Bellevue Gold Limited
Level 2 Fauna Assessment 2018/2019
Bellevue Gold Project

Low shrubland over tussock grass on sandy loam, Kathleen Valley Transect, Bellevue Gold Project (photo: P. Smith).

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Executive Summary

Introduction

Bamford Consulting Ecologists (BCE) was commissioned by Bellevue Gold Limited to conduct a Level 2 fauna assessment (desktop review and field investigation) for the Bellevue/Tribune Gold project. Comprehensive field investigations of the main lease areas were undertaken in spring 2018, and in spring 2019 further field investigations were carried out for an expansion of the initial development areas. The project is located approximately 40 kilometres (km) north of Leinster, 120km south of Wiluna and 400km north-west of Kalgoorlie in the Shire of Leonora Western Australia.

The purpose of this report is to provide information on the fauna values of project area, particularly for significant species, an overview of the ecological function of the site within the local and regional context and to provide discussion on the interaction of development on the site with these fauna values and functions. The report also presents results from the two field surveys (23rd October and 1st November 2018 and 21st to 28th October 2019. There was also a brief reconnaissance visit in August 2018.

BCE uses an impact assessment process with the following components:

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

Study objectives

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

1. Identify significant environments within the new survey area;
2. Identify any new ecological processes in the survey area upon which fauna may depend;
3. Identify general patterns of biodiversity within or adjacent to the survey area, and
4. Identify potential impacts upon fauna and propose recommendations to minimise impacts.

The information gathered from the level 2 field investigations, undertaken in October 2018 and October 2019, enabled a thorough understanding of the fauna assemblage on site and the habitats that support them.

Summary of fauna values

Overview

The survey area ranged from Kathleen Valley and the Violet Range in the north through to Lake Miranda in the south, encompassing rocky hills, sandy loam flats, old mine areas and the margins of Lake Miranda. Field investigations included a broad range of sampling techniques: pitfall and funnel trapping, bird censussing, spotlighting/head-torching, searching, aural recording, motion-sensitive cameras and walking line transects.

The desktop study identified 269 vertebrate fauna species as potentially occurring in the survey area: 10 frogs, 70 reptiles, 153 birds and 36 mammals (28 native and eight introduced species). The assemblage includes up to 35 species of conservation significance. The field investigations in 2018 and 2019 confirmed the presence of 110 vertebrate fauna species including: one frog, 32 reptiles, 64 birds and 12 mammals (eight native and four introduced). Four species of conservation significance were recorded: the listed migratory shorebirds the Common Greenshank and the Sharp-tailed Sandpiper, and the locally significant (CS3) Australian Bustard and Bush Stone-curlew. The 2019 survey added one mammal, two reptile and six bird species not recorded in 2018.

Fauna assemblage

Moderately rich and substantially intact, except for the loss of nine mammal species including the Chuditch, Bilby and Boodie. Overall, the fauna assemblage is likely to be well-represented in the region but is incomplete due to local species loss. Through field investigations, the survey area sampled contained only a subset of the fauna assemblage predicted for the entire region, but fauna is mobile and an assemblage can change over time. The lack of spinifex *Triodia* sp. in the project area may explain the lack of records of some reptile and mammal species that are linked to the presence of this plant.

Species of conservation significance

This list includes up to 34 species (two reptile, 26 bird and six mammal species). Some of the significant species returned from databases are widespread and occur in very extensive regional landscapes, and although possibly present in the broader region they appear to be absent (some may be vagrants following a succession of good seasons) from the project area. These include the Great Desert Skink, Malleefowl, Night Parrot and Black-footed Rock-Wallaby. Similarly, the Brush-tailed Mulgara, Peregrine Falcon and several CS3 parrot species are likely to be irregular visitors to the survey area. Targeted surveys for Malleefowl nesting mounds in mulga woodland and Slender-billed Thornbill in samphire flats were undertaken during the field investigation. Results found no evidence for either species. Audio recording devices were used on the margins of Lake Miranda (on the southern edge of the lease area) in October 2018 to search for the Night Parrot, but no calls were detected.

Up to 10 species of migratory waterbirds are likely to occur on an occasional basis (following heavy rain and flooding) on the adjacent Lake Miranda. They could be very numerous at such times but conditions were not generally suitable in 2018 and 2019. Waterbirds had been recorded by Bellevue staff in early 2018 and one migratory species, the Common Greenshank, was present during a preliminary site visit in August 2019. A second listed migratory species, the Sharp-tailed Sandpiper, was recorded (a single bird) on Lake Miranda in October 2019.

Vegetation and Substrate Associations (VSAs). Six VSAs were identified:

1. Long-leaf Mulga over shrubs and tussock grass on rocks and loam of undulating hills.
2. Broad-leaf Mulga over shrubs and tussock grass on sandy-loam plains.
3. Isolated trees over open shrubland on gypsum soils close to Lake Miranda.
4. Samphire marsh in loam clay on margins and across parts of Lake Miranda.
5. Lake Miranda.
6. Degraded areas.

Patterns of biodiversity

VSAs can be very distinctive, particularly with regard to substrate, and this is likely to result in very different reptile assemblages between them. Sampling in both October 2018 and 2019 yielded low numbers of records, probably due to persistent dry conditions, but there were some patterns of distribution apparent. For example, the restricted VSA3 had a distinctive reptile assemblage including a species well out of range: the legless-lizard *Aprasia repens*. Reptiles of the sandy-loam plains of VSA2 were also a distinctive assemblage, with species such as the Midline Knob-tailed Gecko *Nephrurus vertebralis* found virtually only in this environment at different sampling locations in 2018 and 2019. Limited sampling of invertebrates also found distinct species of slaters (isopods) related to substrate types. Lake Miranda will attract a large number of waterbird and shorebird species following heavy rains.

Key ecological processes

The main processes which may affect the fauna assemblage are likely to be fire regimes and the presence and abundance of feral species, and to a lesser degree landscape connectivity and local hydrology. Inappropriate fire regimes i.e. infrequent, extensive fires compared with a mosaic of fire ages (including long-unburnt areas) created by small, frequent fires have probably contributed to low levels of abundance and possibly local extinction of a number of species of conservation significance. The effect of feral predators (Cat and Fox) is complicated as it interacts with the fire regime, and the feral species interact with each other. Rabbits, goats and camels cause widespread damage to vegetation and habitat.

Impacting processes

Impacting processes (listed above) have to be considered in the context of fauna values and the nature of the proposed action. The impacts of greatest concern are those of habitat loss leading

to population decline, feral species, hydrological change and altered fire regimes. Some of these can occur regardless if a project proceeds or not.

Recommendations

While the development footprint is small in the context of a very broad and continuous landscape, some impacts are of concern because of the potential for significant species to be present, and the landscape-scale ecological processes that may be affected by the proposal. Mining projects can affect the abundance of these species and also provide opportunities for active conservation management. Key management actions can be related to impacting processes as outlined below. Many of these strategies are now considered best practice at most mine sites. Although impacts are mostly expected to be minor to moderate, any reduction in impacts is desirable.

Habitat loss leading to population decline and fragmentation

- Minimise the disturbance footprint and maintain large trees where possible. Large Eucalypt trees are important for fauna, including providing hollows;
- Clearly delineate areas to be cleared to minimise unnecessary vegetation loss;
- Maintain linkages to adjacent vegetation where possible; and
- Rehabilitate as soon as practical.

Habitat degradation due to weed invasion

- Develop and implement a weed management plan.

Ongoing mortality

- Restrict vehicle access;
- Enforce maximum speed limits;
- Entrapment of fauna in exploration sumps and trenches should be minimised through design and inspection;
- Lighting should be used and directed so as to minimise mortality of invertebrates;
- Erect signage in areas of high wildlife activity, if required;
- Educate personnel with respect to fauna through the induction process; and
- Record and report all fauna incidents to the site supervisor and environment department.

Species interactions

- Rehabilitate access tracks as soon as possible to discourage access by feral fauna;
- Develop a predator management programme aimed at suppressing the abundance of the Fox and Cat and maintaining the Dingo population level at a natural density; this to be discussed and developed in consultation with the DBCA;
- Ensure appropriate waste disposal during construction activities to avoid attracting feral and native species to the area; and
- Educate personnel not to feed (deliberately or inadvertently) feral species.

Hydrological changes

- Ensure local hydrology is not affected, including alterations to runoff through the landscape and changes due to groundwater abstraction;
- Avoid runoff to ensure sediment or any chemicals do not contaminate soil, groundwater and Lake Miranda, and install appropriate erosion control, if required; and

- Implement management actions if hydrological changes are likely to affect significant fauna habitats, if required.

Altered fire regimes

- Develop and implement a regional fire management plan during construction and operational activities to ensure wildfires do not occur as a result of activities and appropriate responses are in place should a wildfire occur; and
- Investigate the possibility of a cooperative fire management strategy with other key stakeholders. Such a regional fire management plan would aim at developing a mosaic of fire ages through the frequent occurrence of small fires, including areas of long-unburnt patches and the prevention of extensive fires.

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1 Introduction

Bamford Consulting Ecologists (BCE) was commissioned by Bellevue Gold Limited to conduct a Level 2 fauna assessment (desktop review and field investigation) for the Bellevue/Tribune Gold project. The project is located approximately 40 kilometres (km) north of Leinster, 120km south of Wiluna and 400km north-west of Kalgoorlie in the Shire of Leonora Western Australia (Figure 1). Preliminary geological investigations have identified a high-grade gold and nickel district on the prolific Wiluna-Norseman gold belt. It is proposed to develop the underground deposit to a depth of 500 metres (m).

The project development area covers ca. 544 hectares (ha) and is situated in Mining Tenement M36/25 and Exploration Licence E36/535, and these leases were investigated in October 2018. In October 2019, work was carried out in conjunction with the possible development of a water supply at Kathleen Valley, with this later work being conducted in Mining Tenement M36/25 and Exploration Licence E36/535, and also in Tenements M36/24, 299,660,162 and 176 (Figure 1).

The purpose of this report is to provide information on the fauna values of the project area (also referred to as the survey area), particularly for significant species, an overview of the ecological function of the site within the local and regional context, and to provide discussion comments on the interaction of development on the site with these fauna values and functions. The report is based on the results of a desktop review and field investigations carried out in August 2018 (site reconnaissance) and comprehensive (level 2) sampling surveys in October 2018 and October 2019.

