been developed with reference to the EPA's *Technical guidance - terrestrial vertebrate fauna surveys for environmental impact assessment* (EPA 2020) and *Environmental Factor Guideline - Terrestrial Fauna* (EPA 2016a).

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).

Descriptions and background information on these values and processes can be found in Appendices 1 to 4. In particular, Appendix 1 explains and defines the fauna values, including the recognition of three classes of species of conservation significance (CS): those listed under legislation (CS1), those listed as priority by the Department of Biodiversity, Conservation and Attractions (DBCA; CS2), and those that can be considered of local or other significance, but which have no formal listing (CS3). Appendix 2 outlines the legal definitions and classes of conservation significance, Appendix 3 describes threatening processes, and Appendix 4 presents the threatening processes recognised under legislation. Not all threatening processes are relevant to the current project.

1.2 Description of survey area and background environmental information

1.2.1 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 2024a). 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 2016b). The survey area is within the Merredin (AVW01) subregion of the Avon Wheatbelt bioregion. This bioregion falls within the Bioregion Group 1 (South-West Botanical Province) classification of EPA (2016b) where native vegetation is "extensively cleared for agriculture".

The Merredin subregion was described by Beecham (2001) and a summary of their work follows here. The Avon Wheatbelt is an area of active drainage dissecting a Tertiary plateau in Yilgarn Craton. Gently undulating landscape of low relief. Proteaceous scrubheaths, rich in endemics, on residual lateritic uplands and derived sandplains; mixed eucalypt, *Allocasuarina huegeliana* and Jam-York Gum woodlands on Quaternary alluvials and eluvials. Within this bioregion, AW1 is an ancient peneplain with low relief, gently undulating landscape. There is no connected drainage; salt lake chains occur as remnants of ancient drainage systems that now only function in very wet years. Lateritic uplands are dominated by yellow sandplain. Climate is Semi-arid (Dry) Warm Mediterranean.

Whilst the survey area is technically in the Avon Wheatbelt bioregion, it shares very similar characteristics to the vegetation and soil types of the adjacent Yalgoo bioregion, which is described by Desmond and Chant (2003). The Avon Wheatbelt bioregion is an interzone between the South-western Bioregions and Murchison. It is characterised by low woodlands to open woodlands of *Eucalyptus*, *Acacia* and *Callitris* on red sandy plains of the Western Yilgarn Craton and southern Carnarvon Basin. The latter has a basement of Phanerozoic sediments. Mulga, *Callitris-E. salubris*, and Bowgada open woodlands and scrubs on earth to sandy-earth plains in the western Yilgarn Craton.

1.2.2 Land systems and vegetation complexes

Mitchell *et al*. (1979) have defined and described the land systems that occur in the survey area and the mapping of these is provided by DPIRD (2024a). The survey area is located over four of these:

- Doney Land System: Alluvial plains; Eucalypt woodlands and halophytic understorey;
- Euchre Land System: Mesas, breakaways and stony plains; Acacia or eucalypt woodlands and halophytic shrublands;
- Joseph Land System: Sandplains; Acacia, mallees and heath; and
- Pindar Land System: Wash plains; Eucalypt woodlands with non-halophytic understorey.

FVC (2023a, 2023b) also provided detailed vegetation mapping ,and description of soils and land systems for the survey area.

1.2.3 Land use and tenure

The dominant land uses within the Avon Wheatbelt 1 (AVW01) subregion are cultivation – dry land agriculture and grazing – Improved pastures (dryland), with lesser areas of UCL and Crown reserves, conservation, rural residential and mining (Beecham 2001). The survey area lies in the central-eastern sector of the subregion. At the local scale, the survey area is surrounded by areas of continuous native vegetation.

1.2.4 Recognised sensitive sites

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

One Commonwealth listed Threatened Ecological Community (TEC) and State listed Priority Ecological Community (PEC) was found to occur within the survey area (FVC 2023a):

- Eucalypt Woodlands of the Western Australian Wheatbelt.

1.2.5 Climate information

The survey areas falls within the Köppen climate classification of 'Hot semi-arid climate (*Bsh*)', which is characterised by hot, or sometimes extremely hot, summers and warm to cool winters, with some to minimal precipitation. Hot semi-arid climates are most commonly found around the fringes of subtropical deserts (Anon. 2022; BOM 2022a).

For the Merredin (AVW01) subregion, climate is "Semi-arid (Dry) Warm Mediterranean" (Beecham 2001).

Climate averages (temperate, rainfall, sunshine) for the survey area, as provided by BOM (2024), are presented in Table 1.

Table 1. Climate averages for the survey area.

Data from BOM (2024) for:
Site name = PAYNES FIND
Site number = 007139

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years	
Temperature															
Mean maximum temperature (°C)	37.3	36.3	33.1	28.3	23.3	19.3	18.6	20.2	24.0	28.0	32.0	35.3	28.0	40	1975 2024
Mean minimum temperature (°C)	21.0	21.0	18.4	14.1	9.4	6.5	5.4	6.1	8.2	11.5	15.6	18.6	13.0	40	1975 2024
Rainfall															
Mean rainfall (mm)	20.8	24.5	27.3	24.5	34.9	39.5	34.6	27.5	14.0	10.5	12.5	11.8	281.4	63	1919 2024
Decile 5 (median) rainfall (mm)	8.9	12.0	12.5	16.6	22.6	30.6	30.9	23.4	13.7	6.2	7.9	5.9	287.0	63	1919 2024
Mean number of days of rain ≥ 1 mm	1.5	1.4	1.5	1.7	2.6	3.7	3.6	3.0	1.8	1.2	1.2	1.0	24.2	63	1919 2024

2 Methods

2.1 Overview

2.1.1 Spatial terminology

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

- Study area – the outermost boundary of the desktop assessment that is almost always a specified buffer distance (see Section 2.2.1 below) around the *survey area*. The study area thus encompasses the *survey area* but includes the area from which databases are sourced.
- Survey area – the *survey area* is the area to which the results of the desktop analysis are directed and/or the area within which field investigations are conducted. Note that while the term '*survey area*' is used throughout the guidance provided by EPA (2020), it does not appear to be explicitly defined and, therefore, the above definition has been developed with interpretation of both the guidance and BCE report structure.
- Project area – this may be equivalent to the *survey area* but is strictly the land over which the proponent has tenure or some control and within which on-site impacts may occur.
- Development footprint – the expected extent of land clearing and/or development.

2.1.2 Level of investigations

The approach to terrestrial fauna 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, 2016b, 2016a, 2020), and Commonwealth biodiversity legislation (DotE 2013; DSEWPaC 2013). 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 a 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 Swan Coastal Plain and Jarrah Forest, but also recommending that site and project characteristics be considered. These include: survey objectives, existing available data, information required, presence of significant species, the scale and nature of the potential impacts of the proposal and the sensitivity of the surrounding environment in which the disturbance is planned (including extent of existing regional impact). The EPA (2016b) also indicates that the scale and nature of the proposal can be used to determine the appropriate level of investigations, with, for example, large scale projects requiring higher levels of investigations. This sort of advice from the EPA (2016b, 2020) provides a framework for determining the appropriate level of field investigations. Combined with some other factors based on long experience in fauna investigations for impact assessment, this framework is applied to the current project in Table 2. The results of this application are summarised in Table 3.

Although the 'basic'/'targeted' levels of survey conducted by Biota in 2021 and 2022 are considered appropriate for the project (see Table 2 and Table 3), the more comprehensive 'detailed' and 'targeted' level surveys have been conducted across the survey area. Tetris Environmental requested that a detailed level survey be conducted following the site inspection, in recognition of the value of additional data and as a precaution to ensure compliance with guidance (EPA 2016a, 2020).

Table 2. Assessment of site and project characteristics for level of assessment.

Note that factors are taken from EPA (2020).

Factor: site and project characteristic	Rationale for decision on level of investigations	Application to current project
Level of existing regional knowledge.	*Existing data reduces need for baseline survey. Similarity/uniformity of environments need to be high to extrapolate from regional knowledge.*	Extensive regional knowledge. Previous, project-specific basic, detailed and targeted investigations by Biota in 2021 and 2022.
Type and comprehensiveness of recent local surveys.	*Previous surveys, if adequate, will provide extensive baseline data and therefore reduce the need for additional baseline survey effort. Similarity/uniformity of environments need to be high to extrapolate from regional knowledge.*	Range of studies undertaken in region and in similar landscapes, with a wide range of detection techniques (trapping, cameras, aural, searching). Summarised by Biota (2022).
Degree of existing disturbance or fragmentation at the regional scale.	*The type and scale of existing impacts affect the need for survey. A broadly degraded landscape may need less effort due to the likely loss of biodiversity, but a fragmented landscape may need greater effort as remaining biodiversity may be high in remnant vegetation and this can be an important value to confirm.*	Broad landscape is intact and well-connected. Some previous open cut mining disturbance exists though does not cause significant fragmentation.
Extent, distribution and significance of environments	*In general, rare, unusual, restricted and/or environments linked to significant species need more investigation that broad and widely-represented environments due to their likely higher significance for fauna.*	Survey area supports vegetation and soils that are typical of the broader region and well-represented in adjacent reserves.
Significance of species likely to be present	*Species of conservation significance require additional effort to confirm their presence (if possible; or likelihood of presence), and the identification of habitats and processes, such as connectivity, important for them.*	Limited range of significant species present. Desktop review suggests many significant species are now locally extinct. Vertebrate species that may require investigation during detailed field survey are: Gilled Slender Blue-tongue, Western Spiny-tailed Skink, Malleefowl, Western Rosella – inland, Peregrine Falcon, Southern Whiteface and Central Long-eared Bat. Malleefowl, Peregrine Falcon and Central Long-eared Bat recorded by Biota (2022, 2023). Despite extensive searching, the Gilled Slender Blue-tongue and Western Spiny-tailed Skink were not recorded by Biota in either 2021 or 2022 surveys.

Factor: site and project characteristic	Rationale for decision on level of investigations	Application to current project
		Conservation significant invertebrates possible but addressed separately by Biota (2022, 2023).
Sensitivity of the environment to the proposed action.	*Sensitivity is complex. Environments can be considered sensitive to impacts if the environments are restricted, fragmented or vulnerable to change such as hydrological change or any other alteration caused by the action. Off-site environments may need to be considered.*	Low level of sensitivity as the landscapes present are broadly-represented and continuous in adjacent reserves.
Scale and nature of impact. Geographic position.	*How big is the impact; what proportion of surrounding environments will be impacted; is the impact loss or modification; will there be rehabilitation (i.e. is the impact a permanent change or can at least some fauna values return?); is the impact ongoing (e.g. long-term change to hydrology or a high proportion of the landscape altered). More information on fauna is needed in situations such as where the impact area is large or proportionally large, impacts are upon significant environments and or fauna assemblages, and where baseline data may be needed for ongoing management.*	The impact area is small in a regional context, due to the large reserve system nearby. Some level of rehabilitation is expected.
Potential value of presence, abundance and distributional data.	*There is low value in confirming the presence of common and widespread species within their known range unless this forms part of on-going monitoring such as of rehabilitation, impacts of management or to monitor on-site and/or off-site impacts. There is value where even widespread and common species are very poorly-known or where records even of such species are of conservation interest (islands, highly fragmented landscapes). There is generally high value in developing an understanding of significant species in an area. There is value if data address an ecological question (such as impact of fire).*	Generally low value in obtaining distributional data as the fauna assemblage is already well-known. There is value in and abundance and habitat data if rehabilitation is to be monitored.

Table 3. Level of assessment suggested for the project.

- Low – a low level of additional assessment suggested by the factor. Site inspection.
- Moderate - a moderate level of additional assessment suggested by the factor. Site inspection and targeted surveys.
- High - a high level of additional assessment suggested by the factor. Site inspection, targeted and detailed surveys.

Factor: site and project characteristic	Suggested intensity of assessment
Level of existing regional knowledge.	Moderate
Type and comprehensiveness of recent local surveys.	Moderate
Degree of existing disturbance or fragmentation at the regional scale.	Low
Extent, distribution and significance of environments.	Low
Significance of species likely to be present.	Low
Sensitivity of the environment to the proposed action.	Low
Scale and nature of impact.	Low
Potential value of presence, abundance and distributional data.	Moderate

2.2 Desktop assessment

Biota (2022) conducted a desktop assessment of the vertebrate fauna of the survey area and, following a revision of the proposed development areas by Crimson Metals, this was revisited by Biota (2023). The findings of the Biota studies were used to guide the investigations conducted here.

2.2.1 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 2023. The authorities used for each vertebrate group were: fish (Morgan *et al.* 2014), frogs (Doughty 2023), reptiles (Doughty and Thorn 2023), birds (BirdLife Australia 2022; Gill *et al.* 2024), and mammals (Travouillon 2023). 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 and all English species names are treated as proper nouns (as recommended by most authorities). 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 Field investigations

2.3.1 Overview

The field investigations comprised 'detailed' surveys for terrestrial vertebrates (including pitfall and funnel trapping, bird censusing, motion-sensitive camera trapping and spotlighting) and targeted surveys for species of conservation significance (as identified by Biota 2022, 2023) that are considered to be of most concern (Malleefowl; but also including the Southern Whiteface that has been listed since the Biota investigations). Detailed methodology is presented below.

2.3.2 Dates

The field investigations were predominantly undertaken between the 30th October and 7th November 2023.

2.3.3 Permits

Field investigations were conducted under Department of Primary Industries and Regional Development's Wildlife Animal Ethics Committee (WAEC) Permit number WAEC 23-11-26, and also under the Department of Biodiversity, Conservation and Attractions' Fauna taking (scientific or other purposes) Regulation 27 licence number BA27000966.

2.3.4 Pitfall and funnel trapping

Seventy pitfall traps, arranged in seven transects of ten traps each, were located throughout the survey area as shown in Figure 2. Funnel traps were placed at every second pitfall trap location (all odd-numbered points). Co-ordinates of the trap locations are provided in Appendix 5.

Transect locations were selected to sample the major vegetation and substrate associations (VSA) present in the survey area:

- Site 1. Acacia Shrubland on pale brown/raw umber sandy loam with some coarse gravel; gravel forms a compacted layer at a depth of 30-40 cm. Vegetation included *Borya* and a dryland sedge.
- Site 2. Acacia Shrubland on pale brown/raw umber sandy loam with some coarse gravel through soil profile and a distinct gravel veneer in places. Vegetation included a lot of dryland sedge in parts and a few scattered, small mallee. The site slopes up to the east where gravel is more compacted.
- Site 3. Open Mallee Woodland and scattered *Callitris* over *Acacia* tall shrubland to low woodland on red-brown/burnt umber loam with little gravel but tending to a hardpan at a depth of 30-40 cm. Evidence of fire (dead *Callitris*) probably less than 10 years previously.
- Site 4. Callitris Woodland over a mixed tall shrubland of *Acacia* and *Melaleuca*, and included scattered tall eucalypts. Soil is a red-brown/burnt umber loam with a calcrete layer at a depth of 30-40 cm. Evidence of fire (dead *Callitris*) probably less than 10 years previously.
- Site 5. Eucalypt Woodland of Salmon Gum and York Gum over a low, mid-open shrubland of Bluebush. Considerable number of dead fallen trees and branches. Soil is a red-brown/burnt umber clay or clayey loam with compacted clay at a depth of about 20 cm and a calcrete layer at a depth of 30-40 cm in places.
- Site 6. Allocasuarina Shrubland. Tall, closed shrubland with considerable plant death on pale yellowish sands and sandy loam.
- Site 7. Mallee Woodland over *Acacia* shrubland on red sandy-loam.