1.1 General Approach to Fauna Impact Assessment

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

- The identification of fauna values:
    - Assemblage characteristics: uniqueness, completeness and richness;
    - Species of conservation significance;
    - Recognition of ecotypes or vegetation/substrate associations (VSAs) that provide habitat for fauna, particularly those that are rare, unusual and/or support significant fauna;
    - Patterns of biodiversity across the landscape; and
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- The review of impacting processes such as:
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    - Ongoing mortality from operations;
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    - Altered fire regimes; and

  - Disturbance (dust, light, noise).
- The recommendation of actions to mitigate impacts.

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

Based on this impact assessment process, the objectives of investigations are to: identify fauna values; review impacting processes with respect to these values and the proposed activity; and provide recommendations to mitigate these impacts.

1.2 Study objectives

Study objectives

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

1. Conduct a literature review and searches of Commonwealth and State fauna databases;
2. Undertake an intensive field investigation to provide information on the presence of fauna in the project area with a focus on significant species known from the broader region; e.g Great Desert Skink, Brush-tailed Mulgara, Black-flanked Rock-Wallaby, Malleefowl and Night Parrot;
3. Review the list of fauna expected to occur on the site in the light of fauna habitats present;
4. Identify significant environments within the survey area;
5. Identify any ecological processes in the survey area upon which fauna may depend;
6. Identify general patterns of biodiversity within or adjacent to the survey area; and
7. Identify potential impacts upon fauna and propose recommendations to minimise impacts.

The information gathered from the level 2 field investigation, undertaken in October 2018 and 2019, enabled a thorough understanding of the fauna assemblage on site and the habitats that support them.

1.3 Description of the survey area

The project is situated in an area of extensive historical disturbance from past mining operations. The western and northern areas of the site extend into undisturbed native vegetation. The site consists primarily of mulga over grasses with some rocky hills. Lake Miranda forms part of the southern section and is a large, shallow, salt lake system which floods periodically. Approximately 45.7% (248.5 ha) of the survey area is intact native vegetation. Areas that don't qualify as intact native vegetation are Lake Miranda (112.7 ha) and degraded areas (182.8 ha).

It is our understanding that development will aim to take place in areas that utilise, where possible, all historical disturbance footprints. This can only be confirmed once sterilisation drilling is completed.

The project consists of 10 main impact areas within a larger development envelope including:

1. Underground mine workings (2.05 ha);
2. Tailing storage facility (47.64 ha);
3. Associated infrastructure (20.13 ha);
4. Processing plant (10.01 ha);
5. Waste dumps (20.56 ha);
6. Historical workings (14.62 ha);
7. Old mining pits (21.11 ha);
8. Prosper box cut (2.05 ha);
9. Lay down (1.86 ha); and
10. Pond (0.86 ha)

In addition to these areas, there are proposed locations for groundwater abstraction to the north (multiple mining leases) and west (E 36/535) of the main impact areas (see Figure 1).

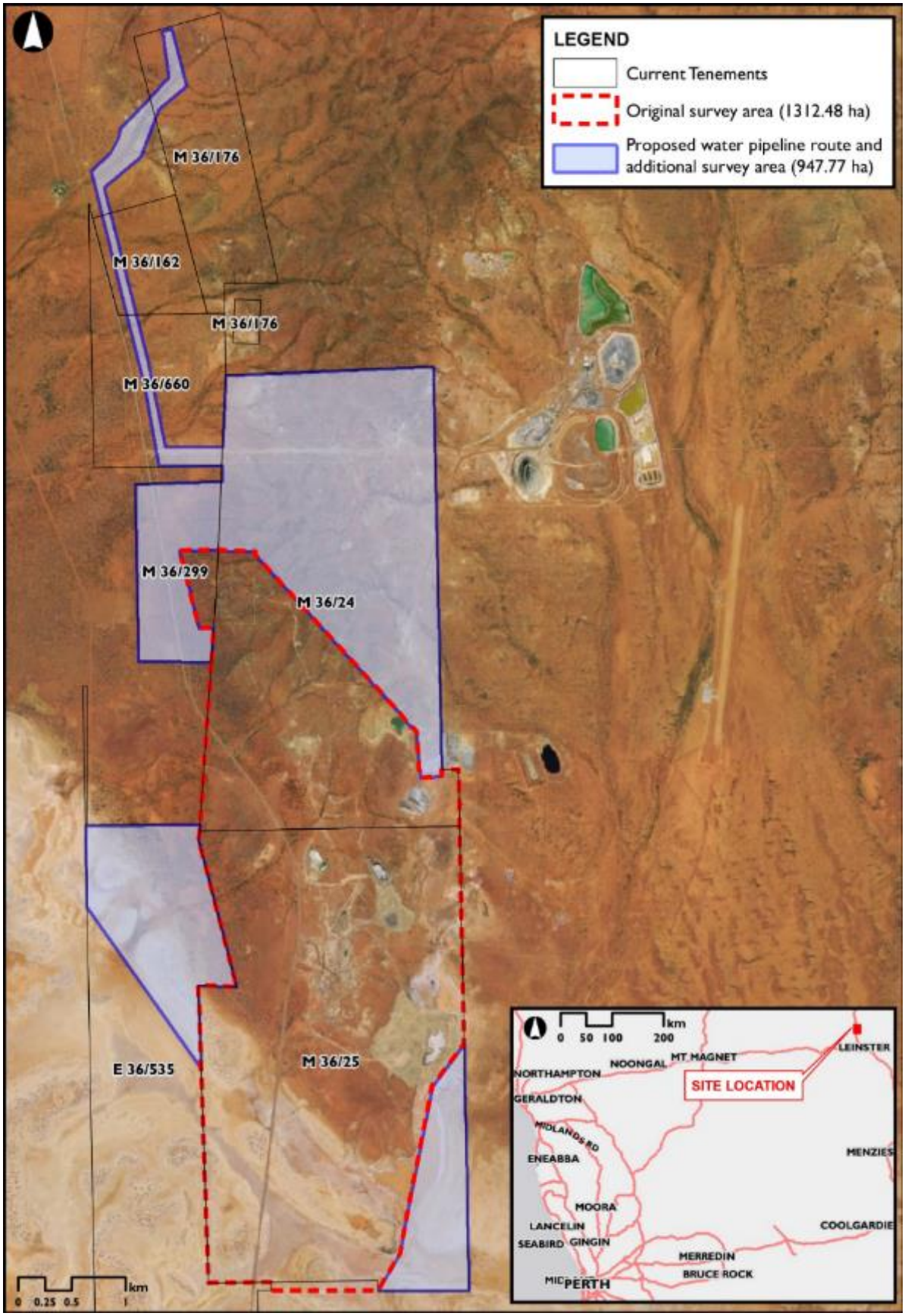

Figure 1. Location of the Bellevue project area. Studies undertaken in 2018 were confined to M36/25 (original survey area); studies in 2019 took place in parts of the areas shaded in blue-grey.

1.4 Regional Description

The Interim Biogeographic Regionalisation of Australia (IBRA) has identified 26 bioregions in Western Australia which are further divided into subregions (Environment Australia 2000). 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 2004). The survey area lies in the East Murchison (MUR1) subregion of the Murchison bioregion (Figure 2).

The Murchison Bioregion falls within the Bioregion Group 2 classification (EPA 2004). Bioregions within Group 2 have "native vegetation that is largely contiguous but is used for commercial grazing."

The general features of the Eastern Murchison subregion are summarised by Cowan (2001). The subregion comprises a rich interzone between the arid and mesic biotas of south-western Australia, corresponding roughly to the "line" between the Mulga/Spinifex country and the Eucalypt environments (Dell *et al*. 1998, McKenzie and Hall 1992). The subregion is characterised by its internal drainage and extensive areas of elevated red desert sandplains with minimal dune development. The climate is arid.

The dominant land use in this subregion is grazing, with smaller areas of crown reserves and mining. Only 1.4 per cent of the subregion is vested within conservation reserves (Cowan 2001). The southern boundary of the Wanjarri Nature Reserve is located approximately 15km north of the survey area and covers an area of 53,200 ha. More than 40 per cent of the Murchison's original mammal fauna is now regionally extinct (McKenzie *et al.* 2003).

Figure 2. IBRA Subregions in Western Australia.

Note the survey area lies within the centre of MUR1 Eastern Murchison IBRA subregion (red dot).

2 Methods

2.1 Overview

The methods used for this assessment are based upon the general approach to fauna investigations for impact assessment as outlined in Section 1.1 and with reference to Appendices 1 to 4. Thus, the impact assessment process involves the identification of fauna values, review of impacting processes and, where possible, preparation of mitigation recommendations.

This approach to fauna impact assessment has been developed with reference to guidelines and recommendations set out by the Western Australian Environmental Protection Authority (EPA) on fauna surveys and environmental protection (EPA 2002, 2004), and Commonwealth biodiversity legislation (DSEWPaC (2010), DotE (2014). The EPA (2010) proposes two levels of investigation that differ in the approach to field investigations, Level 1 being a review of data and (usually) a site reconnaissance to place data into the perspective of the site, and Level 2 (this assessment) being a literature review and intensive field investigations (e.g. trapping and other intensive sampling). The level of assessment recommended by the EPA is determined by the size and location of the proposed disturbance, the sensitivity of the surrounding environment in which the disturbance is planned, and the availability of pre-existing data. Guidance for field investigations methods is provided by the EPA (2010) and by Bamford *et al.* (2013).

The following approach and methods is divided into three groupings that relate to the stages and the objectives of impact assessment:

Desktop assessment. The purpose of the desktop review is to produce a species list that can be considered to represent the vertebrate fauna assemblage of the project area based on unpublished and published data using a precautionary approach.