Pitfall traps (20 litre buckets) were fenced with three 1.2 m flywire drift-fences, extending radially from the bucket, to assist capture success. Where present, funnel traps were positioned along one of these fences, with a further fence segment extending beyond the trap. Soil and artificial shelter (usually neoprene stubby holders) was provided within pitfall traps and shades were placed over funnel traps.

Traps were operated for six nights. Therefore, there was a total sampling effort of 420 pitfall and 210 funnel trap-nights.

Traps were checked within the first three hours of sunrise each day, with captured fauna identified and released near the point of capture. In some cases (hotter days) traps were checked a second time in the late morning (before midday).

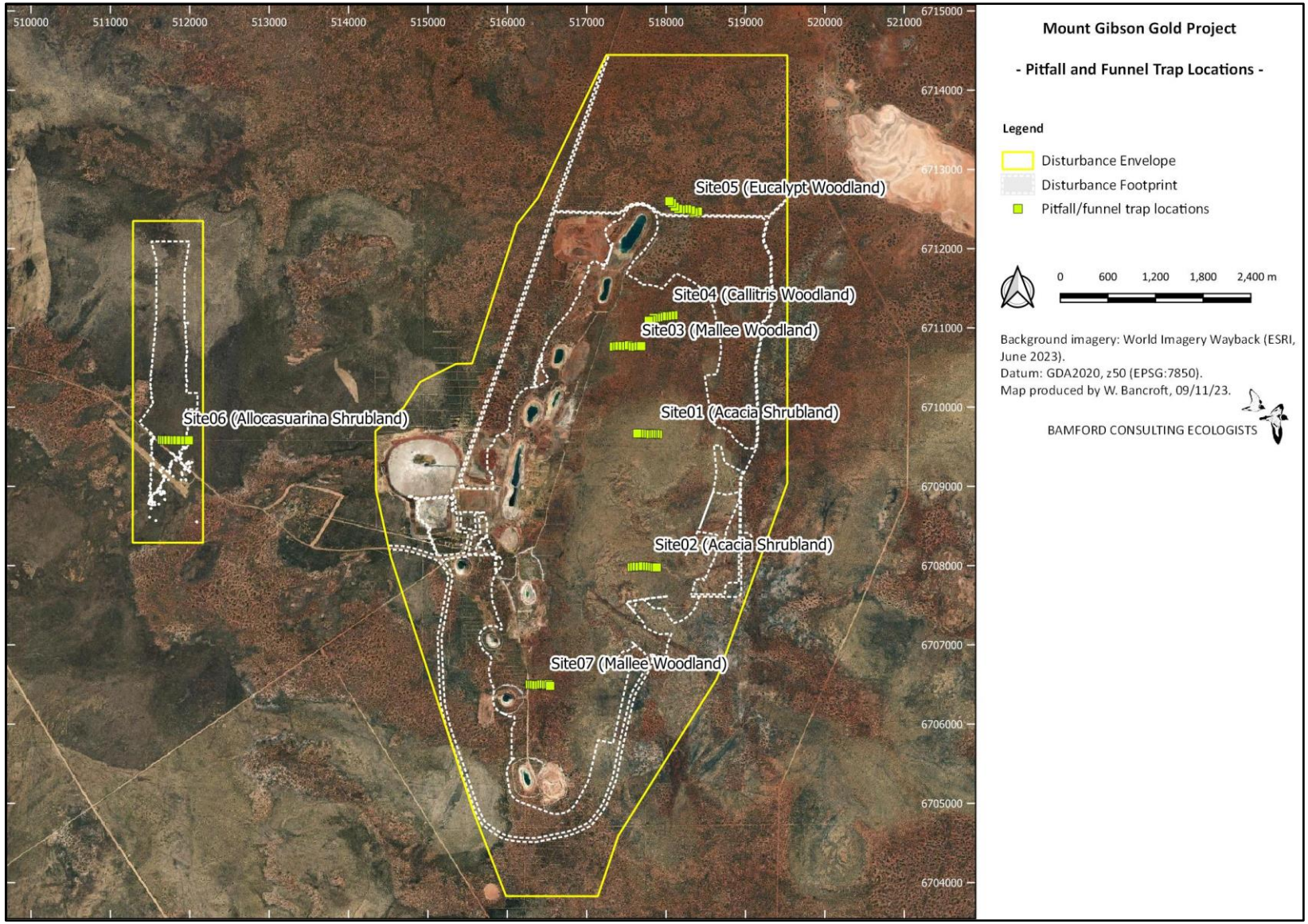

Figure 2. Pitfall and funnel trap locations.

2.3.5 Bird censussing

Transects counts for birds (Recher 1988) were made at each of the seven pitfall and funnel-trap sampling sites (Figure 2), in conjunction with trap checking. The trap line constituted the mid-line of the transect with all birds detected (either by sight or sound) recorded, and all birds within 25 metres of the mid-line counted. Bird surveys were undertaken within the first three hours of daylight and typically took c. 30 minutes to complete. Survey timings were alternated among the sites to ensure that all sites were censused at different times. Six bird transect counts were completed at each site. As a result, 42 transect counts were made.

2.3.6 Motion-sensitive camera trapping

Motion-sensitive cameras were used to survey for several species of threatened (or locally conservation significant) mammals that may occur (having been reintroduced within the adjacent Mount Gibson Wildlife Sanctuary) including Greater Bilby, Numbat, Woylie (Brush-tailed Bettong), Western Barred Bandicoot, Red-tailed Phascogale, Greater Stick-nest Rat, Banded Hare-Wallaby, Shark Bay Mouse, Brushtail Possum and Chuditch, as well as feral mammal species that may have major conservation implications (e.g. Rabbit, Fox and Cat). The motion-sensitive cameras were also aimed to target Malleefowl.

Eleven motion-sensitive cameras were set up in the survey area, and surrounds, as shown in Figure 3. The co-ordinates of the camera locations are provided in Appendix 5.

Nine of the eleven cameras were associated with the pitfall and funnel trapping sites, and were deployed on the 2nd November 2023. Cameras were also placed along the entry road (BCE01) and adjacent to the camp (BCE40) on the 7th November 2023. All cameras were retrieved on the 6th December 2023; equating to 34 (nine cameras) or 29 (two cameras) trap-nights per camera and a total effective sampling effort of 364 camera-trap-nights.

Cameras were generally positioned on a southerly-facing angled branch or trunk (to avoid direct sun exposure into the camera lens), facing the ground and, where appropriate, directed towards notable landscape features such as fallen logs, rock piles or edges of thickets of dense vegetation. A non-reward lure was placed at each camera location to attract animals. These comprised a tethered PVC bait tube containing universal bait (a mixture of sardines, rolled oats, peanut paste and tuna oil). Bait tubes were positioned in the view of the camera and attached to a solid object.

Camera results were recorded as events to give a measure of the abundance of each species at each camera. An event is one or more images of an animal judged to be taken as part of one visit to the camera. For example, there might be 10 photographs of a single Malleefowl taken over a period of five minutes. A separate event (i.e. visit) is considered to occur if a period of more than approximately five minutes elapses before the next photograph is taken. The number of events thus gives a measure of activity at a camera site.

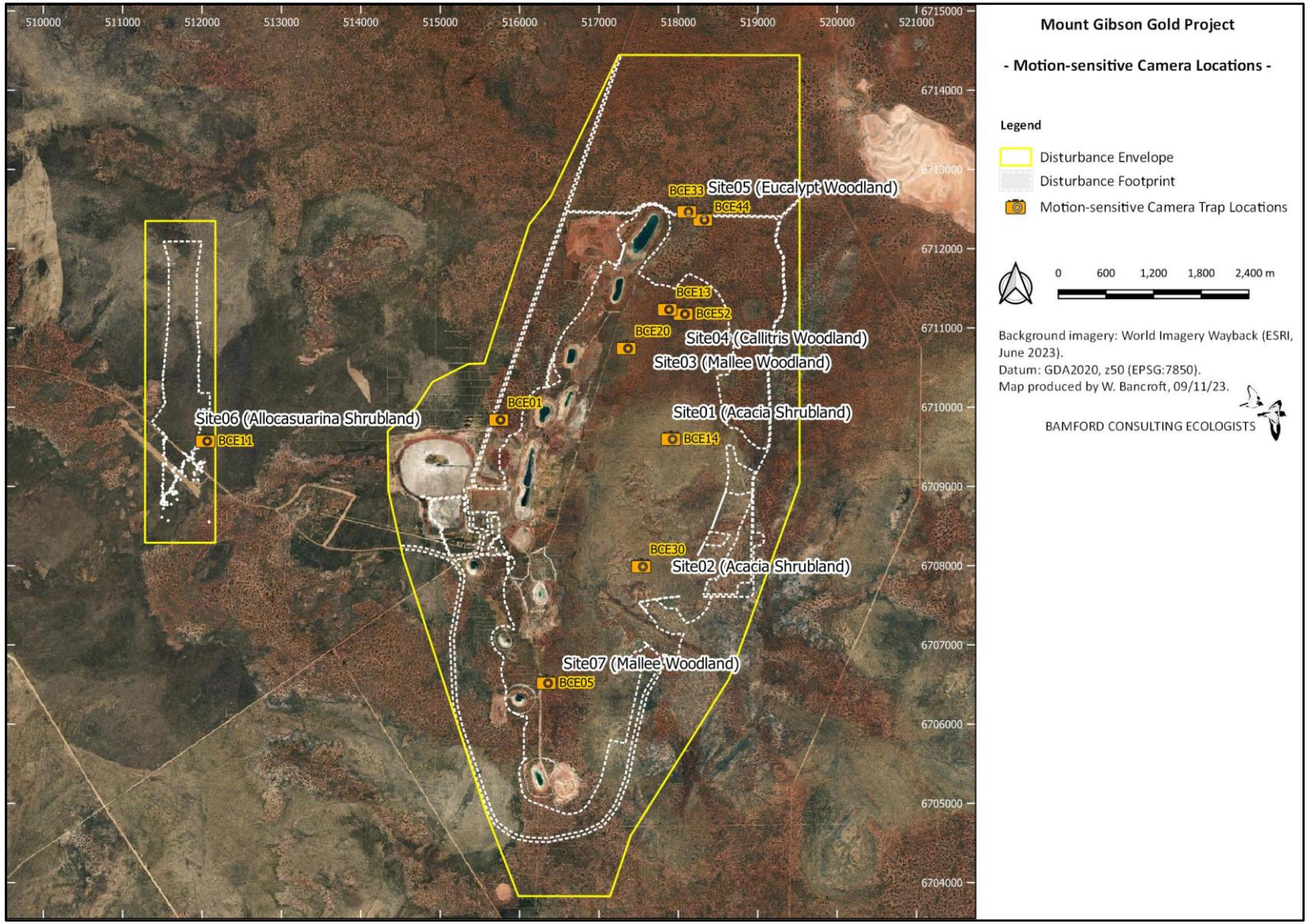

Figure 3. Motion-sensitive camera locations.

2.3.7 Malleefowl nest mound survey

The survey was conducted with reference to the *National Manual for The Malleefowl Monitoring System: Standards, Protocols and Monitoring Procedures* (NHT 2007), the *National Recovery Plan for Malleefowl* (Benshemesh 2007) and the *Survey Guidelines for Australia's Threatened Birds* (DSEWPaC 2010).

Previous surveys at the site (Biota 2022, 2023) have identified (using lidar and high resolution aerial imagery) the locations of likely Malleefowl mounds in the area (see Figure 4 for the lidar survey area) some of which have been subsequently verified or assessed for Malleefowl activity. In addition, other mounds have been recorded opportunistically by staff or contractors as they have been working on site. Known nest mounds within the survey area (the co-ordinates of which are provided in Appendix 6) were re-visited and re-examined (for signs of activity) and scored for mound profile and age, as described below:

Mound Profile

The profile of a Malleefowl mound changes with breeding activity and age (erosion and vegetation growth). A number of profile stages are classified according to age (NHT 2007):

- Profile 1: Typical crater with raised rims. This is the typical shape of an inactive nest. However, this is also the profile of a mound being worked early in the breeding season;
- Profile 2: Nest fully dug out. The characteristic of this profile is that the crater slopes down steeply and at the base the sides drop vertically to form a box- like structure with side usually 20 to 30 cm deep. Often, litter will have been raked into windrows, and may have started to enter the nest;
- Profile 3: Nest with litter. This is the next stage after profile 2. Litter will have been raked into the nest by Malleefowl, and thick layers of litter are evident on the surface. There may or may not be sand mixed with the litter at this stage;
- Profile 4: Nest mounded up (no crater). This is the typical profile of an active but unopened Malleefowl nest. The active mound is closed and dome shaped;
- Profile 5: Nest a crater with peak in centre. This is a typical profile of an active nest which is in the process of being closed by Malleefowl; and
- Profile 6: Nest low and flat without peak or crater. This mound has not been used for some time and weathering and erosion have 'flattened" the original mound.

Mound Age

- Active: Fresh scratching, Malleefowl scats, loose soil, mound may be dug out in preparation for the breeding season or mounded for breeding;
- Recently used (1-5 years): Mound contains signs of recent activity (e.g., eggshell fragments) and mound may still contain large amounts of leaf litter if not excavated. Soil surface compacted, mound structure intact with well-defined central depression. No vegetation colonising mound;
- Moderately old (5-20 years): No recent activity, mound compacted. Surface of mound showing some weathering and some minor plant colonisation possibly present. Mound profile raised; central depression defined;

- Old (20-100 years): Mound moderately to very weathered, often with a veneer of gravel on the slopes because of removal of fine materials from the surface. Extensive plant colonisation. Mound profile raised; no or minimal central depression; and
- Very old (100+ years): Mound very weathered, with a low profile. Bushes and even small trees growing on mound. No central depression.

Surveyors also looked for direct (e.g. sighting, calls) or secondary evidence (feathers, tracks, droppings) of Malleefowl presence.

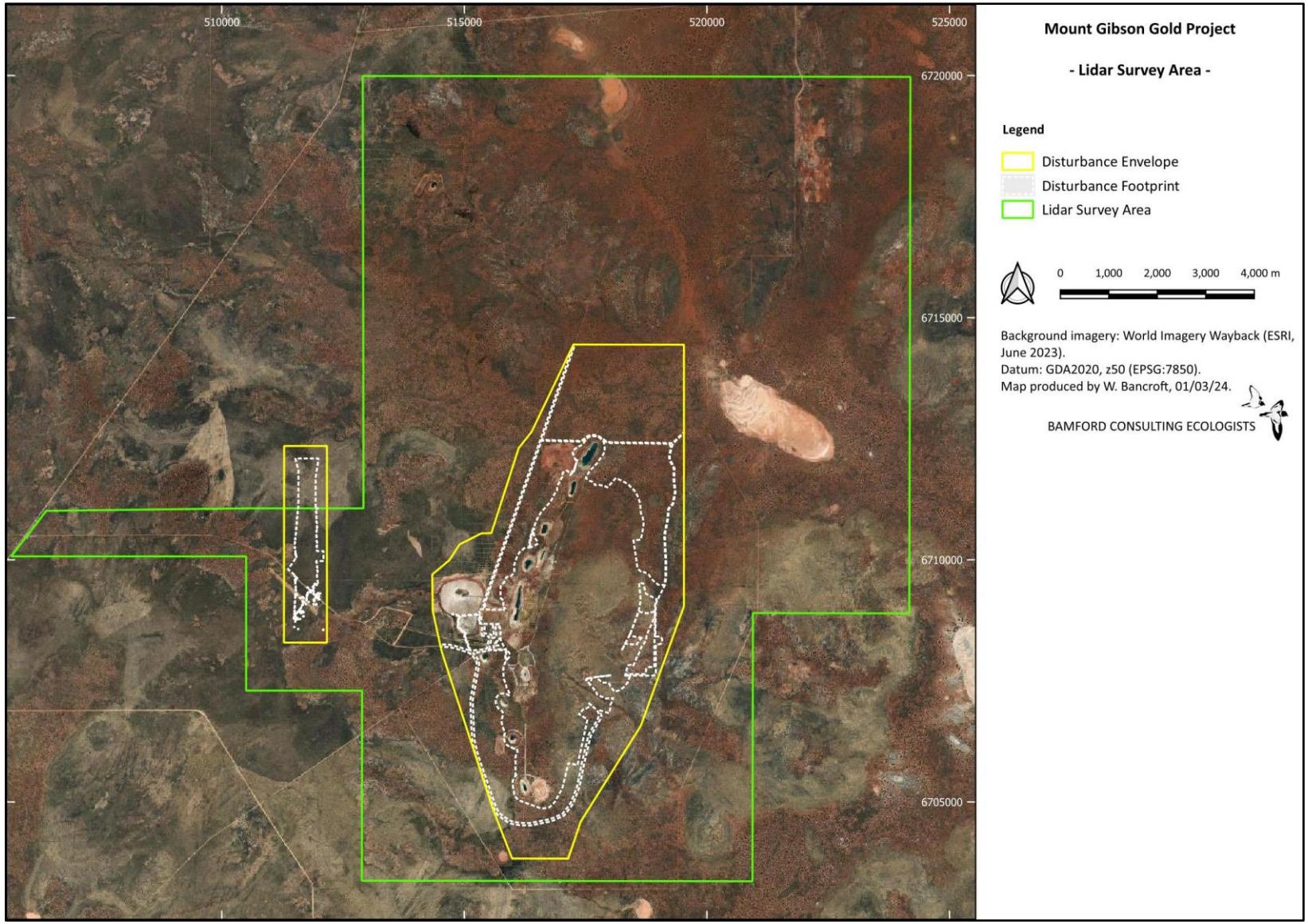

Figure 4. Lidar survey area.

2.3.8 Southern Whiteface surveys

DCCEEW (2023) stated that the Southern Whiteface inhabits "… a wide range of open woodlands and shrublands where there is an understorey of grasses or shrubs, or both. These areas are usually in habitats dominated by acacias or eucalypts on ranges, foothills and lowlands, and plains." In addition, DCCEEW (2023) define 'habitat critical to the survival of the Southern Whiteface' as:

- relatively undisturbed open woodlands and shrublands with an understorey of grasses or shrubs, or both;
- habitat with low tree densities and an herbaceous understorey litter cover which provides essential foraging habitat;
- living and dead trees with hollows and crevices which are essential for roosting and nesting.

Surveys for Southern Whiteface were conducted in suitable habitat within the survey area, either standalone or in conjunction with other work (e.g. Malleefowl mound surveys). Corresponding survey tracks are shown in Figure 5. Personnel kept watch out for the species at all other times, including when travelling between sampling locations (often at a slow speed). Transit tracks are shown in Figure 6.

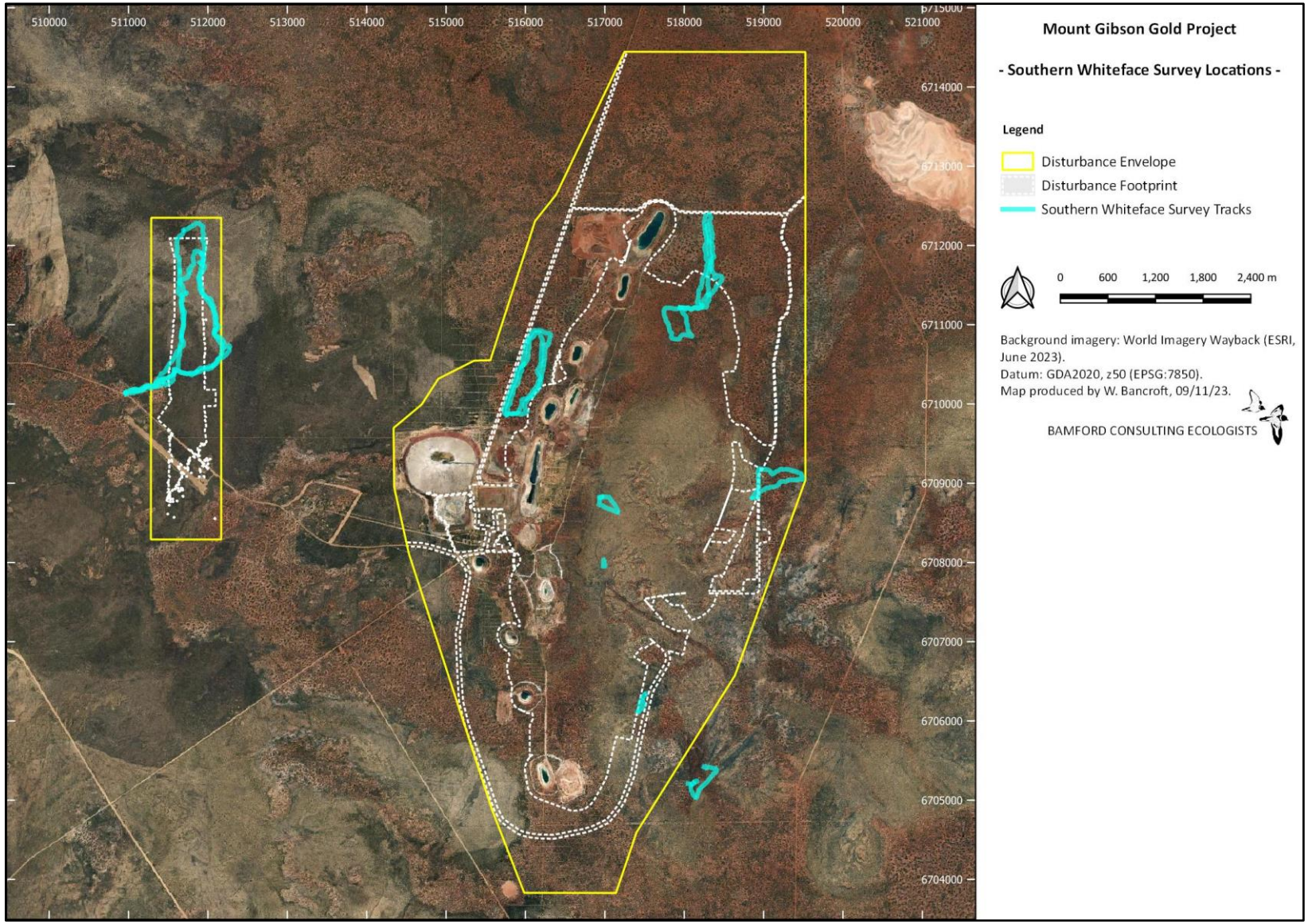

Figure 5. Southern Whiteface survey tracks.

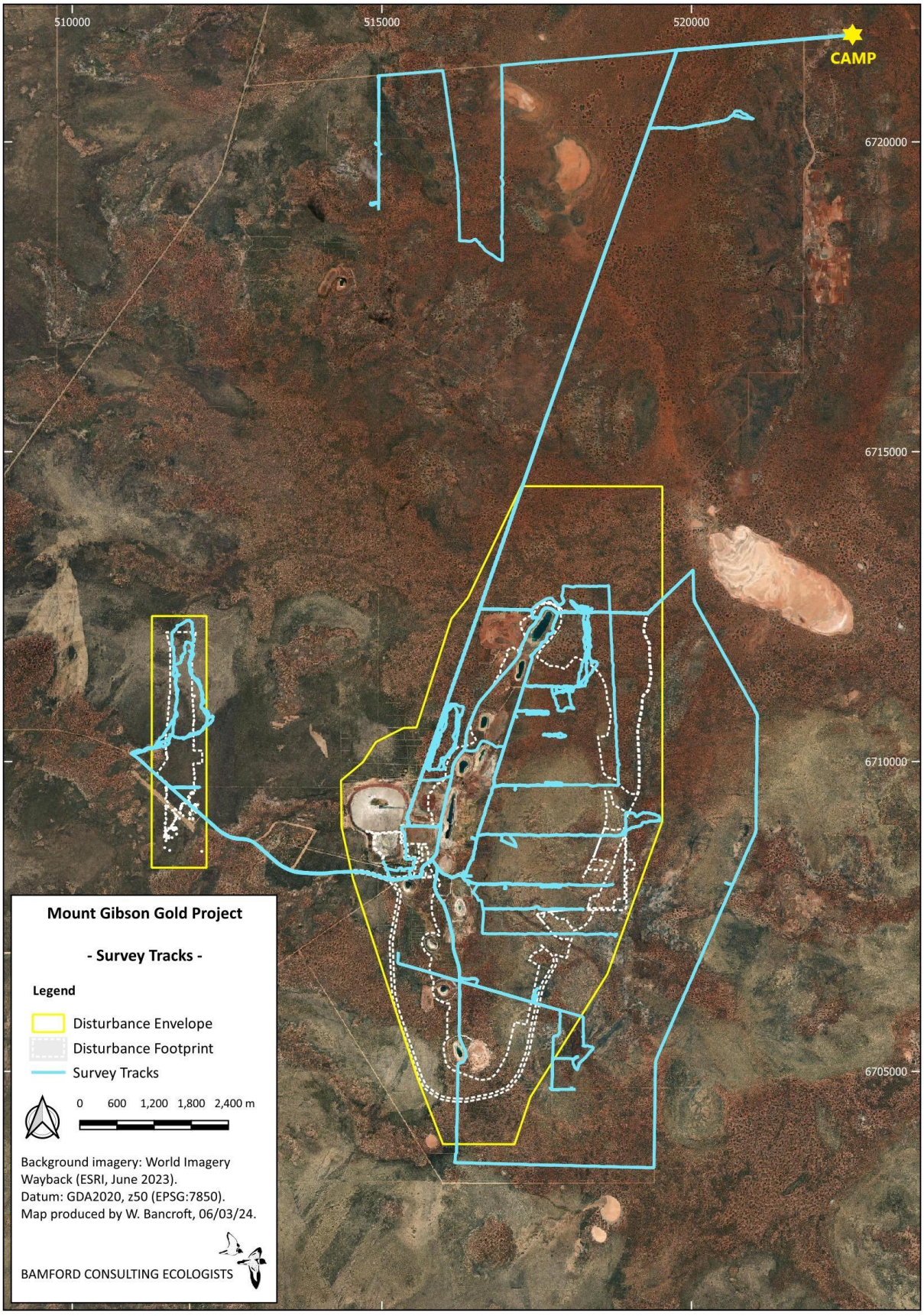

Figure 6. Transit tracks.

2.3.9 Spotlighting

Spotlighting involved searching for nocturnal animals at night, on foot and using a head-torch. Two of the pitfall trapping sites within the survey area were targeted for these investigations: Site 5 (on 01/11/2023) and Site 4 (on 03/11/2023). See Figure 2 for site locations.

2.3.10 Opportunistic observations

At all times, observations of fauna were noted when they contributed to the accumulation of information on the fauna of the site. These included such casual observations as reptiles, birds or mammals seen while travelling through and near the site.

2.3.11 Survey limitations

The EPA's technical guidance for terrestrial fauna surveys (EPA 2020) outlines a number of limitations that may arise during field investigations for Environmental Impact Assessment (EIA). These survey limitations are discussed in the context of the BCE investigation of the survey area in Table 4.

Table 4. 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 Biota 2022). Not a limitation.
Competency/experience of the survey team, including experience in the bioregion surveyed.	Field and reporting personnel have extensive experience in the region and with fauna investigations for impact assessment (see Table 5). Not a limitation.
Scope of the survey, e.g. were faunal groups excluded from the survey.	The investigations here focused on terrestrial vertebrate fauna and fauna values, including significant species. Scope was to target information on significant species and to provide an indicative assemblage. Not a limitation.
Timing, weather and season.	Daily maxima were very high through some of the survey period and the region appears to have had below-average rainfall for 2023. The results of the field investigations reflect this. Not a limitation.
Disturbance that may have affected results, e.g. Fire, flood.	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 survey area was well-covered in the site inspection and detailed investigations, with all major 'fauna habitats' (vegetation and substrate associations) sampled. Not a limitation.
Access problems.	There were no access problems encountered. Not a limitation.

EPA Survey Limitations	BCE Comment
Problems with data and analysis, including sampling biases.	There were no data problems. Not a limitation.

2.4 Personnel

Personnel involved in the field investigations and report preparation are listed in Table 5.

Table 5. Personnel involved in the field investigations and report preparation.

Personnel	Consulting Experience	Field Investigations	Report Preparation
Dr Mike Bamford *BSc (Biology), Hons (Biology), PhD (Biology)*	43 years	+	+
Dr Wes Bancroft *BSc (Zoology/Microbiology), Hons (Zoology), PhD (Zoology)*	26 years	+	+
Dr Jamie Wadey *BSc (Zoology/Ecology), Hons (Ecology), PhD (Movement Ecology)*	8 years	+	
Mr Nathan Ducker *BEd*	2 years	+	
Mr James Hesford *BSc* (*Env. Science/Biology*) – Tetris Environmental	25 years	+	

2.5 Presentation of results for Impact Assessment

While some impacts are unavoidable during a development, of concern are long-term, deleterious impacts upon biodiversity. This is reflected in documents such as the Significant Impact Guidelines provided by DoTE (2013), 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.

2.5.1 Criteria for impact assessment

Impact assessment criteria are based on the severity of impacts on the fauna assemblage and conservation significant fauna, and quantified on the basis of predicted population change (Table 6). 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 (2016b) suggested that the availability of fauna habitats within a radius of 15 km can be used as a basis to predict low, moderate or high impacts. In this case, a high impact is where the impacted environment and its component fauna are

rare (less than 5% of the landscape within a 15 km radius or within the Bioregion), whereas a low impact is where the environment is widespread (e.g. >10% of the local landscape). Under the Ramsar Convention, a wetland that regularly supports 1% of a population of a waterbird species is considered to be significant. These provide some guidance for impact assessment criteria. In the following criteria (Table 6), 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.