Field investigations. The purpose of the field investigations is to gather information on this assemblage: confirm the presence of as many species as possible (with an emphasis on species of conservation significance), place the list generated by the desktop review into the context of the environment of the project area, collect information on the distribution and abundance of this assemblage, and develop an understanding of the project area's ecological processes that maintain the fauna. Note that field investigations cannot confirm the presence of an entire assemblage, or confirm the absence of a species. This requires far more work than is possible in the EIA process. For example, in an intensive trapping survey, How and Dell (1990) recorded in any one year only about 70% of the vertebrate species found over three years. In a study spanning over two decades, Bamford *et al.* (2010) has found that the vertebrate assemblage varies over time and space, meaning that even complete sampling at a set of sites only defines the assemblage of those sites at the time of sampling.

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

2.2 Desktop Assessment

2.2.1 Sources of information

Information on the fauna assemblage of the survey area was drawn from a wide range of sources. The information used included state and federal government databases and results of regional studies. Databases accessed were the Department of Biodiversity, Conservation and Attractions (DBCA) NatureMap (incorporating the Western Australian Museum's FaunaBase and the DBCA Threatened and Priority Fauna Database), BirdLife Australia's Atlas Database (BA) and the EPBC Protected Matters Search Tool of the Department of the Environment and Energy (DEE) (Table 1). Databases were accessed in2018 to inform the initial period of field investigations, and these records are considered adequate and current as the likelihood of new records being added since that time is very low. Information from the above sources was supplemented with species expected in the area based on general patterns of distribution. Sources of information used for these general patterns were:

Frogs: Tyler *et al.* (2009) and Anstis (2013);
Reptiles: Storr *et al.* (1983, 1990, 1999 and 2002) and Wilson and Swan (2017);
Birds: Johnstone and Storr (1998, 2004) and Barrett *et al.* (2003); and
Mammals: Menkhorst and Knight (2010); Churchill (2008); and Van Dyck and Strahan (2008).

Table 1. Sources of information used for the desktop assessment.

Database	Type of records held on database	Area searched
NatureMap (DBCA 2018)	Records in the WAM and DBCA databases. Includes historical data and records on Threatened and Priority species in WA.	Point search: -27.594977°, 120.581479° plus 20 km buffer. Searched: August 2018.
BirdLife Australia Atlas Database (BirdLife Australia, 2018)	Records of bird observations in Australia, 1998-2018.	Point search: -27.594977°, 120.581479° plus 20 km buffer. Searched: August 2018.
EPBC Protected Matters (DEE 2018a)	Records on matters of national environmental significance protected under the EPBC Act.	Point search: -27.594977°, 120.581479° plus 40 km buffer. Searched: August 2018.

2.2.2 Previous fauna surveys

Multiple fauna surveys and studies have been conducted in the general area, both by BCE and other consultants. Including recent site visits and surveys by BCE in 2018.
References include:

- Dell. J., How, R.A., Milewski, A.V. and Keighery, G.J. (1998). The biological survey of the eastern Goldfields of Western Australia. Part 7. Edjudina-Menzies Study Area. Records of the Western Australian Museum, Supplement No. 31:1-137. Perth, WA.

- Cowan, M. (2001). Murchison 1 (MUR1 – East Murchison subregion) in A biodiversity audit of Western Australia's 53 Biogeographical Subregions in 2002. Department of Conservation and Land Management, Western Australia.
- ATA (2005). Fauna Assessment, Western Mining Corporation, Yakabindie - Version 2 Report 2004/209. Unpublished report for Sinclair Knight Merz, ATA Environmental.
- Biota Environmental Sciences (2006a). Wanjarri Nature Reserve Land Swap Proposal. Unpublished report for Sinclair Knight Merz, Western Australia.
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- Thompson, S.A. and Thompson, G.G. (2006). Reptiles of the Western Australian Goldfields. Kalgoorlie, WA: Goldfields Environmental Management Group.
- Bamford, M., Huang, N., and Turpin, J. (2011). Vertebrate Fauna Assessment Yeelirrie Project Baseline Report. Unpublished report prepared for URS Australia Pty Ltd. February 2011.
- Bamford, M., and Turpin, J. (2015). Yeelirrie Terrestrial Vertebrate Fauna Review. Unpublished report prepared for Cameco Australia. April 2015.
- Biota Environmental Sciences (2017a). Mt Keith Satellite Proposal Vertebrate Fauna Review. Report prepared for BHP Billiton. July 2017.
- Biota Environmental Sciences (2017b). Mt Keith Satellite Night Parrot Survey. Report for BHP Billiton Nickel West. July 2017.

2.2.2 Nomenclature and taxonomy

As per the recommendations of EPA (2004), the nomenclature and taxonomic order presented in this report are based on the Western Australian Museum's (WAM) Checklist of the Fauna of Western Australia 2017. The authorities used for each vertebrate group were: amphibians (Doughty *et al.* 2017a), reptiles (Doughty *et al*. 2017b), birds (Johnstone and Darnell 2017), and mammals (Travouillon 2016). In some cases, more widely-recognised names and naming conventions have been followed, particularly for birds where there are national and international naming conventions in place (e.g. the BirdLife Australia working list of names for Australian Birds). English names of species where available are used throughout the text; Latin species names are presented with corresponding English names in tables in the appendices.

2.2.3 Interpretation of species lists

Species lists generated from the review of sources of information are generous as they include records drawn from a large region and possibly from environments not represented in the survey area. Therefore, some species that were returned by one or more of the data searches have been excluded because their ecology, or the environment within the survey area, meant that it is highly unlikely that these species will be present. Such species can include, for example, seabirds that might occur as extremely rare vagrants at a terrestrial, inland site, but for which the site is of no importance. Some waterbirds were included, because there are environments suitable for these species within the project site, such as rivers, creeks, dams and large flat inundated areas. A number of species may also nest on the site.

Species returned from the databases and not excluded on the basis of ecology or environment are therefore considered potentially present or expected to be present in the survey area at least occasionally, whether or not they were recorded during field surveys, and whether or not the survey area is likely to be important for them. This list of expected species is therefore subject to interpretation by assigning each a predicted status in the survey area.

The status categories used are:

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

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

2.3 Field Investigation

2.3.1 Survey overview

The field surveys incorporated a range of survey techniques so as to maximise sampling results. The following techniques were used:

- Identification of VSAs;
- Systematic sampling transects;
    - Pit trapping;
    - Funnel trapping (October 2018 only);
    - Bird census;
    - Targeted Malleefowl mounds
    - Targeted Slender-billed Thornbill
- Motion sensitive cameras
- Bat echolocation devices (October 2018 only)

- Audio recording devices (October 2018 only)
- Nocturnal searching
- Opportunistic invertebrate collection, and
- Opportunistic observations.

Methods used only in 2018 were either ineffective/inappropriate for conditions in 2019 (funnel traps) or were deemed adequate after the 2018 round of sampling.

2.3.2 Dates and Personnel

- The project area was initially visited on the 14th August 2018 by Dr Mike Bamford – BSc (Biol.), Hons (Biol.), PhD (Biol.) for the purpose of site familiarisation and to enable Lake Miranda to be visited while it still contained water. The site visit involved walking over the proposed project development area to enable environmental descriptions to be prepared and some opportunistic observations on fauna to be made. Following this, comprehensive field investigations were undertaken as outlined above from the 23rd November to 1st October 2018, and from 21st to 28th October 2019. Personnel on field surveys were:
  - Dr Mike Bamford (B.Sc. Hons. Ph.D.) (2018 and 2019);
  - Mr Peter Smith (As.Dip.Ag) (2018 and 2019);
  - Mr Andy McCreery (B.Sc.) (2018 and 2019);
  - Mr Tim Gamblin (B.Sc. Cert. Env. Man. (2018);
  - Dr Jamie Wadey (B.Sc. Hons. Ph.D.) (2019).

The field investigations were carried out under Regulation 17 permit No 08-002996-01 (2018) and BA27000167 (2019). This fauna assessment report was prepared initially by Cameron Everard (B.Sc. (Env Sci), M.Sc. (Env Sci) and Mike Bamford following the 2018 survey, and was revised and updated by Tim Gamblin and Mike Bamford after the 2019 survey.

2.3.3 Vegetation and Substrate Associations

Vegetation and Substrate Associations (VSAs) in the survey area were assessed during the desktop review and site inspection in 2018 and during both level 2 assessments in 2018 and 2019. Within the survey area, all major VSAs were visited to develop an understanding of major fauna habitat types present and to assess the likelihood of conservation significant species being present in the area. BCE were able to access and use the vegetation descriptions from Environmental Consultant, RPS, which contributed to providing more detailed VSAs.

2.3.4 Targeted searching for conservation significant fauna

Significant fauna species identified during the desktop assessment include several that can be found by searching for evidence of their activities (e.g. scats, tracks, diggings, burrows), including Great Desert Skink, Brush-tailed Mulgara, Black-flanked Rock-Wallaby, Malleefowl. Signs of these species were searched for while walking over the project area during the site visit in August 2018 and field investigation in October 2018 and 2019. Some of these species can also be detected by trapping,

but searching for evidence can be more efficient and provide reasonable estimates of distribution and abundance.

Targeted searches for Malleefowl and the Slender-billed Thornbill were undertaken during the field investigation in October 2018 and 2019. These involved walking transects where personnel searched for mounds and the target species, and made other fauna observations (Figures 3 and 4). Malleefowl mound transects were located in areas of mulga over tussock grass on sandy loam and rocky hills within the project area. This was identified as prime habitat for mound construction (based on previous experience of the field team). Personnel searched for active and old mounds and footprints in sandy areas, and also recorded other fauna and evidence of fauna, including abandoned Boodie warrens and evidence of feral animals. Mounds are easily detectable due to the displacement of soil and debris into a large and distinctive feature. Mounds can be detected in the landscape many years since last use. The total distance covered for all personnel walking transects in 2019 was approximately 74.3km, encompassing 362 ha when combining areas in-between personnel and line of sight.

Slender-billed Thornbill transects included areas on the margins of chenopod shrublands associated with Lake Miranda and Trapping Site 10. The species is not easily detectable as they are quiet, inconspicuous and less inquisitive than other Thornbills (DEE 2010). In order to increase the likelihood of detectability, four personnel walked in unison 50 metres apart to create a higher likelihood of disturbing individuals if encountered (Figure 4). All members of the team held binoculars. The total distance covered for all personnel walking transects was approximately 100.3km, encompassing 498ha when combining areas in-between personnel and line of sight.