Table 6. 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.

2.6 Mapping and spatial data

Low resolution maps have been provided within the body this report. Higher resolution maps and GIS files can be supplied if required. While the recommendation of the EPA (2020) was that maps use the GDA94 datum (and are projected into the appropriate Map Grid of Australia (MGA94) zone), this has been superseded by the GDA2020 (projected to MGA2020) datum used here (and recommended by DWER 2023).

3 Fauna values

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

Vegetation and substrate associations within the survey area are a mosaic, largely reflecting soil types and topography. Biota (2022) outlined 'fauna habitats' within the survey area and FVC (2023a, 2023b) provided a detailed assessment of the vegetation within the survey area. From these and observations made during the field investigations described in this report, eight major vegetation and substrate associations (VSAs) were identified in relation to fauna in the survey area:

VSA 1. Acacia Shrubland. Shrublands (or tall shrublands) dominated by *Acacia* spp. (e.g. *A. acuminata*, *A. effusifolia*) with occasional *Allocasuarina acutivalvis* subsp. *acutivalvis* on pale brown/raw umber sandy loam with some gravel. Gravel forms a hard layer at a depth of about 30cm. See Plate 1 and Plate 2.

VSA 2. Allocasuarina Shrubland. Tall shrubland dominated by *Allocasuarina acutivalvis* subsp. *acutivalvis* with some *Acacia* spp. (e.g. *A. effusifolia*, *A. longispinea*) on pale yellowish sands and sandy loam. See Plate 3.

VSA 3. Callitris Woodland. Low woodland of *Callitris columellaris* with occasional eucalypts over a diverse and varied shrub storey on red-brown/burnt umber loam. See Plate 4.

VSA 4. Eucalypt Woodland. Open woodland dominated by *Eucalyptus* spp. (e.g. *E. loxophleba* subsp. *supralaevis*, *E. salmonophloia*, *E. salubris*) over a low, mid-open chenopod shrubland (including *Olearia muellerii*, and *Maireana* spp.) on red-brown/burnt umber clay or clayey loam. Considerable number of dead fallen trees and branches. See Plate 5.

VSA 5. Mallee Woodland. Open woodland dominated by *Eucalyptus* spp. (e.g. *E. capillosa*, *E. horistes*, *E. kochii*, *E. leptopoda* subsp. *arctata*) over *Acacia* spp. shrubland on red-brown/burnt umber loam or red sandy loam. See Plate 6 and Plate 7.

VSA 6. Mixed Shrubland. Complex shrubland often with dominant *Melaleuca* spp.

VSA 7. Rehabilitation. Previously mined or disturbed areas that have been rehabilitated.

VSA 8. Cleared. Cleared or disturbed areas.

The extent of the VSAs in the survey area is mapped in Figure 7. All VSAs except VSAs 6, 7 and 8 were sampled with pitfalls, funnels, cameras and bird censussing (see Figure 2 and Figure 3). VSA 7 (rehabilitation) and VSA 8 (cleared) were not included in sampling as they were degraded and expected to be of low value for fauna. VSA 6 (Mixed Shrubland) was not sampled as it was only a small area located immediately adjacent to previous mining (Figure 7) and similar to VSA 1 (Acacia Shrubland) in structure, floristics and soil, except with a higher representation of *Melaleuca* species in the shrub stratum.

Plate 1. VSA 1: Acacia Shrubland (Trapping Site 1).

Plate 2. VSA 1: Acacia Shrubland (Trapping Site 2).

Plate 3. VSA 2: Allocasuarina Shrubland (Trapping Site 6).

Plate 4. VSA 3: Callitris Woodland (Trapping Site 4).

Plate 5. VSA 4: Eucalypt Woodland (Trapping Site 5).

Plate 6. VSA 5: Mallee Woodland (Trapping Site 3).

Plate 7. VSA 5: Mallee Woodland (Trapping Site 7).

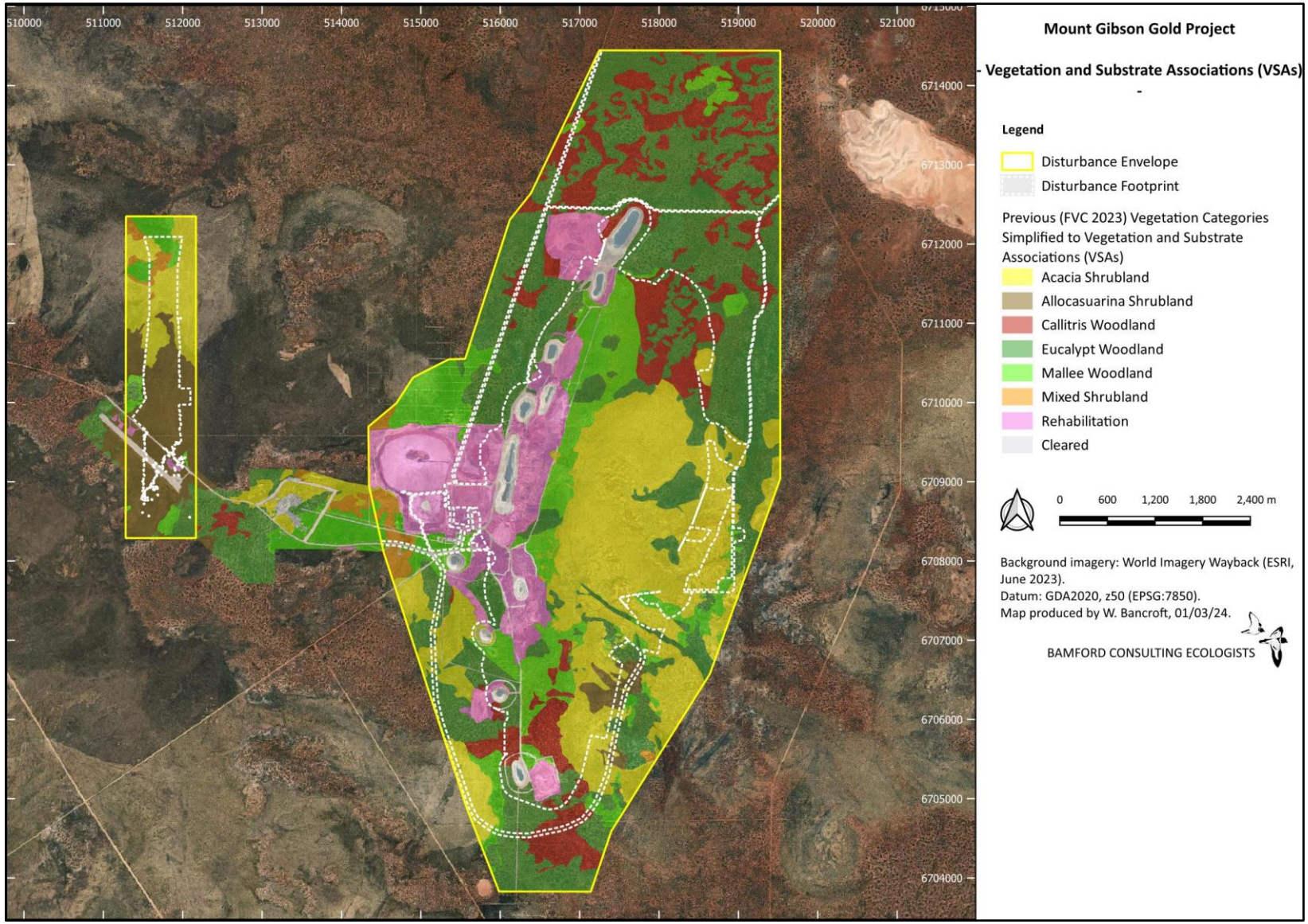

Figure 7. Vegetation and substrate associations.

3.2 Field investigations

3.2.1 Pitfall and funnel trapping

Forty-nine captures of 18 species were made by pitfall (420 pitfall trap-nights) and funnel trapping (210 funnel trap-nights) in the survey, as shown in Table 7. The most commonly captured species was the gecko *Gehyra variegata* (Varied Dtella) and this species was also captured at the most sites (six out of the seven sites). Most species were represented by only one or two captures (see Table 7). Despite the low capture rates (likely a strong reflection of dry conditions in the region in recent years), it was apparent that the *VSA 4 – Eucalypt Woodland* and *VSA 5 – Mallee Woodland* sites were the most biodiverse. The capture of just one mammal specimen (an introduced House Mouse) is also suggestive of poor seasonal conditions.

Table 7. Pitfall and funnel trapping results (captures per species per site).

See Appendix 7 for a list of common names.
† indicates introduced species.

Species	Site 1 Acacia Shrubland	Site 2 Acacia Shrubland	Site 3 Mallee Woodland	Site 4 Callitris Woodland	Site 5 Eucalypt Woodland	Site 6 Allocasuarina Shrubland	Site 7 Mallee Woodland	Total Captures
Diplodactylus granariensis					4			4
Diplodactylus pulcher		1	1		2			4
Lucasium maini							2	2
Rhynchoedura ornata	1							1
Gehyra variegata	1		2	1	6	4	1	15
Heteronotia binoei			1					1
Ctenophorus scutulatus	1					1		2
Pogona minor							1	1
Ctenotus schomburgkii				1		2		3
Lerista gerrardii					2			2
Lerista kingii					1			1
Liopholis inornata		1	1	1			3	6
Menetia greyii					1		1	2
Morethia butleri					1			1
Anilios waitii							1	1
Pseudonaja mengdeni						1		1

Species	Site 1 Acacia Shrubland	Site 2 Acacia Shrubland	Site 3 Mallee Woodland	Site 4 Callitris Woodland	Site 5 Eucalypt Woodland	Site 6 Allocasuarina Shrubland	Site 7 Mallee Woodland	Total Captures
Simoselaps bertholdi					1			1
Mus musculus †		1						1
Species Richness	**3**	**3**	**4**	**3**	**8**	**4**	**6**	**18**
Total Captures	**3**	**3**	**5**	**3**	**18**	**8**	**9**	**49**
Trap-nights (pitfalls plus funnels)	90	90	90	90	90	90	90	630

3.2.2 Bird censussing

Thirty-eight bird species were recorded in the systematic sampling (a total of 42 surveys), as shown in Table 8. The most widely encountered species were Copper-backed Quail-thrush, Crested Bellbird, Singing Honeyeater and Weebill (all recorded at six of the seven sites). Bird numbers were very low so presence is used here as a proxy for abundance. The most commonly encountered species were Singing Honeyeater, Weebill, Copper-backed Quail-thrush, Grey Shrike-thrush and Inland Thornbill which were all recorded in more than one quarter of the total surveys.

The *VSA 3 – Callitris Woodland* and the *VSA4 – Eucalypt Woodland* sites were the most biodiverse, with the *VSA 1 – Acacia Shrubland* having the lowest bird species richness.

3.2.3 Motion-sensitive camera trapping

Motion-sensitive cameras recorded 16 species despite only six of the 11 cameras getting photographs of animals (Table 9). The cameras confirmed the presence of one lizard species, the Crested Dragon, and one small mammal, Mitchell's Hopping-Mouse, not detected by any other means. Malleefowl were recorded on two cameras but no other significant species were detected. The Feral Cat was recorded, with different animals at BCE 30 and BCE 33. The large number of the Rufous Treecreeper recorded at BCE 33 was due to a single bird repeatedly visiting the location to eat ants attracted to the bait. Examples of photographs from cameras are presented in Appendix 8.

Table 8. Bird censussing results (number of surveys in which each per species was recorded per site, and total count).

A total of six surveys was conducted at each site.
The number of surveys in which each species was recorded is shown with the total count of individuals (within 25 m of the trapping transect) shown in parentheses. "o" indicates a species was only detected 'outside' of this 25 m zone (and was therefore not counted; see Section 2.3.5).
Species are presented in alphabetical order. Scientific names are provided in Appendix 7.

Species	Site 1 Acacia Shrubland	Site 2 Acacia Shrubland	Site 3 Mallee Woodland	Site 4 Callitris Woodland	Site 5 Eucalypt Woodland	Site 6 Allocasuarina Shrubland	Site 7 Mallee Woodland	Total Sites
Australian Hobby	1 (o)							1
Australian Raven		1 (o)					1 (o)	2
Black-breasted Buzzard				1 (o)				1
Black-faced Cuckoo-shrike						1 (o)		1
Black-faced Woodswallow		1 (o)						1
Brown Falcon	1 (o)			1 (o)				2
Brown Goshawk	1 (o)				1 (1)			2
Chestnut-rumped Thornbill		1 (1)	2 (3)	6 (19)		1 (4)		4
Common Bronzewing				1 (o)				1
Copper-backed Quail-thrush		3 (3)	1 (o)	3 (3)	2 (3)	1 (o)	2 (o)	6
Crested Bellbird		2 (1)	1 (o)	1 (o)	1 (o)	1 (o)	2 (o)	6
Grey Butcherbird					3 (o)			1
Grey Shrike-thrush			1 (o)	3 (1)	3 (1)	2 (o)	3 (1)	5
Horsfield's Bronze-Cuckoo				1 (o)				1
Inland Thornbill	2 (2)	4 (7)		3 (8)			3 (4)	4
Jacky Winter					2 (3)			1
Rainbow Bee-eater				1 (2)	2 (o)	1 (o)		3
Red-capped Robin				1 (o)				1

Species	Site 1 Acacia Shrubland	Site 2 Acacia Shrubland	Site 3 Mallee Woodland	Site 4 Callitris Woodland	Site 5 Eucalypt Woodland	Site 6 Allocasuarina Shrubland	Site 7 Mallee Woodland	Total Sites
Redthroat							1 (o)	1
Rufous Fieldwren	1 (o)	2 (1)					1 (1)	3
Rufous Treecreeper					6 (6)			1
Rufous Whistler				2 (2)	3 (o)	1 (o)	2 (o)	4
Singing Honeyeater		4 (1)	5 (2)	5 (2)	3 (o)	3 (2)	3 (1)	6
Southern Scrub-robin			1 (o)			2 (2)	1 (1)	3
Spiny-cheeked Honeyeater		1 (2)		1 (1)	6 (16)	1 (o)		4
Splendid Fairy-wren		1 (4)		1 (2)				2
Striated Pardalote					4 (3)			1
Tree Martin			1 (6)	1 (o)	4 (31)			3
Weebill	1 (1)		2 (2)	3 (2)	3 (2)	1 (o)	4 (5)	6
Western Whistler						1 (o)		1
Western Yellow Robin						1 (1)	1 (o)	2
White-backed Swallow				1 (o)				1
White-browed Babbler			1 (6)	1 (2)		1 (o)	2 (6)	4
White-fronted Honeyeater					4 (8)		1 (2)	2
Willy Wagtail							1 (o)	1
Yellow-plumed Honeyeater					6 (16)			1
Yellow-rumped Thornbill					1 (o)			1
Yellow-throated Miner					3 (o)			1
Species Richness	**6**	**10**	**9**	**19**	**18**	**14**	**15**	**38**

Table 9. Number of events of each species on each camera.

Note there were no photographs of animals at: BCE 14, BCE 32, BCE 40, BCE 20, BCE 44.

See Figure 3 for camera locations.

Scientific names are provided in Appendix 7.

† indicates introduced species

Species	Motion-sensitive Camera Number					
	BCE 05	BCE 11	BCE 13	BCE 16	BCE 30	BCE 33
Lozenge-marked Dragon			1		1	
Crested Dragon			1			
Yellow-spotted Monitor	2	4				
Malleefowl	3		2			
Rufous Treecreeper						40
Splendid Fairy-wren			5			
Crested Bellbird			4			
Grey Shrike-thrush		1				
Rufous Whistler			1			
Southern Scrub-robin		2				
Copper-backed Quail-thrush	2					
Australian Raven			2			
Grey Currawong		1				
Mitchell's Hopping Mouse					8	
Rabbit †					4	
Feral Cat †					2	1

3.2.4 Malleefowl nest mound survey

3.2.4.1 Potential Malleefowl nest mound locations in the survey area

The lidar surveys by Biota (2022, 2023) and other opportunistic observations have been collated to provide a list of all known (and suspected) Malleefowl nest mounds within the survey area. Given the Lidar approach, it is expected that the majority of mounds have been detected across the survey area.

For the survey area (development envelope), there are currently (at November 2023) 47 *potential* Malleefowl nest mound locations, as shown in Figure 8. Of these, 28 are in the proposed mine envelope and the remaining 19 are in the proposed airport envelope, with a summary of the results shown in

Table 10.

A total of 29 potential Malleefowl nest mound locations (25 within the mine envelope and four within the airport envelope) were inspected by BCE in the November 2023 survey. These were assessed for activity and age, as shown in

Table 10. One active mound (MM235) was recorded in the November 2023 survey (in the mine envelope), with photographs of that mound shown in Plate 8 to Plate 10. Nine mounds were inactive but considered to have been recently used by Malleefowl (within the last five years, see Section 2.3.7), seven of which were in the mine envelope and two in the airport envelope. All other locations inspected in 2023 were either inactive and not recently used, or were not Malleefowl nest mounds (e.g. rock or spoil piles).

Of the remaining 18 (of 47) potential mound locations within the survey area (i.e. that were not inspected by BCE in 2023), 13 were ground-truthed in 2022 (by Tetris and/or Biota; one within the mine envelope and 12 within the airport envelope) but not assigned an activity status or age by BCE in 2023, and five (two in the mine envelope and three in the airport envelope) have not yet been ground-truthed. Details of all potential Malleefowl nest mound locations within the survey area, including activity status, age, profile and dimensions (where known), are presented in Appendix 6.

Mounds appear to be concentrated in two VSAs: *VSA 1 – Acacia Shrubland* and *VSA 2 – Allocasuarina Shrubland*, with the highest density of mounds in areas of *Allocasuarina* shrubland (VSA 2) in the proposed airport envelope.

As part of the assessment of mound locations visited by BCE in the November 2023 survey, a determination of whether future surveys (for environmental impact) should be conducted was made. It is considered that only active mounds, recently inactive (likely to have been used within the last five years) mounds and locations where mound status is yet to be confirmed (included unsurveyed potential locations) should be the subject of subsequent visits. These are indicated in

Table 10 and Appendix 6, and include the active (one mound), recent (nine mounds) and unaged mounds (13 mounds), and the locations that have yet to be ground-truthed (five locations): a total of 28 locations (11 locations in the proposed mine envelope and 17 locations in the proposed airport envelope). Other non-recent inactive mounds and non-mounds are unlikely to require further inspection (19 locations).

In addition to the systematic mound surveys, a number of opportunistic Malleefowl observations were made, and these are presented in Section 3.2.7.1.

Table 10. Summary of potential Malleefowl mound locations in the survey area.

* indicates those locations that will likely require subsequent surveys.

Location	Survey Status	Mound Status (at November 2023)	Count
Proposed Mine Development Envelope	Surveyed	Active	1*
		Inactive: Recent	7*
		Inactive: Moderately old	2
		Inactive: Old	3
		Inactive: Very old	2
		Non-mound	10
		Ground-truthed in 2022	1*
	Unsurveyed		2*
Proposed Airport Development Envelope	Surveyed	Inactive: Recent	2*
		Inactive: Moderately old	1
		Inactive: Old	1
		Ground-truthed in 2022	12*
	Unsurveyed		3*
Total			***47***

Plate 8. Malleefowl Mound MM235, active in November 2023.

Note, mound diameter c. 6 m.

Plate 9. Malleefowl Mound MM235, active in November 2023.

Note, mound diameter c. 6 m.

Plate 10. Malleefowl Mound MM235, active in November 2023.

Note, mound diameter c. 6 m.

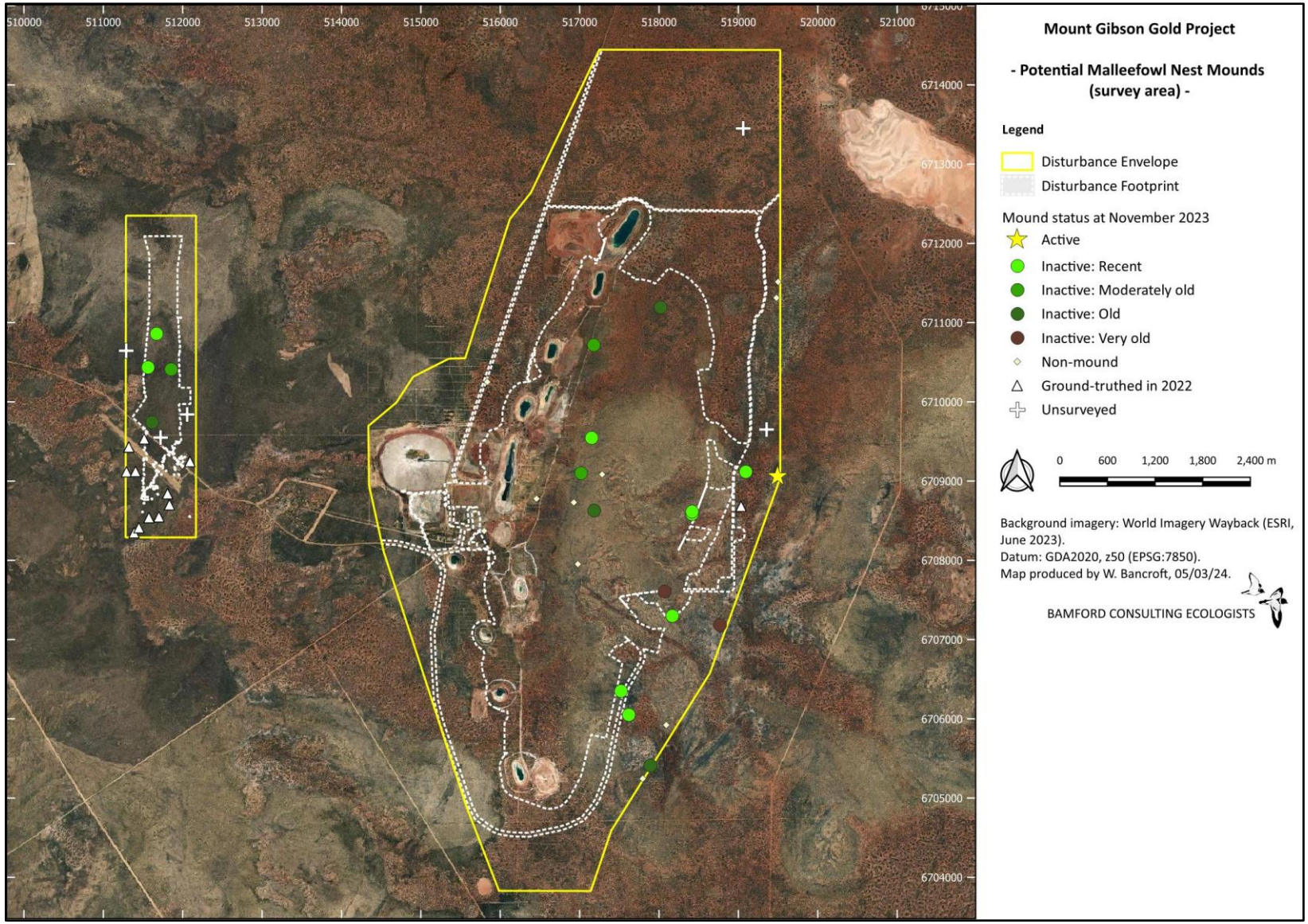

Figure 8. Locations of potential Malleefowl nest mounds in the survey area.

3.2.5 Southern Whiteface surveys

Surveys for Southern Whiteface (see Figure 5 and Figure 6) failed to detect this species within the survey area. Approximately 17.3 person-hours were spent searching for Southern Whiteface within the survey area.

Opportunistic Southern Whiteface observations are presented in Section 3.2.7.3.

3.2.6 Spotlighting

Twelve individuals from six species were recorded in the spotlighting surveys, as shown in Table 11. All were reptiles. One of these, the arboreal Reticulated Velvet Gecko (*Hesperoedura reticulata*), was not recorded by any other method. Approximately 6.6 person-hours were spent spotlighting.

Table 11. Results from the spotlighting surveys.

Area:	Site 5	Site 4
Date:	1/11/2023	3/11/2023
Time:	19:00 - 20:25	19:00 - 20:10
Personnel:	3	2
Diplodactylus granariensis granariensis	1	1
Diplodactylus pulcher	1	
Hesperoedura reticulata	3	
Rhynchoedura ornata	1	
Gehyra variegata	4	
Heteronotia binoei		1

3.2.7 Opportunistic observations

3.2.7.1 Malleefowl

A single Malleefowl was seen, opportunistically, crossing the main site entry road on 6th November 2023, as shown in Figure 9. Anecdotal evidence suggests that this species is seen in this general location on a reasonably regular basis by site staff.

Malleefowl tracks were observed in almost all locations where field work was undertaken and, therefore, no specific records are presented here. Recent to fresh tracks were found at almost every location where the soil was sufficiently soft for tracks to be visible. This included a bird that walked along the trapline at Site 6 during the survey.

3.2.7.2 Peregrine Falcon

A pair of Peregrine Falcons was seen, opportunistically, adjacent to an existing mine pit within the survey area on 1st November 2023 and again (presumably the same pair) in the same location on 4th November 2023, as shown in Figure 9.

3.2.7.3 Southern Whiteface

Southern Whiteface were not recorded within the survey area (either systematically, see Section 3.2.5, or opportunistically) but were opportunistically detected in the area surrounding the exploration camp (522543 E, 6721796 N, GDA2020). Up to three birds were observed foraging (predominantly on the ground) in very open eucalypt woodland alongside thornbill species (e.g. Yellow-rumped and Chestnut-rumped Thornbills) on several occasions throughout the survey period. This location is approximately 8 km to the north-west of the nearest survey area boundary.

3.2.7.4 Other fauna

At least 90 vertebrate species were recorded during the site inspection (including systematic records): no fish, no frogs, 24 reptiles, 59 birds and 7 mammals. An additional five species (all birds) were recorded along the Great Northen Highway between Wubin and the survey area. An annotated list of all species is provided in Appendix 7.

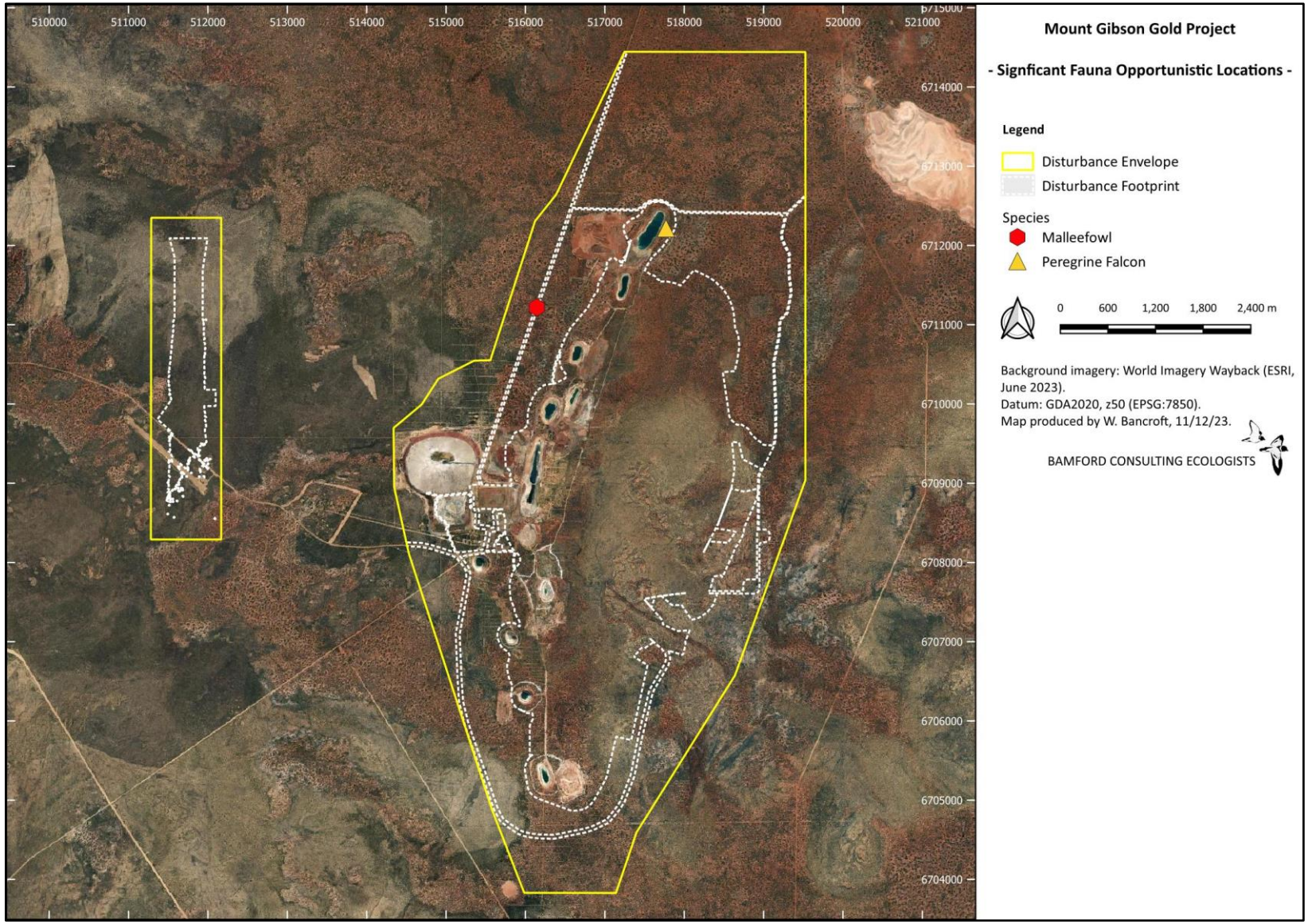

Figure 9. Opportunistic recordings of conservation significant fauna.