Kathleen Valley pipeline corridor.
Transects were walked by four personnel along the Kathleen Valley Pipeline Corridor including parallel to the Cosmos Haul Road (Figure 6). Way-pointed photos with vegetation associations as well as fauna observations were recorded on these transects.

2.3.5 Systematic Fauna Sampling

Nine systematic sampling sites were deployed in October 2018 and six in October 2019. Each sampling site consisted of a transect of 10 pitfall traps with the pitfalls at 20-30m intervals. Pitfall configuration consisted of one 20 litre bucket with three fences (approximately 1.2 metres in length) extending radially from the bucket to allow fauna to fall into the pit when following the fence line. Six systematic sampling transects covered most major VSAs except for Lake Miranda and highly disturbed areas. Descriptions of sampling transects, including VSA, dates sampled, sampling effort and locations are given in Table 2; positions of transects are indicated on Figure 5. Two Funnel trap configurations were established separately to pitfalls at site 1 in 2018. Each funnel configuration consisted of five funnels spread approximately 25 metres in length, connected by drift fences. Total trapping effort was 828 pitfall nights and 30 funnel trap nights.

Bird census surveys were recorded during each pitfall check for the length of the transect and 25m on either side of the transect line. Birds were identified visually and acoustically. The length of transects were approximately 225m but varied due to different spacing of pitfalls (related to the

difficulty of installing pitfalls). This was considered when comparing bird census results; but numbers were so low that only very general comparisons could be made irrespective of sampling effort. Total bird census effort was 83 surveys along transects.

Table 2. Systematic sampling transect locations, description and trapping effort. Sites 1 to 9 were operated within the period 23 October to 1 November 2018, and Sites 10 to 15 in the period 21 to 28 October 2019. VSAs (Vegetation and Substrate Associations) are described in Section 3.1.

Site	Trap transect end coordinates		Description	Sampling effort
Site 1	Pit 1	51 J 257580 6943479	VSA2; Broad-leaf Mulga over shrubs and tussock grass on red, sandy loam soils.	60 pitfall trap nights, 30 funnel trap nights 6 bird surveys
	Pit 10	51 J 257824 6943593		
Site 2	Pit 1	51 J 258200 6943764	VSA1; Narrow-leaf Mulga over sparse shrubs and tussock grass on rocky hills.	60 pitfall trap nights 6 bird surveys
	Pit 10	51 J 258301 6943645		
Site 3	Pit 1	51 J 258575 6943123	VSA1; Narrow-leaf Mulga over open shrubs and tussock grass on rocky hills.	60 pitfall trap nights 6 bird surveys
	Pit 10	51 J 258666 6942921		
Site 4	Pit 1	51 J 259040 6938860	VSA2; Broad-leaf Mulga over shrubs and tussock grass on red, sandy loam soils.	60 pitfall trap nights 6 bird surveys
	Pit 10	51 J 258770 6939015		
Site 5	Pit 1	51 J 258224 6939708	VSA2; Broad-leaf Mulga and Allocasuarina over shrubs and tussock grass on red, sandy loam soils.	60 pitfall trap nights 6 bird surveys
	Pit 10	51 J 258205 6939912		
Site 6	Pit 1	51 J 259195 6940188	VSA1; Heavily degraded narrow-leaf Mulga over sparse shrubs and tussock grass on shallow soils.	60 pitfall trap nights 6 bird surveys
	Pit 10	51 J 259173 6940136		
Site 7	Pit 1	51 J 258002 6939567	VSA3; Isolated trees over open shrubland on gypsum soils	60 pitfall trap nights 6 bird surveys
	Pit 10	51 J 257850 6939737		
Site 8	Pit 1	51 J 257761 6939820	VSA3; Isolated trees over open shrubland on gypsum soils	60 pitfall trap nights 6 bird surveys
	Pit 10	51 J 257596 6940019		
Site 9	Pit 1	51 J 259881 6941243	VSA4; Samphire marsh in loam clay	50 pitfall trap nights 5 bird surveys
	Pit 10	51 J 259808 6940971		
Site 10	Pit 1	256632 6941678	Edge of chenopod shrublands in calcrete soils (VSA3) and into mulga over low shrubs and clumped grasses on red loam (VSA2). Badly degraded by cattle in parts.	50 pitfall trap nights 5 bird surveys
	Pit 10	256854 6941659		
Site 11	Pit 1	256831 6941425	VSA2. Shrubland on loam into mulga over shrubs and clumped grasses on slightly sandy loam.	50 pitfall trap nights 5 bird surveys
	Pit 10	257072 6941482		

Site	Trap transect end coordinates		Description	Sampling effort
Site 12	Pit 1	257473 6940589	VSA2. Red sand dune supporting mulga over shrubs and clumped grasses. Pitfall 8 to 10 on loam-clay flat with scattered shrubs and sparse low shrubs and herbs.	50 pitfall trap nights 5 bird surveys
	Pit 10	257728 6940605		
Site 13	Pit 1	259907 6944579	Drainage line of tall Mulga over shrubs and grasses. Soil a hard loam with areas of sand and rock where water flows. Within VSA1.	50 pitfall trap nights 5 bird surveys
	Pit 10	259485 6944588		
Site 14	Pit 1	257565 6945022	VSA2. Tall Mulga over shrubland and mostly dense, clumping grasses on red loamy-sand flats.	50 pitfall trap nights 5 bird surveys
	Pit 10	257573 6944594		
Site 15	Pit 1	258101 6945006	Minor creekline with rocky slopes supporting miniritchi over scattered shrubs; larger acacia and scattered shrubs on rocky/loam in poorly-defined drainage line. Within VSA1.	48 pitfall trap nights. 5 bird surveys.
	Pit 10	258366 694636		

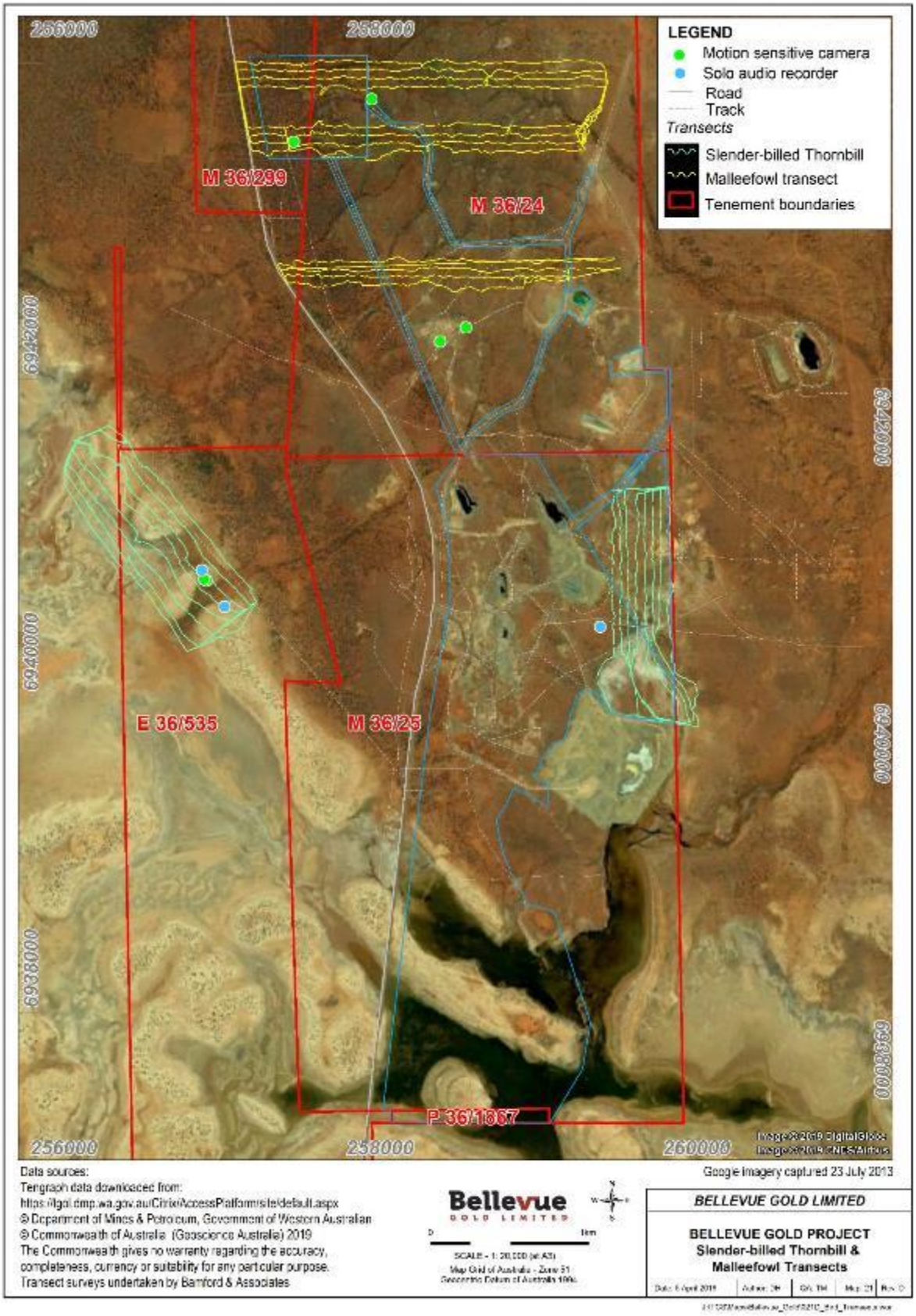

Figure 3. Locations of motion sensitive cameras, audio detectors and Malleefowl and Slender-billed Thornbill transects in October 2018.

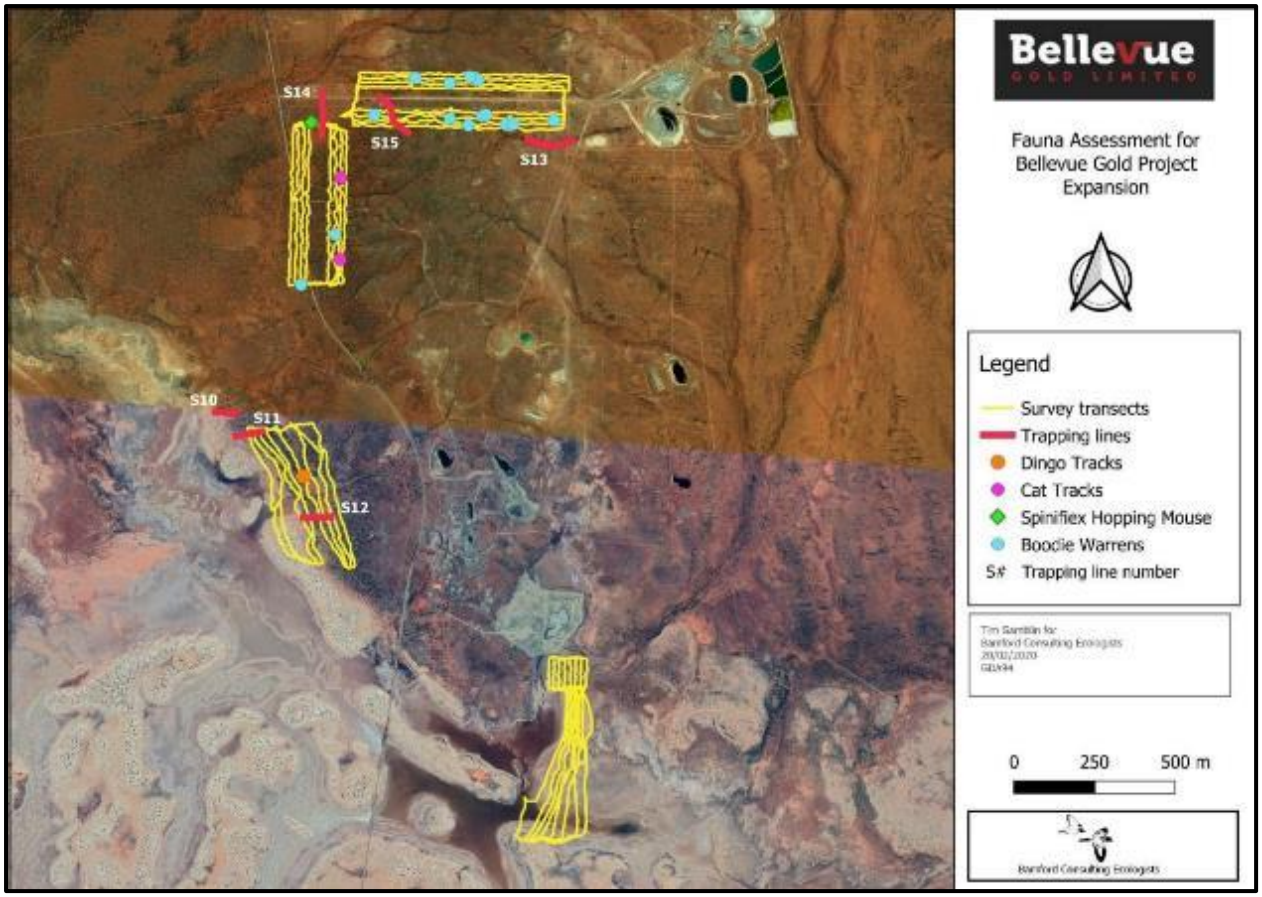

Figure 4. Locations of Malleefowl and Slender-billed Thornbill transects (yellow), and systematic sampling (trapping and census lines; red), in October 2019. Two motion-sensitive cameras were set on S15.

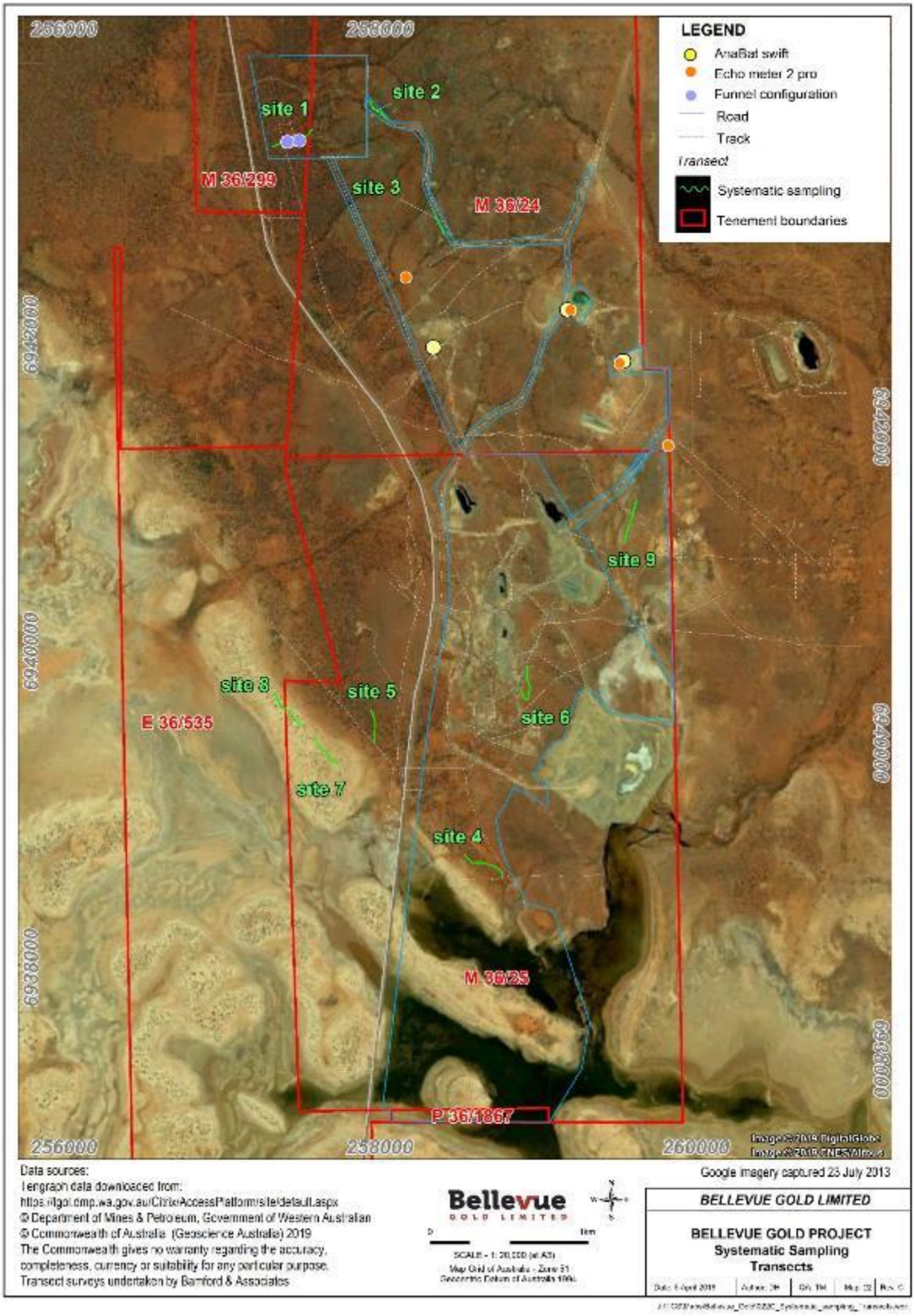

Figure 5. Locations of systematic sampling transects (trapping and census lines; green), funnel configurations and recording devices in October 2018.

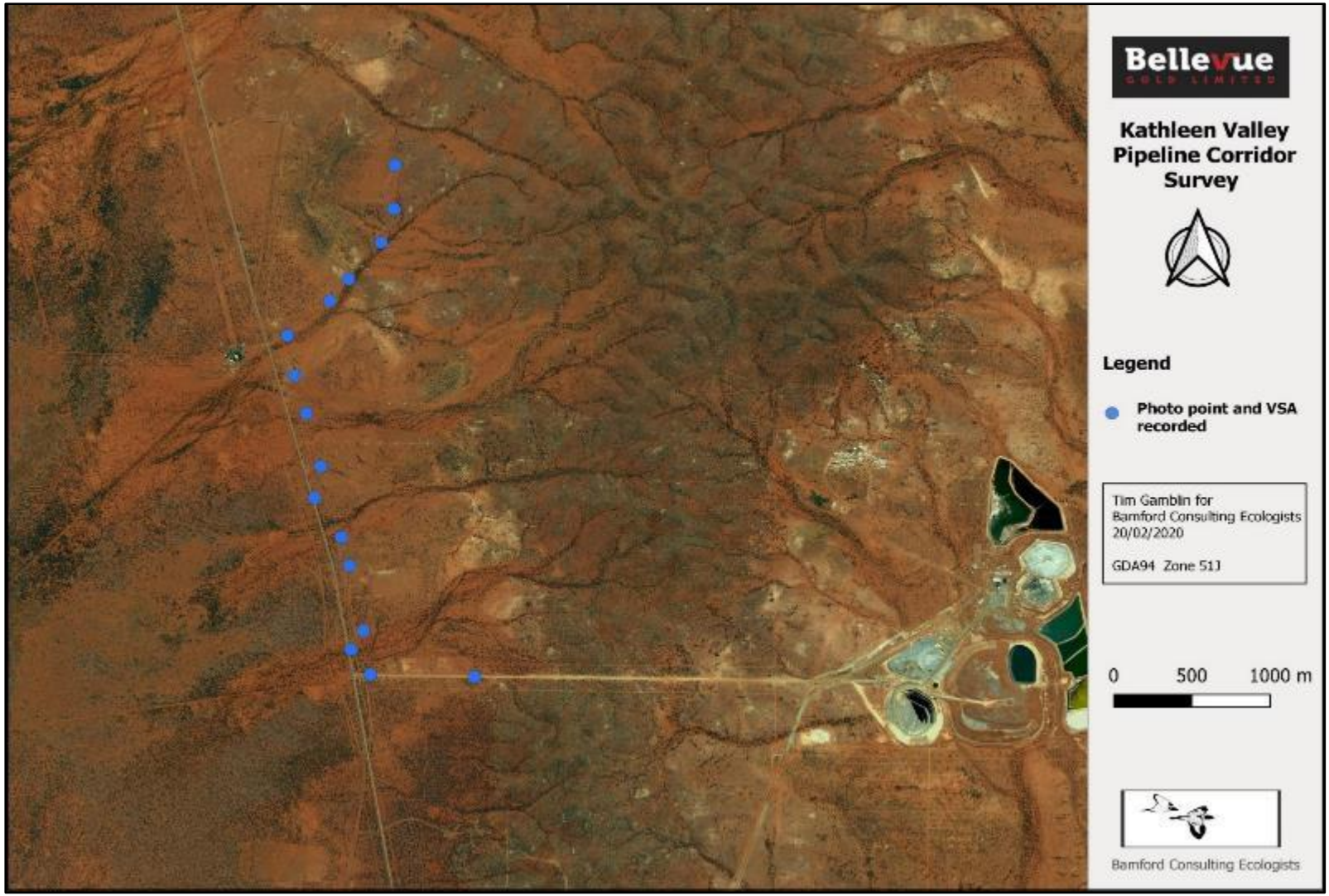

Figure 6. Kathleen Valley Pipeline Corridor, survey points in 2019. A photograph and vegetation association description were recorded at each point.