3.3 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. Broadly speaking, areas of *VSA 4 – Eucalypt Woodland* had the highest species richness and abundance of vertebrate fauna (see, in particular, the pitfall and funnel trapping, and bird censusing Sections 3.2.1 and 3.2.2). It is probable that this is driven by species dependent upon large eucalypts (such as birds that forage in the canopy and species that shelter in large tree hollows) or by species that depend upon ground refugia (e.g. fallen logs, leaf litter).

While the least biodiverse VSA, generally, was *VSA 1 – Acacia Shrubland*, it is this and *VSA 2 – Allocasuarina Shrubland* (in particular) that support the highest densities of Malleefowl nest mounds.

3.4 Ecological processes

The nature of the landscape and the fauna assemblage indicate some of the ecological processes that may be important for ecosystem function (see Appendix 1 and Appendix 3 for descriptions and other ecological processes). These include the aspects discussed below.

Local hydrology. Interruptions of hydro-ecological processes can have large effects because they underpin primary production in ecosystems and there are specific, generally rare habitats that are hydrology-dependent. There are no surface drainage features within the survey area; although there are a number of claypans and salt lakes in the nearby areas. Beecham (2001) noted that "there is no connected drainage" in the region and suggested that surface drainages may only function irregularly, in very wet periods. Some of the VSAs within the survey area may be drained by sheetflow (e.g. *VSA 4 – Eucalypt Woodland*), which can be disturbed by surface earthworks. Intersection of groundwater through mining operations will need to be managed. Roads and mining may also alter both surface and sub-surface hydrology.

Fire. There was no evidence of fire affecting native vegetation at the time of the field investigations. 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 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). While 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) there appears to be no suggestion that this has occurred, or will occur, within the survey area.

Kangaroo populations can be artificially increased, and overpopulated, in areas of anthropogenic disturbance (e.g. agriculture) and this can have a negative effect on the biodiversity and conservation of other fauna (and flora) in these areas (Wilson and Edwards 2019; Croft and Witte 2021; Gordon *et al.* 2021). There is no evidence to indicate that this is the case within the survey area.

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. Adjacent nature reserves have undertaken feral control and there may be some flow-on effects of this to the survey area. Equally, additional control efforts in surrounding areas may provide a regional net benefit to fauna.

Habitat degradation due to weed invasion. Native vegetation is largely intact, with the majority of the survey area considered by FVC (2023a) to be in 'Excellent' condition and with very low levels of (or no) weed invasion. FVC (2023a) noted that weed invasion was apparent in areas that had previously been disturbed (*VSA 7 – Rehabilitation*, and *VSA 8 – Cleared*).

Connectivity and landscape permeability. The survey area lies within a well-connected and largely undisturbed landscape and has no obvious restrictions to landscape permeability. The non-disturbance VSAs present in the survey area (VSAs 1 to 6, see Section 3.1) are extensively represented outside of the proposed disturbance footprint and outside of the survey area, with a large proportion of surrounding lands vested in conservation estate. FVC (2023a) provided detail on these lands and, immediately adjacent to the survey areas, they include Charles Darwin Conservation Reserve, Biluny Wells Nature Reserve and Mount Gibson Private Nature Reserve.

3.5 Conservation significant vertebrate fauna synopsis

3.5.1 Cyclodomorphus branchialis (Gilled Slender Blue-tongue)

Listed as **Vulnerable** under both the EPBC Act and the WA BC Act.

Biota (2023) assessed the 'likelihood of occurrence' of the Gilled Slender Blue-tongue as 'may occur' (either a limited amount of suitable habitat or the species is recorded infrequently in the locality) but did not detect this species in targeted searches. It was also not recorded in the field investigations reported here. The habitat and range of the species is described by Wilson and Swan (2021) as 'Semi-arid shrublands on heavy red soil from the Irwin River north to the Murchison River, and inland to Mt Magnet'. The survey area may therefore lie just south of this distribution. Furthermore, BCE has three records of the species with recorded environment: all three were in rocky landscapes. One was under a rock embedded in heavy loam soil at Galena (Murchison River), while the other two were on rocky ridges on the Blue Hills Range (Karara Station) about 40km north-west of the survey area. One was caught in a funnel trap on a rocky ledge while the other was under a rock lying on a rocky surface. There was soil in both locations. Based on these observations, it can be concluded that the species is unlikely to be present; if present it would most likely be restricted to rocky areas (present regionally but not in the survey area). If present in nearby rocky areas, individuals may occasionally move through the survey area (thus could be defined as irregular visitors or vagrants). It cannot be categorically stated that the species is absent, as it is highly cryptic and difficult to find. Whether absent or occurring only as occasional dispersing animals, the proposed development is unlikely to have a significant impact on the species.

3.5.2 Egernia stokesii badia (Western Spiny-tailed Skink)

Listed as **Endangered** under the EPBC Act and **Vulnerable** under the WA BC Act.

Biota (2023) assessed the 'likelihood of occurrence' of the Western Spiny-tailed Skink as 'likely to occur' (previously recorded in close proximity to the survey area and suitable habitat is present within the survey area) but did not detect this species in targeted searches. It was also not recorded in the field investigations reported here. The survey area appears to be on, or just outside, the north-eastern edge of its known range (ALA 2023). It is typically associated with log piles of York Gum in which it shelters in small groups, and is generally easy to detect as the animals use a communal latrine which persists for many months even when the animals are concealed or absent. While York Gum was limited in the survey area, the skink will shelter in log piles of other species so suitable habitat is present. However, given the species can readily be detected, it seems likely it is absent. The existence of nearby records means individuals could occasionally move through the survey area (as vagrants). Another consideration is that the species may formerly have been present and may have declined, which means it could recolonise if conditions change. Such a decline could have been due to vegetation degradation as a result of grazing (livestock and the Rabbit). Whether absent or occurring only as occasional dispersing animals, the proposed development is unlikely to have a significant impact on the species. If the species did recolonise the area, it would favour the Eucalypt Woodlands.

3.5.3 Leipoa ocellata (Malleefowl)

Listed as **Vulnerable** under both the EPBC Act and the WA BC Act.

Known to occur in the survey area. Malleefowl sightings were made in or adjacent to the study area by Biota (2022), Ecotec (2023) and in the present (BCE) study. Active or recently used nesting mounds were recorded by Biota (2022, 2023), Ecotec (2023) and in the present (BCE) study. It is clear that this species occurs as a (breeding) resident within the survey area and surrounds. As such, further management prior to the commencement of mining operations is likely to be required.

While Malleefowl may utilise all habitats within the survey area (for foraging, movement through the landscape, etc.), two VSAs appear to be strongly favoured for the construction of nest mounds: *VSA 1 - Acacia Shrubland* and *VSA 2 - Allocasuarina Shrubland* (see Sections 3.1, 3.2.4 and 3.2.7.1).

3.5.4 Platycercus icterotis xanthogenys (Western Rosella – inland)

Ranked as **Priority 4** by DBCA.

Biota (2023) assessed the 'likelihood of occurrence' of the Western Rosella (inland) as 'may occur' (either a limited amount of suitable habitat or the species is recorded infrequently in the locality) but did not detect this species in targeted searches. It was also not recorded in the field investigations reported here. The survey area is probably just outside the known extent of this species' range (ALA 2023). If it occurs at all, it its likely to be as an irregular visitor or vagrant to the survey area. As such, the proposed development is unlikely to have a significant impact on the Western Rosella (inland).

3.5.5 Falco peregrinus (Peregrine Falcon)

Listed as **Specially Protected** under the WA BC Act.

Known to occur in the survey area. Peregrine Falcons were recorded within the survey area by Biota (2022) and in the present (BCE) study. All sightings have been adjacent to existing mine pits which

replicate the cliff-faces often preferred by this species. Breeding was reported to occur in a mine pit to the north-west of the survey area, suggesting there is a resident pair that breeds on the artificial cliffs of mine pits. Some open pits are expected to remain at mine closure, thus creating potential artificial breeding areas for this species.

3.5.6 Aphelocephala leucopsis (Southern Whiteface)

Listed as **Vulnerable** under the EPBC Act.

The Southern Whiteface was not assessed by Biota (2022, 2023) and was not recorded within the survey area in the present (BCE) study. It was, however, recorded in the vicinity (near the exploration camp, see Section 3.2.7.3). Higgins and Peter (2002) and Garnett and Baker (2021) describe the habitat of the species broadly as open woodlands and shrublands in a range of landscape positions, from ranges to plains, but at least in the Murchison and Yilgarn, it favours loam to clayey-loam flats that support scattered eucalypts and widely-spaced mounded shrubs (including species of acacia, chenopods and saltbush), with open ground supporting low shrubs and herbs between (M. Bamford pers obs). The mixture of dense shrubs and open spaces supporting low shrubs and herbs appears to be important and is also mentioned by Higgins and Peter (2002), although their habitat descriptions are much broader. This was the type of vegetation and soil around the exploration camp.

Within the survey area, *VSA 4 – Eucalypt Woodland* (see Section 3.1) bears some resemblance to the preferred habitat of the species, but generally lacks the low shrub and herb stratum. The poor development of this stratum in what otherwise might have been suitable habitat may explain the lack of records. It may occur only as individuals in small numbers dispersing from more favoured habitat outside the survey area nearby. It is not a particularly conspicuous species, but it would almost certainly have been seen if it was common given the amount of time spent by experienced observers in the area.

The Southern Whiteface is considered to be sedentary, with some juvenile dispersal, and possibly with some movement in response to changing conditions (fire, drought); under adverse conditions, it may move to slightly mesic refugia such as close to lake systems (Higgins and Peter (2002). Conditions were dry at the time of the survey and rainfall appeared to have been poor for at least the previous year (based on scarcity of small mammals and low level of breeding activity by the Malleefowl). This could have caused a decline in abundance, but birds were clearly still present as at the exploration camp.

The species was only recently (March 2023) added to the EPBC Act in response to documented declines across parts of its distribution in the Eastern States, although some localised increases in abundance have been reported (Garnett and Baker 2021). As the species is considered to have declined in regions where there has been little clearing, other factors are likely to have contributed to this decline, such as livestock grazing (Garnett and Baker 2021). Grazing has historically occurred in the project area. It is also considered to be at some risk from declining rainfall due to climate change, but has a very broad distribution across a range of climatic zones.

3.5.7 Nyctophilus major tor (Central Long-eared Bat)

Ranked as **Priority 3** by DBCA.

Known to occur in the survey area. The Central Long-eared Bat was recorded in almost all habitats sampled by Biota (2022) and is likely to forage over all VSAs within the survey area. Day roost sites are likely to be confined to those VSAs that have sufficient shelter (e.g. tree hollows) such as *VSA 3 - Callitris Woodland* and *VSA 4 - Eucalypt Woodland* (see Section 3.1). Clearing in these VSAs will result in some loss of roosting habitat, but this is extensive in the region and therefore the impact of the proposed development would be negligible.

3.6 Short range endemic (SRE) invertebrates synopsis

Biota (2022) considered potential SRE invertebrates in their detailed assessment of the survey area, including mygalomorph (trapdoor) spiders, harvestmen, millipedes and snails. Their desktop analysis identified 67 species-level taxa within these groups that had been recorded from the locality. Of these, two were known to be SRE species and are listed under the WA BC Act (*Idiosoma kopejtkaorum*, the Lake Goorly Shield-backed Trapdoor Spider; and *Idiosoma formosum*, the Ornate Shield-backed Trapdoor Spider), and a further 46 represented potential SREs. No expected SRE invertebrates are listed under the EPBC Act (Biota 2022).

Their field sampling was conducted in 'Eucalypt Woodland' and 'Mixed Shrubland (defined more broadly than in the current report, and encompassing most VSAs), and confirmed the presence of the Lake Goorly Shield-backed Trapdoor Spider. They also recorded 18 potential SRE invertebrate taxa including "10 nominal mygalomorph spider species from three taxonomic families are known solely from the study area". Biota (2022) concluded that "habitat attributes are unlikely to result in a high risk of species … being restricted to the … study area". They also noted that "there are no obvious geomorphological or habitat attributes that would suggest a high risk of restricted distributions in respect to the fauna of the study area." While not confirmed present, Biota (2022) considered that the Ornate Shield-backed Trapdoor and the Tree-stem Trapdoor Spider (*Aganippe castellum*; ranked as a priority 4 species by DBCA), are likely to occur in the local area.

Therefore, one species of conservation significant invertebrate species has been confirmed present and two could occur within the survey area and surrounds:

- *Idiosoma kopejtkaorum* (Lake Goorly Shield-backed Trapdoor Spider) – Endangered under the WA BC Act.
- *Idiosoma formosum* (Ornate Shield-backed Trapdoor Spider) – Endangered under the WA BC Act.
- *Aganippe castellum* (Tree-stem Trapdoor Spider) – ranked as Priority 4 by DBCA.

In addition, '10 nominal mygalomorph spider species from three taxonomic families are known solely from the study area', but it is likely that these, and the three listed species, will be distributed widely at least locally, and will thus not be restricted to impact areas (Biota 2022).

4 Impact assessment

Crimson Metals is proposing to recommence mining operations at the Mount Gibson Gold Mine. The following sections examines 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 6.

4.1 Review of threatening processes

Habitat loss leading to population decline. *Minor*

The areas in which clearing is proposed to be undertaken has already been partly disturbed (though previous mine operations). The proposed development footprint is c. 1686 ha and this comprises c. 1154 ha (68%) native vegetation (as mapped by DPIRD 2024b). This represents c. 0.9% of the c. 123,202 ha of native vegetation within 15 km of the survey area boundary (the local area). It is expected that not all of the native vegetation within the development footprint will be cleared. All VSAs present in the survey area are extensively represented outside of the survey area so, if these occur in similar proportions in the region, habitat loss will likely be relative to the extent of clearing (i.e. up to 0.9% of the local area for each VSA).

While some existing Malleefowl mounds are likely to be impacted, very few of these appear to be active or recently used (10, see

Table 10) and can likely be managed. Given the expansive areas of suitable surrounding Malleefowl breeding habitat, it is highly unlikely that this will lead to population decline for this species (even at the local scale).

Population decline due to habitat loss is, therefore, likely to be minor in impact.

Habitat loss leading to population fragmentation. *Negligible*

The proposed development footprint will expand on existing developed areas, with native vegetation surrounding. The proposed clearing will 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, pipelines, bunds etc.) have the potential to pose a barrier to fauna movement for some smaller, ground-dwelling, non-volant fauna (e.g. small reptiles) but, given the scale of the proposal, and the vast areas of surrounding native vegetation, this is expected to have negligible impact on the connectivity of terrestrial fauna populations.

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

Within the survey area, generally, the level of weed invasion was low (or near-zero) in the native vegetation area (VSAs 1 to 6, see Section 3.1) but weeds were present in previously disturbed areas (VSAs 7 and 8, see Section 3.1). There is potential for development to increase the spread of weeds (particularly during clearing), but standard weed control programmes and hygiene measures will 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. *Minor*

This is a concern mostly on animal welfare grounds. Animals will inevitably be killed during clearing but there are standard practices for reducing fauna mortality during such activities. Pre-clearance surveys may be required for some conservation significant species (such as Malleefowl).