2.3.6 Nocturnal searching

Spotlighting for fauna involved four personnel searching over six nights in 2018, and four people over three nights in 2019. In October 2018, areas near Lake Miranda on the intact gypsum dunes around sites 7 and 8 were searched for two nights. The Boyd's Well area was searched on foot followed by a slow drive searching for nocturnal fauna via sites 1, 2 and 3. The perimeter of existing mining pit "Vanguard" was investigated for one night in areas of roadside vegetation and on the pit wall. The team spent one night in an area towards the northern section, where historical mining activities were undertaken. This area was heavily degraded with some vegetation clearing, and what remained was an old water tower, pieces of sheet metal, many historical artefacts and a few mine shafts. The final night involved driving along the Goldfields Highway using two vehicles, each team drove 10 kilometres from the entrance gate, one north, the other south, searching for reptiles utilising the warm road. In October 2019, the areas searched were site 15, the gypsum ridge in the south-west near Site 11 and the Vanguard pit (as in 2018). Spotlighting included observations made while driving at night to and from the locations described above.

2.3.7 Active hand searching

This method involved turning over ground debris including log, rocks and junk to detect fauna. This was done whenever the opportunity arose such as while doing transect walks and establishing the sampling transects. The high volume of foreign materials left over from previous mining activities provided many sheltered habitats for reptiles.

2.3.8 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 birds or reptiles seen while walking through the survey area.

2.3.9 Opportunistic invertebrate fauna collection

Collecting of invertebrate fauna was limited to those taxonomic groups that potentially include short range endemic (SRE) species such as Isopods, scorpions, pseudoscorpions, mygalomorph spiders and millipedes. Opportunistic searching for potential SREs included turning over logs and rocks. Potential SRE specimens caught as by-catch in the vertebrate fauna traps were also collected and sent to specialists for identification. Specimens were collected in both major surveys.

2.3.10 Bat Echolocation devices

An Anabat Swift (Titley) was deployed in various locations throughout the Bellevue study area for overnight recording during the October 2018 fauna assessment. Additional recordings were taken during evening fauna surveys on an Echo Meter 2 Pro allied to an iphone 7 running Echo Meter software. The Echo meter was used in shorter intervals in a range of locations, often for the period of nocturnal searches. On the evening of 31 October, the echo meter was activated over a distance of approximately 12 km starting from camp, through central areas of the survey area and then proceeding south along the Goldfields Highway. A summary of bat echolocation device locations is displayed in Table 3.

Table 3. Locations for the Swift and EMT 2 deployment.

Date	Easting	Northing	Description of deployment location
Anabat Swift			
26 Oct	259798	6942118	Camp
27th Oct	259445	6942441	Vanguard Pit
28th Oct	258597	6942204	Old mine workings, including old water tank
EMP 2			
23nd Oct	259776	6942106	Camp
25th Oct	258422	6942648	Bat walk around old mine workings
27th Oct	259463	6942440	Vanguard Pit
31st Oct	260083	6941583	Driving survey from camp to -27.71933, 120.5405

Calls were assessed using Anabat Insight software and compared against previously collected calls using the following characteristics.

Fmax (kHz): Average maximum frequency of call pulses within each call sequence;
Fpeak (kHz): Average frequency of peak energy within call pulses, within each call sequence;
Fmin (kHz): Average minimum frequency of call pulses within each call sequence;
Dur (ms): Average duration of call pulses.

2.3.11 Audio recorders

Solo Audio recording devices were utilised to detect the presence of Night Parrots in October 2018. Two devices were set out in five locations to capture 11 recording nights. To maximise detection of bird calls, devices were set up in elevated and open positions in the landscape. Details of audio recorders are outlined in Table 2 (Locations on Figure 5).

Table 4. Location of Solo audio recorders

Location	Recording device	Device ID	Description	Set	Removed	Easting	Northing
Site 9	Solo Audio recorder	Solo 1	Chenopod Shrubland	25/10/18	27/10/18	259881	6941243
Lake Miranda crossing	Solo Audio recorder	Solo1	Lake Miranda	27/10/18	29/10/18	259648.8	6940441
West of Site 8	Solo Audio recorder	Solo1	Chenopod Shrubland	29/10/18	31/10/18	257273.8	6940568
Between Sites 7 and 8	Solo Audio recorder	Solo 2	Gypsum ridge	26/10/18	29/10/18	257800	6939650
Gypsum dune	Solo Audio recorder	Solo2	NW of site 8	29/10/18	31/10/18	257130.7	6940798

2.3.12 Motion sensitive cameras

Motion sensitive cameras were set up to detect vertebrate fauna on site. A non-reward lure was used to attract fauna in the form of bait tubes filled with universal bait (peanut butter, oats and sardines). Bait tubes were placed into the camera frame and attached to a solid object. Cameras were positioned in areas selected to maximise fauna detection, mostly near artificial excavations of old mine shafts and Boyd's Well. The details of camera deployment are given in Table 5 (see also Figure 3).

Table 5. Description and location of motion sensitive cameras.

Location	Camera type	Camera ID	Description	Set	Removed	Easting	Northing
Site 1	Reconyx	CAM1	Broad-leaf Mulga on sandy-loams	26/10/18	28/10/18	E 257710	S 6943507
Site 2	Reconyx	CAM2	Narrow-leaf Mulga on Violet Range	26/10/18	28/10/18	E 258204	S 6943777
Boyds' Well	Reconyx	BCE10	Old water tank south of Well	28/10/18	29/10/18	E 258800	S 6942333
Boyds' Well	Reconyx	BCE11	Old water tank south of Well	28/10/18	29/10/28	E 258637	S 6942245
West of Site 8	Reconyx	BCE10	Set on old Boodie warren	29/10/18	31/10/18	257159.2	6940733
West of Site 8	Reconyx	BCE11	Set on old Boodie warren	29/10/18	31/10/18	257144.2	6940741

2.4 Survey Limitations

The EPA Guidance Statement 56 (EPA 2004) outlines a number of limitations that may arise during surveying. These survey limitations are discussed in the context of the BCE investigation of the survey area in Table 6.

Table 6. Survey limitations as outlined by EPA.

EPA Limitation	Comment
Level of survey.	Level 2 (desktop study and field investigation). Survey intensity was deemed adequate due to the condition of the project area, scale of the project and the amount of data records available in the region.
Competency/experience of the consultant(s) carrying out the survey.	The ecologist has had extensive experience in conducting fauna surveys and have conducted several fauna studies within the region, focussing on relevant conservation significant species including Great Desert Skink, Black-flanked Rock-Wallaby, Malleefowl and Night Parrot.
Scope. (What faunal groups were sampled and were some sampling methods not able to be employed because of constraints?)	The survey focussed on vertebrate fauna, and fauna values for of the significant species potentially occurring, although some potential short-range endemic species were collected when encountered.
Proportion of fauna identified, recorded and/or collected.	All species encountered were identified.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	Abundant information from databases e.g. DBCA, EPBC and previous studies, e.g. *Dell et al*. (1998), Cowan (2001), ATA (2005), Biota Environmental Sciences (2006a, b), Thompson and Thompson (2006), Bamford *et al*. (2011), Bamford and Turpin (2015), Biota Environmental Sciences (2017a, b) and Everard and Bamford (2019).
The proportion of the task achieved and further work which might be needed.	The survey was completed and the report provides fauna values for the survey area. Waterbird survey for Lake Miranda may be required after a period of heavy rain.
Timing/weather/season/cycle.	Surveys were conducted in October 2018 and October 2019. The ideal time for Level 2 surveys in the Murchison coincides in Spring. However, conditions had been very dry for several years and levels of abundance were low, particularly in 2019. This issue is discussed later in the report.
Disturbances (e.g. fire, flood, accidental human intervention etc.) that affected results of survey.	None
Intensity. (In retrospect, was the intensity adequate?)	All major VSAs were visited and significant species habitat and traces were identified. VSAs beyond the survey area

	limits were also visited to gain local context of the species habitat.
Completeness (e.g. was relevant area fully surveyed).	Sites were fully surveyed to the level appropriate for a Level 2 assessment. Fauna database searches covered a >10 km radius beyond the survey area boundary.
Resources (e.g. degree of expertise available in animal identification to taxon level).	Field personnel have extensive experience with fauna and habitat in the region.
Remoteness and/or access problems.	There were no remoteness/access problems encountered.
Availability of contextual (e.g. biogeographic) information on the region.	Extensive regional information was available and was consulted.

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). 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; and
- 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:

<u>Fauna values</u>

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

- Assemblage characteristics (uniqueness, completeness and richness) - based upon desktop assessment and information from the site inspection;
- Species of conservation significance – based upon desktop assessment and site inspection;
- Recognition of ecotypes or vegetation/substrate associations (VSAs) - based upon desktop assessment and site inspection;

- Patterns of biodiversity across the landscape - based upon desktop assessment and site inspection;
- Ecological processes upon which the fauna depend - based upon desktop assessment and site inspection.

Impact assessment

This section reviews impacting processes (as described in detail in Appendix 2) with respect to the proposed project and examines the potential effect of these impacts upon biodiversity of the survey 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 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; and
  - Disturbance (dust, light, noise).
- Summary of impacts upon significant species, and other fauna values.