Ongoing mortality. *Minor*

This results mainly from roadkill due to vehicle movements close to native vegetation, fauna striking infrastructure and the effects of lighting. An increased in vehicle movements and lighting is expected however standard management practices can reduce the impacts.

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 feral predator control programmes, not feeding wildlife and managing waste.

Hydrological change. *Minor*

There is no surface water and groundwater interactions are expected to be carefully managed, 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 expected to be coupled with a fire management plan and are, therefore, unlikely to lead to increased fire frequency.

Disturbance (dust, noise, light). *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.

Overall, the effects of impacting processes are considered to be Minor or Negligible; this is mainly due to targeted management actions (towards species of greatest conservation significance and/or risk), and the continuous, extensive and fairly uniform environment in which the proposed development envelope sits. Potentially minor impacts that may need to be addressed are:

- Mortality of fauna during construction.
- Ongoing mortality.
- Disturbance by dust, noise or light.

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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* (WA 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 *Biodiversity Conservation Act 2016* 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 2024b). The EEZ extends to 200 nautical miles (approximately 350 kilometres) from the coast (DAWE 2024b). 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 2024c) 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 survey 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*:

EX	Extinct	Taxa not definitely located in the wild during the past 50 years.
EW	Extinct in the Wild	Taxa known to survive only in captivity.
CR	Critically Endangered	Taxa facing an extremely high risk of extinction in the wild in the immediate future.
EN	Endangered	Taxa facing a very high risk of extinction in the wild in the near future.
VU	Vulnerable	Taxa facing a high risk of extinction in the wild in the medium-term future.
NT	Near Threatened	Taxa that risk becoming Vulnerable in the wild.
CD	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.
DD	Data Deficient (Insufficiently Known)	Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.
LC	Least Concern	Taxa that are not Threatened.

Categories used in the WA *Biodiversity Conservation Act 2016:*

THREATENED SPECIES		
CR	Critically Endangered	Threatened species considered to be "facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with criteria set out in the ministerial guidelines".
EN	Endangered	Threatened species considered to be "facing a very high risk of extinction in the wild in the near future, as determined in accordance with criteria set out in the ministerial guidelines".
VU	Vulnerable	Threatened species considered to be "facing a high risk of extinction in the wild in the medium term future, as determined in accordance with criteria set out in the ministerial guidelines".
EXTINCT SPECIES		
EX	Extinct	Species where "there is no reasonable doubt that the last member of the species has died", and listing is otherwise in accordance with the ministerial guidelines (section 24 of the BC Act).
EW	Extinct in the Wild	Species that "is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; and it has not been recorded in its known habitat or expected habitat, at appropriate seasons, anywhere in its past range, despite surveys over a time frame appropriate to its life cycle and form", and listing is otherwise in accordance with the ministerial guidelines (section 25 of the BC Act).
SPECIALLY PROTECTED SPECIES		
MI	Migratory	Fauna that periodically or occasionally visit Australia or an external Territory or the exclusive economic zone; or the species is subject of an international agreement that relates to the protection of migratory species and that binds the Commonwealth; and

		listing is otherwise in accordance with the ministerial guidelines (section 15 of the BC Act).
CD	Conservation Dependent	Species of special conservation need that are dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened, and listing is otherwise in accordance with the ministerial guidelines (section 14 of the BC Act).
OS	Other Specially Protected	Species otherwise in need of special protection to ensure their conservation, and listing is otherwise in accordance with the ministerial guidelines (section 18 of the BC Act).

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

P1	Priority 1	Poorly-known species. Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, for example, agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements for threatened listing and appear to be under immediate threat from known threatening processes. These species are in urgent need of further survey.
P2	Priority 2	Poorly-known species. Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, for example, national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements for threatened listing and appear to be under threat from known threatening processes. These species are in urgent need of further survey.
P3	Priority 3	Poorly-known species. Species that are known from several locations and the species does not appear to be under imminent threat or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. These species need further survey.

		Rare, Near Threatened and other species in need of monitoring. (a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection but could be if present circumstances change. These species are usually represented on conservation lands. (b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for vulnerable but are not listed as a conservation dependent specially protected species. (c) Species that have been removed from the list of threatened species or lists of conservation dependent or other specially protected species, during the past five years for reasons other than taxonomy. (d) Other species in need of monitoring.
P4	Priority 4	

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 (2013) 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 22 key threatening processes listed by the federal Department of Climate Change, Energy, the Environment and Water (DCCEEW 2024):

- Aggressive exclusion of birds from potential woodland and forest habitat by over-abundant noisy miners (*Manorina melanocephala*).
- Competition and land degradation by rabbits.
- Competition and land degradation by unmanaged goats.
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*).
- Fire regimes that cause declines in biodiversity.
- 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 Climate Change, Energy, the Environment and Water (DCCEEW) outline 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 (DotE 2013):

- 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. Sampling location details.

Datum = GDA2020, zone 50.

Site	Location	Easting	Northing	Sampling Type
Site 1	P01	517899.9472	6709655.541	Pitfall & funnel
	P02	517868.2406	6709661.465	Pitfall
	P03	517834.782	6709660.3	Pitfall & funnel
	P04	517815.0585	6709661.771	Pitfall
	P05	517785.7594	6709661.597	Pitfall & funnel
	P06	517754.3294	6709659.098	Pitfall
	P07	517728.705	6709659.028	Pitfall & funnel
	P08	517695.4485	6709663.291	Pitfall
	P09	517667.9908	6709665.772	Pitfall & funnel
	P10	517637.0502	6709667.04	Pitfall
Site 2	P11	517566.8991	6707978.158	Pitfall & funnel
	P12	517597.071	6707982.875	Pitfall
	P13	517629.7561	6707987.256	Pitfall & funnel
	P14	517665.1391	6707985.87	Pitfall
	P15	517708.3643	6707991.342	Pitfall & funnel
	P16	517760.7639	6707990.372	Pitfall
	P17	517792.1813	6707987.885	Pitfall & funnel
	P18	517825.7244	6707984.618	Pitfall
	P19	517856.0692	6707976.48	Pitfall & funnel
	P20	517882.5597	6707976.438	Pitfall
Site 3	P21	517341.2183	6710762.36	Pitfall & funnel
	P22	517383.1949	6710766.616	Pitfall
	P23	517410.4727	6710771.117	Pitfall & funnel
	P24	517453.8934	6710771.16	Pitfall
	P25	517497.3119	6710769.762	Pitfall & funnel
	P26	517532.2383	6710779.902	Pitfall
	P27	517578.4391	6710764.427	Pitfall & funnel
	P28	517613.7315	6710761.269	Pitfall
	P29	517653.3911	6710767.966	Pitfall & funnel
	P30	517686.9493	6710768.91	Pitfall
Site 4	P31	518092.5838	6711159.953	Pitfall & funnel
	P32	518053.8944	6711156.248	Pitfall
	P33	518012.0109	6711150.886	Pitfall & funnel
	P34	517975.9308	6711145.958	Pitfall

Site	Location	Easting	Northing	Sampling Type
	P35	517947.9828	6711146.446	Pitfall & funnel
	P36	517903.8658	6711135.215	Pitfall
	P37	517874.4562	6711128.836	Pitfall & funnel
	P38	517842.5367	6711125.23	Pitfall
	P39	517816.0941	6711099.344	Pitfall & funnel
	P40	517781.2632	6711089.317	Pitfall
Site 5	P41	518402.1761	6712469.262	Pitfall & funnel
	P42	518349.5413	6712457.604	Pitfall
	P43	518313.3143	6712483.813	Pitfall & funnel
	P44	518264.204	6712498.187	Pitfall
	P45	518222.714	6712500.027	Pitfall & funnel
	P46	518185.3675	6712492.332	Pitfall
	P47	518153.4647	6712501.47	Pitfall & funnel
	P48	518109.2101	6712528.134	Pitfall
	P49	518074.1757	6712574.618	Pitfall & funnel
	P50	518040.845	6712598.162	Pitfall
Site 6	P51	511648.6183	6709586.581	Pitfall & funnel
	P52	511673.5628	6709584.007	Pitfall
	P53	511699.4752	6709582.318	Pitfall & funnel
	P54	511729.3547	6709583.173	Pitfall
	P55	511769.2896	6709583.241	Pitfall & funnel
	P56	511809.6086	6709580.761	Pitfall
	P57	511840.842	6709581.725	Pitfall & funnel
	P58	511884.45	6709580.571	Pitfall
	P59	511941.3057	6709579.956	Pitfall & funnel
	P60	511987.9127	6709580.128	Pitfall
Site 7	P61	516284.2009	6706498.867	Pitfall & funnel
	P62	516312.0388	6706497.164	Pitfall
	P63	516335.722	6706496.797	Pitfall & funnel
	P64	516363.4578	6706491.438	Pitfall
	P65	516399.5149	6706491.385	Pitfall & funnel
	P66	516430.3647	6706499.982	Pitfall
	P67	516461.2058	6706502.707	Pitfall & funnel
	P68	516491.3561	6706495.793	Pitfall
	P69	516518.236	6706499.963	Pitfall & funnel
	P70	516539.9591	6706481.648	Pitfall
Site 6	BCE11	512041.3468	6709578.466	Motion-sensitive Camera

Site	Location	Easting	Northing	Sampling Type
Site 7	BCE05	516335.8274	6706524.555	Motion-sensitive Camera
Site 2	BCE30	517530.3441	6707994.455	Motion-sensitive Camera
Site 1	BCE14	517905.1444	6709603.296	Motion-sensitive Camera
Site 3	BCE20	517343.1958	6710748.895	Motion-sensitive Camera
Site 4	BCE52	518060.5714	6711182.116	Motion-sensitive Camera
Site 4	BCE13	517859.9985	6711239.724	Motion-sensitive Camera
Site 5	BCE44	518306.4224	6712371.75	Motion-sensitive Camera
Site 5	BCE33	518105.3185	6712474.24	Motion-sensitive Camera
Camp	BCE40	522615.0511	6721799.894	Motion-sensitive Camera
Entry Road	BCE01	515737.1045	6709847.557	Motion-sensitive Camera

Appendix 6. Potential Malleefowl nest mound locations within the survey area.

Datum = GDA2020, zone 50.
See Section 2.3.7 for elaboration of Activity Status, Age and Profile Category. These were determined by BCE in 2023.
"Not assessed" indicates mounds that were not checked by BCE in November 2023 but had previously been visited by personnel from Tetris or Biota.
"Unsurveyed" indicates features identified by lidar but which have not been ground-truthed.
Mound locations that are likely to require further investigation are shown in maroon font.

Location ID	Easting	Northing	Activity Status	Age	Revisit?	Diameter (m)	Height (mm)	Depth (mm)	Profile Category
Proposed MINE Development Envelope									
MM174	515798	6708371	Non-mound	Non-mound	No	NA	NA	NA	NA
MM177	515837	6710251	Non-mound	Non-mound	No	NA	NA	NA	NA
MM182	516457	6708777	Non-mound	Non-mound	No	NA	NA	NA	NA
MM191	516927	6708730	Non-mound	Non-mound	No	NA	NA	NA	NA
MM192	516978	6707952	Non-mound	Non-mound	No	NA	NA	NA	NA
MM193	517019	6709099	Inactive	Moderately old	No	5	300	100	6
MM194	517152	6709545	Inactive	Recent	Yes	4	400	600	1
MM195	517179.377	6710716.621	Inactive	Moderately old	No	6	300	100	1
MM196	517183	6708627	Inactive	Old	No	6	200	0	6
MM198	517284	6709084	Non-mound	Non-mound	No	NA	NA	NA	NA
MM199	517521.541	6706349.29	Inactive	Recent	Yes	4	500	NA	3
MM200	517619.704	6706049.076	Inactive	Recent	Yes	4	700	NA	4
MM202	517795	6705244	Non-mound	Non-mound	No	NA	NA	NA	NA

Location ID	Easting	Northing	Activity Status	Age	Revisit?	Diameter (m)	Height (mm)	Depth (mm)	Profile Category
MM203	517893	6705409	Inactive	Old	No	12	200	100	6
MM205	518020.35	6711191.45	Inactive	Old	No	4	400	300	1
MM208	518071	6707605	Inactive	Very old	No	5	100	100	6
MM210	518092	6705921	Non-mound	Non-mound	No	NA	NA	NA	NA
MM215	518168	6707298	Inactive	Recent	Yes	5	600	NA	3
MM221	518417	6708583	Inactive	Recent	Yes	5	300	400	3
MM222	518417.408	6708614.041	Inactive	Recent	Yes	5	400	500	1
MM224	518768	6707182	Inactive	Very old	No	8	200	100	6
MM225	519034	6708682	Not assessed	Not assessed	Yes	NA	NA	NA	NA
MM226	519060.832	6713450.459	Unsurveyed	Unsurveyed	NA	NA	NA	NA	NA
MM227	519094.23	6709116.34	Inactive	Recent	Yes	5	600	800	1
MM232	519355.447	6709650.466	Unsurveyed	Unsurveyed	NA	NA	NA	NA	NA
MM234	519480	6711312	Non-mound	Non-mound	No	NA	NA	NA	NA
MM235	519493.261	6709059.831	Active	Active	Yes	6	400	NA	4
MM236	519501	6711514	Non-mound	Non-mound	No	NA	NA	NA	NA
Proposed AIRPORT Development Envelope									
MM052	511287.574	6710644.621	Unsurveyed	Unsurveyed	NA	NA	NA	NA	NA
MM053	511291	6709117	Not assessed	Not assessed	Yes	NA	NA	NA	NA
MM054	511318	6709427	Not assessed	Not assessed	Yes	NA	NA	NA	NA

Location ID	Easting	Northing	Activity Status	Age	Revisit?	Diameter (m)	Height (mm)	Depth (mm)	Profile Category
MM055	511321	6709430	Not assessed	Not assessed	Yes	NA	NA	NA	NA
MM056	511387	6708348	Not assessed	Not assessed	Yes	NA	NA	NA	NA
MM057	511405	6709121	Not assessed	Not assessed	Yes	NA	NA	NA	NA
MM058	511448	6708411	Not assessed	Not assessed	Yes	NA	NA	NA	NA
MM059	511514	6709533	Not assessed	Not assessed	Yes	NA	NA	NA	NA
MM060	511562.932	6710434.184	Inactive	Recent	Yes	4	500	NA	1
MM061	511574	6708539	Not assessed	Not assessed	Yes	NA	NA	NA	NA
MM062	511615.069	6709741.842	Inactive	Old	No	5	300	NA	6
MM064	511670.294	6710858.866	Inactive	Recent	Yes	3.5	1000	NA	4
MM065	511700	6708549	Not assessed	Not assessed	Yes	NA	NA	NA	NA
MM066	511720.33	6709548.555	Unsurveyed	Unsurveyed	NA	NA	NA	NA	NA
MM067	511809	6708840	Not assessed	Not assessed	Yes	NA	NA	NA	NA
MM068	511833	6708701	Not assessed	Not assessed	Yes	NA	NA	NA	NA
MM069	511854.429	6710409.775	Inactive	Moderately old	No	4	400	NA	1
MM070	512055.5	6709840.716	Unsurveyed	Unsurveyed	NA	NA	NA	NA	NA
MM071	512091	6709246	Not assessed	Not assessed	Yes	NA	NA	NA	NA

Appendix 7. Species recorded in the field investigations.

Recorded: Direct = directly recorded (seen or heard); Indirect = indirectly recorded by scats, tracks, diggings, etc.; Highway = seen along the Great Northern Highway between Wubin and the survey area.

Species	Common Name	Recorded	Annotations
Carphodactylidae (Carphodactylid geckos)			
Underwoodisaurus milii	Southern Barking Gecko	Direct	Several, including a large adult, active around camp.
Diplodactylidae (Diplodactylid geckos)			
Diplodactylus granariensis granariensis		Direct	Trapped and head-torched in various locations.
Diplodactylus pulcher		Direct	Trapped and head-torched in various locations.
Hesperoedura reticulata	Reticulated Velvet Gecko	Direct	Several seen on York Gums during head-torching in Eucalypt woodland; above the bark collar.
Lucasium maini		Direct	Trapped.
Rhynchoedura ornata	Western Beaked Gecko	Direct	Trapped and head-torched in various locations.
Gekkonidae (Gekkonid geckos)			
Gehyra variegata		Direct	Trapped and head-torched in various locations.
Heteronotia binoei	Bynoe's Gecko	Direct	Trapped and head-torched.
Agamidae (Dragons)			
Ctenophorus cristatus	Crested Dragon	Direct	Recorded on camera
Ctenophorus maculatus maculatus		Direct	Seen in north of airstrip area in acacia shrubland.
Ctenophorus scutulatus	Lozenge-marked Dragon	Direct	Regularly seen throughout. Also trapped.
Pogona minor minor	Western Bearded Dragon	Direct	Trapped.
Scincidae (Skinks)			

Species	Common Name	Recorded	Annotations
Ctenotus schomburgkii		Direct	Trapped. One also seen at Site 1 (Acacia shrubland).
Eremiascincus richardsonii	Broad-banded Sand Swimmer	Direct	One found under plank at camp, one seen around dongas at night.
Lerista gerrardii		Direct	Trapped.
Lerista kingi		Direct	Trapped.
Liopholis inornata		Direct	Trapped, and several burrow clusters seen throughout development envelope.
Menetia greyii		Direct	Trapped.
Morethia butleri		Direct	Trapped.
Varanidae (Monitors and goannas)			
Varanus gouldii	Bungarra or Sand Goanna	Direct	Two animals seen in main development envelope.
Varanus panoptes panoptes		Direct	Lots of foraging holes. Large adult in camp.
Typhlopidae (Blind snakes)			
Anilios waitii		Direct	Trapped.
Elapidae (Venomous land snakes)			
Pseudechis australis	Mulga Snake	Indirect	Seen by geologists/drilling crews and photographed.
Pseudonaja mengdeni	Gwardar; Western Brown Snake	Direct	Trapped.
Simoselaps bertholdi	Jan's Banded Snake	Direct	Trapped.
Casuariidae (Emus and Cassowaries)			
Dromaius novaehollandiae	Emu	Indirect	Tracks seen regularly along access roads. Scats throughout.
Megapodiidae (Megapodes)			
Leipoa ocellata	Malleefowl	Direct	Tracks seen almost throughout. Mounds inspected and many had been used in 2022. One individual seen on entry road on 6/11/23.
Columbidae (Pigeons and Doves)			

Species	Common Name	Recorded	Annotations
Phaps chalcoptera	Common Bronzewing	Direct	Two seen at camp (31/10) and one or two seen along entrance road into site on most days.
Cuculidae (Cuckoos)			
Chalcites basalis	Horsfield's Bronze-Cuckoo	Direct	
Otididae (Bustards)			
Ardeotis australis	Australian Bustard	Highway	
Accipitridae (Eagles, Kites, Goshawks)			
Hamirostra melanosternon	Black-breasted Buzzard	Direct	
Hieraaetus morphnoides	Little Eagle	Direct	One near Site 1 (30/10).
Accipiter fasciatus	Brown Goshawk	Direct	Individual birds seen on most days (espcially near Site 4, Site 3 and Site 2).
Haliastur sphenurus	Whistling Kite	Highway	
Strigidae (Hawk-Owls)			
Ninox novaeseelandiae	Southern Boobook	Direct	Heard near camp most nights.
Meropidae (Bee-eaters)			
Merops ornatus	Rainbow Bee-eater	Direct	Few seen and heard throughout.
Alcedinidae (Kingfishers)			
Todiramphus pyrrhopygius	Red-backed Kingfisher	Direct	
Falconidae (Falcons)			
Falco cenchroides	Nankeen Kestrel	Direct	
Falco longipennis	Australian Hobby	Direct	
Falco berigora	Brown Falcon	Direct	One east of site 1 (30/10). One seen or heard most days within survey area.

Species	Common Name	Recorded	Annotations
Falco peregrinus	Peregrine Falcon	Direct	Pair reported (J. Hesford) to breed in slope of highway it to NW. Pair seen near site 5 (and near a large pit) on 1/11 and 4/11.
Cacatuidae (Cockatoos and Corellas)			
Calyptorhynchus banksii	Red-tailed Black-Cockatoo	Highway	
Eolophus roseicapilla	Galah	Highway	
Cacatua sanguinea	Little Corella	Highway	
Psittaculidae (Parrots, Lorikeets and Rosellas)			
Psephotellus varius	Mulga Parrot	Direct	Pair along access road in north (30/10). Group of five at camp (2/11) and several around old offices, including a juvenile.
Barnardius zonarius	Australian Ringneck	Direct	Seen occasionally throughout. Not common. Usually pairs.
Climacteridae (Treecreepers)			
Climacteris rufus	Rufous Treecreeper	Direct	Few seen and heard in Eucalypt tall woodland regularly.
Maluridae (Fairy-wrens, Emu-wrens and Grasswrens)			
Malurus pulcherrimus	Blue-breasted Fairy-wren	Direct	Party in acacia shrubland in north of airstrip (1/11). Coloured male seen clearly; coverts same blue as crown, and no pale lavender on upper flank. Breast not seen well but suggestion of Prussian blue. Adult female had large rufous eye-ring same colour as beak.
Malurus splendens	Splendid Fairy-wren	Direct	Recorded in bird surveys.
Meliphagidae (Honeyeaters and Chats)			
Lichmera indistincta	Brown Honeyeater	Direct	Few heard around old offices (2/11).
Melithreptus brevirostris	Brown-headed Honeyeater	Direct	Group seen near site 7 in mallee (1/11, 5/11).
Acanthagenys rufogularis	Spiny-cheeked Honeyeater	Direct	Heard and seen in woodland to mallee areas.
Gavicalis virescens	Singing Honeyeater	Direct	Individual birds common throughout.

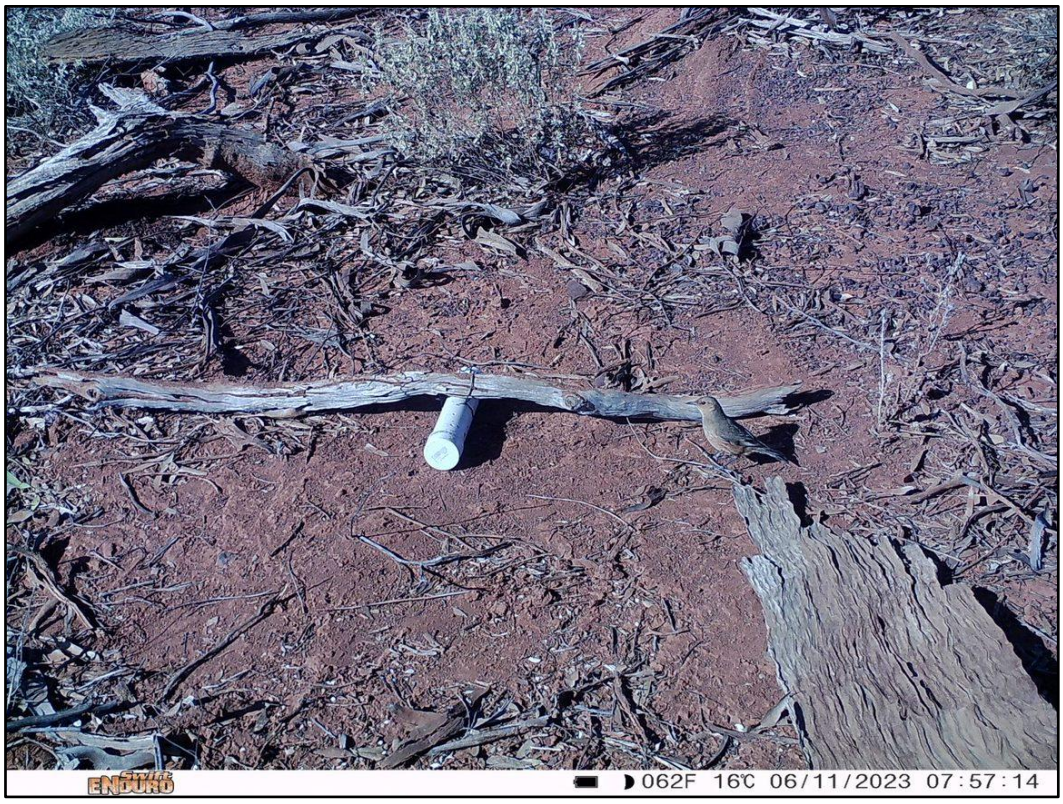
Species	Common Name	Recorded	Annotations
Ptilotula ornata	Yellow-plumed Honeyeater	Direct	Few seen and heard in eucalypt woodland.
Purnella albifrons	White-fronted Honeyeater	Direct	Heard and seen in woodland to mallee areas.
Manorina flavigula	Yellow-throated Miner	Direct	Heard and seen in tall eucalypt area.
Pardalotidae (Pardalotes)			
Pardalotus striatus	Striated Pardalote	Direct	Heard in eucalypt tall woodland.
Acanthizidae (Thornbills and Gerygones)			
Smicrornis brevirostris	Weebill	Direct	Few in eucalypt areas.
Pyrrholaemus brunneus	Redthroat	Direct	
Calamanthus campestris	Rufous Fieldwren	Direct	
Aphelocephala leucopsis	Southern Whiteface	Direct	Party around camp in scattered shrubs and open herbfield with eucalypt woodland nearby.
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	Direct	
Acanthiza apicalis	Inland Thornbill	Direct	Seen occasionally in most woodland and mallee areas. Also in acacia shrubland.
Acanthiza uropygialis	Chestnut-rumped Thornbill	Direct	Seen regularly in most woodland and mallee areas.
Pomatostomidae (Australian Babblers)			
Pomatostomus superciliosus	White-browed Babbler	Direct	Party at Site 3 (30/10) and in airstrip area (1/11).
Campephagidae (Cuckoo-shrikes and Trillers)			
Coracina novaehollandiae	Black-faced Cuckoo-shrike	Direct	One or two seen most days.
Cinclosomatidae (Quail-thrush)			
Cinclosoma castanotum	Chestnut (Copper-backed) Quail-thrush	Direct	Heard or seen regularly, more or less throughout.
Pachycephalidae (Whistlers, Shrike-thrushes and allies)			
Pachycephala rufiventris	Rufous Whistler	Direct	Heard or seen occasionally, throughout.

Species	Common Name	Recorded	Annotations
Pachycephala pectoralis occidentalis	Western Whistler	Direct	Heard near site 6 in mallee and thickets (1/11).
Colluricincla harmonica	Grey Shrike-thrush	Direct	Seen and herd occasionally in areas of tall thickets and mallee.
Oreoicidae (Australo-Papuan Bellbirds)			
Oreoica gutturalis	Crested Bellbird	Direct	Heard site 2 (30/10).
Artamidae (Woodswallows, Currawongs, Butcherbirds and Magpie)			
Strepera versicolor	Grey Currawong	Direct	Heard near site 4 (30/10). One seen along airstrip road near site 6 (1/11).
Gymnorhina tibicen	Australian Magpie	Direct	Party around camp.
Cracticus nigrogularis	Pied Butcherbird	Direct	Camp.
Cracticus torquatus	Grey Butcherbird	Direct	Heard near site 6 (1/11).
Artamus cinereus	Black-faced Woodswallow	Direct	Few around eucalypt woodland.
Artamus minor	Little Woodswallow	Direct	Few around mine pits and around old offices.
Rhipiduridae (Fantails)			
Rhipidura leucophrys	Willie Wagtail	Direct	Pair at old offices. Occasional individuals throughout.
Corvidae (Crows and Ravens)			
Corvus orru	Torresian Crow	Direct	Camp.
Corvus coronoides	Australian Raven	Direct	Seen and heard occasionally.
Petroicidae (Australian Robins)			
Petroica boodang	Scarlet Robin	Direct	
Petroica goodenovii	Red-capped Robin	Direct	
Microeca fascinans	Jacky Winter	Direct	
Drymodes brunneopygia	Southern Scrub-robin	Direct	Heard in Allocasuarina closed tall shrubland and in Acacia shrubland. Recorded on camera.

Species	Common Name	Recorded	Annotations
Eopsaltria griseogularis	Western Yellow Robin	Direct	
Estrildidae (Weaver Finches)			
Taeniopygia guttata	Zebra Finch	Direct	Flock of 15 at old offices (2/11).
Hirundinidae (Swallows and Martins)			
Cheramoeca leucosterna	White-backed Swallow	Direct	
Petrochelidon nigricans	Tree Martin	Direct	Few around camp and old offices. Very common in eucalypt woodland at Site 5.
Hirundo neoxena	Welcome Swallow	Direct	Few around old offices.
Tachyglossidae (Echidnas)			
Tachyglossus aculeatus acanthion	Short-beaked Echidna	Indirect	Diggings throughout.
Macropodidae (Kangaroos)			
Macropus fuliginosus melanops	Western Grey Kangaroo	Direct	One seen along entrance road evening 1/11.
Muridae (Rats and mice)			
Mus musculus	House Mouse	Direct	Trapping.
Notomys mitchellii	Mitchell's Hopping-mouse	Direct	Camera-trapping.
Leporidae (Rabbits and hares)			
Oryctolagus cuniculus	Rabbit	Direct	Seen and on camera
Canidae (Dogs)			
Vulpes vulpes	Red Fox	Indirect	Scats and tracks.
Felidae (Cats)			
Felis catus	Cat	Indirect	Scats and tracks. Camera-trapping.

Appendix 8. Examples of photographs from motion-sensitive cameras.

BCE 16. Crested Dragon.



BCE 33. Rufous Treecreeper. The same individual appeared to visit the location repeatedly, apparently feeding on ants attracted to the bait.

BCE 30. Mitchell's Hopping-Mouse.

BCE 30. Rabbit.

BCE 30. Feral Cat.

BCE 33. Feral Cat.

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