The impact assessment concludes with recommendations based upon predicted impacts and designed to mitigate these. Note that the terms direct and indirect impacts are not used in this report; for further explanation see Appendix 2.

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 were quantified on the basis of predicted population change (Appendix 2). 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 (2004) suggests that the availability of fauna habitats within a radius of 15km 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 is rare (<5% of the landscape within a 15km radius or within the Bioregion), whereas a low impact is where the environment is widespread (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, but are really only appropriate when considering very large proposed developments in broad landscapes.

This is the case for the Bellevue Gold survey area. In the following criteria (Table 7), the significance of impacts is based upon percentage population decline within an estimated 15km radius 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 distribution of a species derived from the extent of available habitat, while for a few species, such as the black-cockatoos (although not relevant to the current project), there is guidance for the assessment of impact significance. The impact assessment concludes with recommendations based upon predicted impacts and designed to mitigate these.

Table 7. Assessment criteria of 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 the immediate area. No change in viability or conservation status of taxon.
Moderate	Permanent population decline 1-10% within the immediate area. No change in viability or conservation status of taxon.
Major	Permanent population decline >10% within the immediate area. No change in viability or conservation status of taxon.
Critical	Taxon extinction within the immediate area and/or change in viability or conservation status of taxon.

3 Results and discussion

3.1 Vegetation and Substrate Associations (VSAs)

Six key Vegetation and Substrate Associations (VSAs) were recorded during the site visit. Photographs of VSAs are shown in Plates 1 to 6 and described below. VASs are mapped on Figure 7.

7. **Long-leaf Mulga over shrubs and tussock grass on rocks and loam of undulating hills**. Miniritchie *Acacia grasbyi, Acacia sp. and A. xanthocarpa* grow where soil is very shallow and is present on slopes of the Violet Range. Below the canopy, dominant shrubs of this VSA include *Eremophila forrestii forrestii, E. exilifolia, Ptilotus obovatus* and *Grevillia inconspicua* (Priority 4). The ground cover of this rocky substrate is open with sparse tufts of tussock grasses *Aristida contorta, Enneapogon caerulescens* and *E. polyphyllus*. Minor drainage lines occur at the bottom of stony valleys and these often have dense thickets and Minirithie. This VSA is well represented and in good condition in the north of the site, including the Karthleen Valley area, but degraded around the old Bellevue mine. In the southern part of this VSA, the Acacia are stunted and vegetation characterises a low, open shrubland. A small hill in the Tribune area is an aboriginal sacred site and access is not permitted. Development will not impact the heritage site. Plates 1 and 2.

8. **Broad-leaf Mulga over shrubs and tussock grass on sandy-loam plains.** *Acacia sp.* and *A. ramulosa var. linophylla* dominate the canopy within this VSA. At the shrub layer, similar to VSA 1, *Eremophila forrestii forrestii* and *Ptilotus obovatus* is present as well as *Solanum lasiophyllum.* Comparative to other VSAs on site, this habitat contained the highest density of ground cover due to tussock grasses *Aristida holathera* var. *holathera, Eragrostis eriopoda, Monachather paradoxus and Eriachne sp.* and a light covering of leaf litter. This VSA is extensive and in good condition to the west of the Violet Range. However, within the Tribune area it is degraded due to past and current exploration and mining activities. Areas west of the Goldfields highway are in good condition. Plate 3.

9. **Isolated trees over open shrubland on gypsum soils close to Lake Miranda.** This VSA is limited to small patches surrounding salt lakes in the region and contains flora associated with hard crusted soil (Hall *et al.* 1994). The open canopy consists of *Eucalyptus striaticalyx* and *Casuarina pauper* over a shrub layer of *Lycium australe, Lawrencia helmsii, Maireana* spp. and flowering *Grevillia sarissa.* The sparse ground cover is dominated by *Aristida contorta, Aristidea chaetopoda and Frankenia* spp. The crusted surface was shallow and underneath, the substrate gave way to a very fine, powder-like consistency. Good examples of this VSA are located west of the highway. The open shrubland also occurs to the south of the project area on Long Island. Plate 4.

10. **Samphire marsh in loam clay on margins and across parts of Lake Miranda.** Samphire species *Tecticornia spp*. dominated this VSA with other shrubs *Maireana spp*., *Sclerolaena spp*. and *Atriplex sp*.. Occasional grasses, *Eragrostis* spp*. and Aristida contorta were* also present. The clay loam substrate was very dry and compact at the time of the field investigation. Plate 5.

11. **Lake Miranda**. A very shallow and hypersaline lake with soft sediments. Lake Miranda was mostly dry during the site visit (14th August 2018) and completely dry during the major field investigations (October 2018 and October 2019), but mine personnel report that the lake had been full for many months following summer rains of 2016/2017 and 2017/2018. Charophyta green algae were present in the lake. Lake Miranda is a large playa salt lake located in the southern part of the survey area (Figure 1). The lake is shallow, approximately 15km by 10km and seasonally inundated following heavy rains (often after major summer events as occurred in summer 2017/2018. Water quality is generally hypersaline due to low annual rainfall coupled with high summer temperatures and high evapo-concentration rates, with the exception, after heavy summer rains when a lens of fresh water is likely to stratify at the lake surface. Over 50 bird species have been recorded from Lake Miranda (BirdLife Australia 2018). Numerous other salt lake systems with similar physical and geochemical properties as Lake Miranda occur throughout the region. It should be highlighted that Lake Miranda has previously been used as a discharge lake for saline mine dewatering (Outback Ecology 2009). Historical mining operations, and in particular the storage of mine waste adjacent to the lake, have been reported to have leached contaminants into the lake such that concentrations of some metals were elevated above baseline conditions (Finucane 2001, Finucane *et al.* 2003).

12. Degraded areas. Isolated trees over sparse shrubland, tussock grass and scattered herbs on flats. The areas identified as degraded are a mixture of two VSAs. The northern degraded areas are the rocky ridgeline communities of VSA 1, while the sandy loam flats of VSA 2 is represented in the southern degraded areas. Soil is either original (rocky loam and loam) or is overburden (thus a mixture of rock, loam and clay). Some of these areas have historical disturbance that date back to 1897. Plate 6.

Plate 1. Long-leaf Mulga over shrubs and tussock grass on rocks and loam of undulating hills (VSA 1)

Plate 2. Miniritchie over scattered shrubs on rocky loam slopes in drainage lines (VSA1).

Plate 3. Broad-leaf Mulga over shrubs and tussock grass on sandy-loam plains (VSA 2)

Plate 4. Open Chenopod shrublands on gypsum/calcrete soils close to Lake Miranda (VSA 3). VSA2 in background.

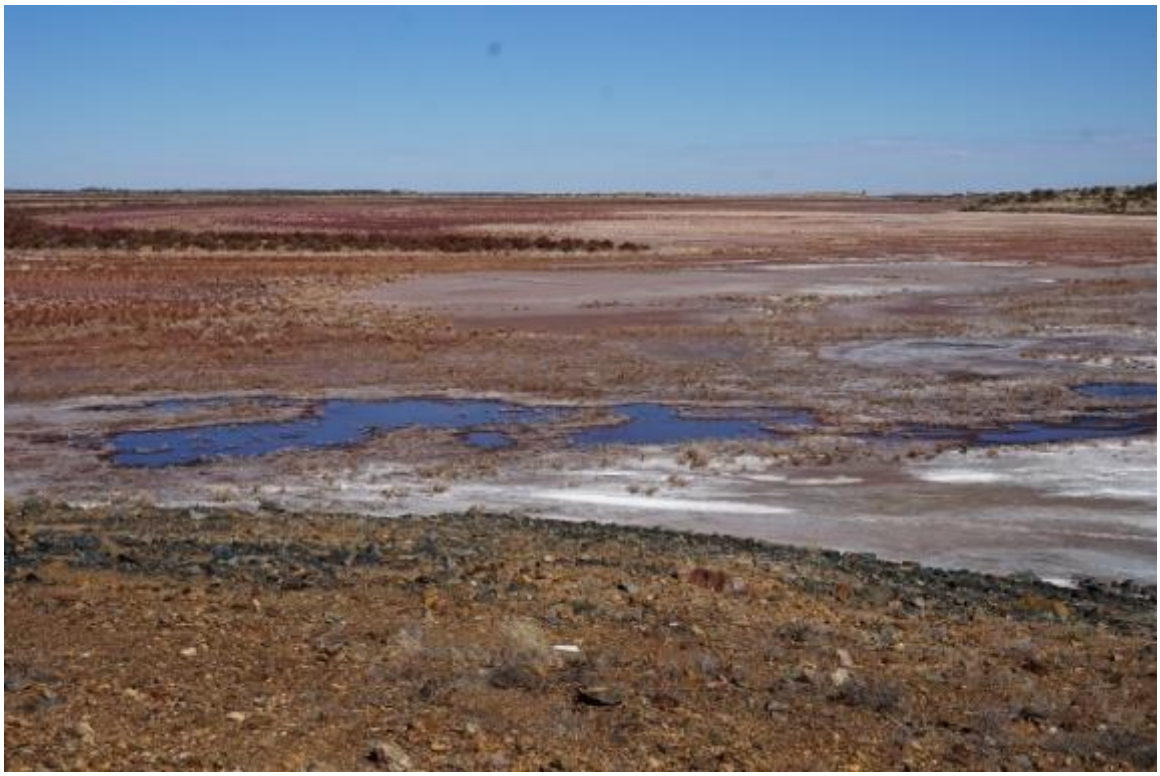

Plate 5. Samphire marsh in loam clay (VSA4) and Lake Miranda (VSA 5)

Plate 6. Degraded areas. Sparse shrubland with some tussock grass, scattered herbs on rocky loam, loam or overburden (VSA 6)

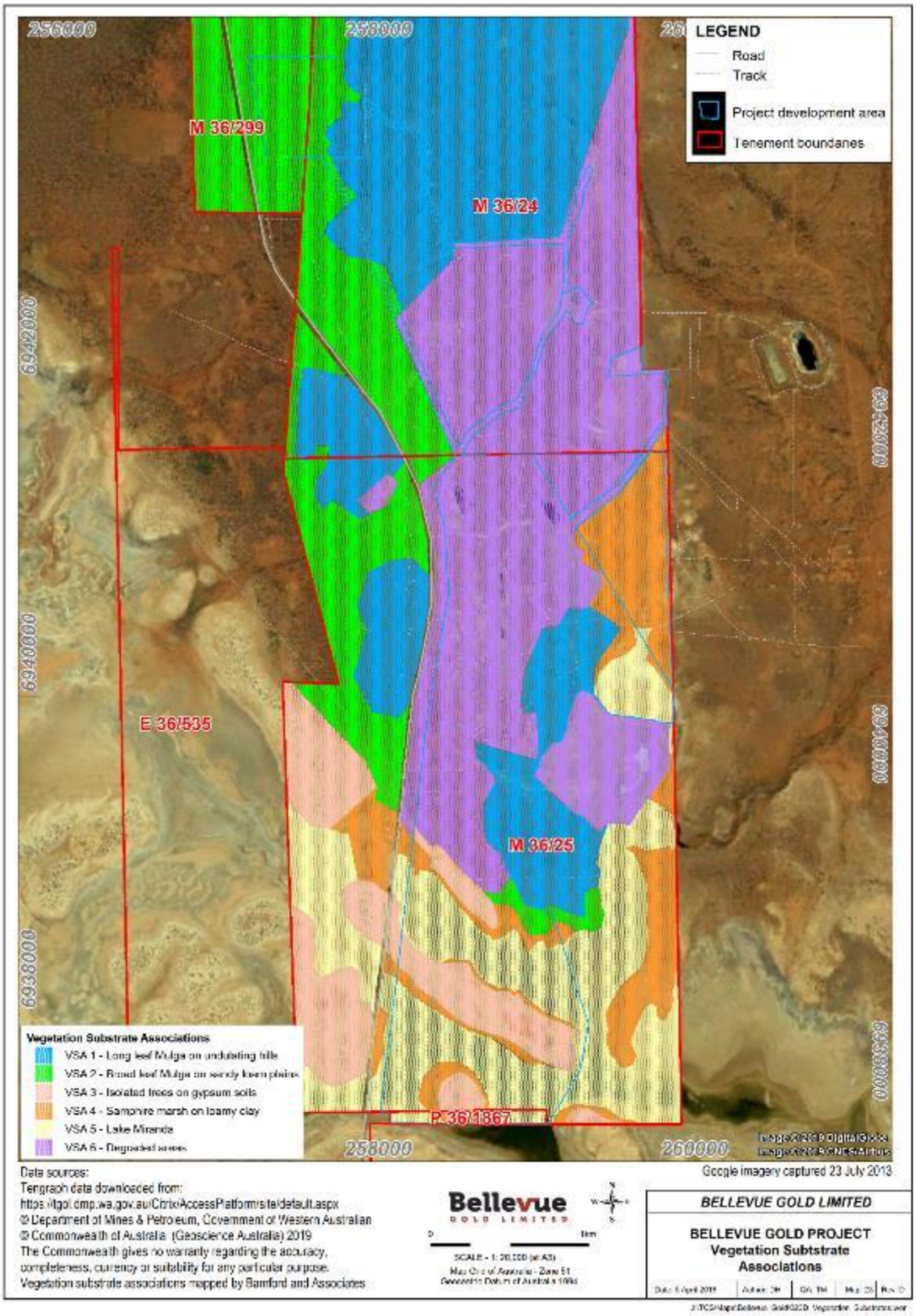

Figure 7. Vegetation and Substrate Associations within the development zone of the project area. Note that VSA1 is extensive in unmapped areas in the north, and VSA2 is extensive in unmapped areas west of the highway.

Kathleen Valley

Kathleen Valley is a proposed pipeline corridor that passes largely through VSA2. In the north, it lies in a broad valley between low, rocky hills (VSA1) and alongside a drainage line. It passes through VSA2 alongside the Goldfields Highway and along much of the Cosmos Haul road before entering VSA1 in the east. Details of the vegetation and corresponding images (photo points were taken every 300 to 400m on both sides of the corridor-see Figure 6) are described below with representative photographs in Plates 7 to 13.

Plate 7. Ironstone plain with dense mulga along drainage line (VSA 1 -257345E, 6948506N).

Plate 8. Sparse shrubs on gravelly slope (VSA 1 - 257345E, 6948836N).

Plate 9. Dense mulga in creekline with mixed shrubs on ironstone lower slope (VSA 1 - 257065E, 6947970N).

Plate 10. Mulga shrubland with tussock grasses on sandy loam
(VSA 2 - 256681E, 6947536N).

Plate 11. Sparse mulga with eremophila over dense tussock grasses on sandy loam (VSA 2 - 256880E, 6946314N).

Plate 12. Mulga shrubland with tussock grasses on loam (VSA 2 -257113E, 6945805N).

Plate 13. Dense tall mulga over mixed shrubs on rocky/gravelly rise (VSA 2 - 257137E, 6945171N).

3.2 Fauna

3.2.1 Overview of fauna assemblage

The desktop study identified 269 vertebrate fauna species as potentially occurring in the survey area (Table 8 and Appendix 5): 10 frogs, 70 reptiles, 153 birds, and 28 native and eight introduced mammals. The assemblage includes 35 species of conservation significance (Section 3.3.2). Note that this assemblage originates from databases and includes species that may occur occasionally in the survey area, but for which it is not important (such as birds that rarely fly overhead). Many species may also occur as vagrants at the site. Some species occur in the region but have specific habitat requirements that are not present in the project area. In particular, spinifex grassland (*Triodia sp.*) is not present within the project area and therefore spinifex specialist fauna would be unlikely to occur regularly on site. Species returned from databases that are unlikely to occur due to habitat requirements, and species considered to be extinct in the survey area, have been removed from the expected species list and are displayed in Appendix 5. Appendix 7 presents an annotated species list with notes on observations of each species in the project area.

The field investigation in 2018 confirmed the presence of 100 vertebrate fauna species including: one frog, 29 reptiles, 58 birds and 12 mammals (eight native and four introduced). The 2019 investigations confirmed the presence of just nine additional species (2 reptiles, 6 birds and one mammal). The confirmed assemblage therefore consists of 110 species: one frog, 32 reptiles, 64 birds and 13 mammals (nine native and four introduced). Two species of conservation significance were confirmed present: the schedule 1 listed migratory wetland shorebird, the Sharp-tailed Sandpiper and the locally significant (schedule 3) Australian Bustard. All fauna records have been compiled in the fauna list in Appendix 5; this includes observations made during the field investigation in 2018.

Frogs. Up to 10 species (1 confirmed) may be present in the area and are considered resident, although adults may leave the survey area to breed in other areas. *Litoria rubella* was recorded in 2018 (but only around the Bellevue Camp) however no frogs were recorded in 2019. All the frog species rely on seasonal freshwater for breeding and are therefore sensitive to changes in hydrology and water quality. Detection of frog presence was unlikely during the field investigation due to the dry conditions. No frogs of conservation significance are expected to occur.

Reptiles. Up to 70 species are known from the general area, but distributions can be patchy and therefore not all 70 species may be present in the project area. The virtual absence of spinifex (*Triodia* spp.) is likely to mean that a whole suite of spinifex-dependent lizards is scarce or absent. Of the 32 species confirmed, 14 were found only by searching (including head-torching) and just 11 were found only by trapping. The large contribution of results from searching means that a species accumulation curve cannot be used to predict the actual number of species present, but no additional species were added by trapping after the fifth night in October 2018, and only one species was added to the overall list by the trapping carried out in October 2019. The other species added to the overall list in 2019 was observed only. The overall total of 32 species was reached on the fourth field day in October 2019. This does suggest a total assemblage of <40 species, but conditions were dry and therefore levels of abundance may have been low. The Great Desert Skink *Liopholis kintorei* (CS1: Vulnerable) and the Black-headed Worm-lizard *Aprasia picturata* (CS3) are

the only reptiles of conservation significance returned from databases that may occur in the project area, but neither was recorded and neither seems likely to be present. They are discussed further below (Section 3.3.2).

Birds. Up to 153 species may be present, of which 72 are classed as residents, 34 regular visitors, 32 irregular visitors and 15 Vagrants. The majority of the 64 species confirmed are residents and all but six were recorded in October 2018. The salt-lake system of Lake Miranda provides a foraging resource for some waterbirds and shorebirds during times of inundation; some species may also breed there. Waterbirds were reported by staff to be abundant at Lake Miranda following summer rains (2017/2018) and were likely to include several duck species (e.g. Grey Teal, Australian Shelduck and Australian Wood Duck), stilts, avocets, terns and herons. During the August site visit, Common Greenshank, Black Swan and Red-capped Plover were recorded using the salt-lake.

Mammals. The mammal assemblage is depauperate with several locally extinct species including the Chuditch, Boodie (Burrowing Bettong) and several bandicoot species (Appendix 5). Abandoned Boodie warrens were found to be abundant, indicating that the species had formerly been common in the area. Twenty-eight native mammals and eight introduced mammal species may occur in the survey area, but only eight native species were confirmed during field investigations. The terrestrial mammal fauna, and in particular small species, was virtually absent. This is likely to be the result of annual and seasonal conditions being extremely dry, as the populations of many terrestrial mammals decline in poor periods. Six mammals of conservation significance occur in the region (Table 6).

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

- Uniqueness: The assemblage is likely to be typical of the region, and due to the project's location the assemblage is expected to include elements of the Murchison and arid interior, and with some fauna species expected occur near the extreme edge of their range. Previous assessments by BCE and other consultants in the region have confirmed a rich regional assemblage but the virtual absence of spinifex (*Triodia*) may reduce the numbers of reptile species present in particular.
- Completeness: The assemblage is likely to be incomplete due largely to the loss of some mammal species (e.g. critical weight range species). Many of the species expected may only utilise the area occasionally, when conditions are suitable (e.g. nomadic or migratory birds at Lake Miranda), and therefore it would take multiple surveys over several years to confirm the majority of the assemblage.
- Richness: The assemblage is likely to vary annually and seasonally according to climatic conditions. The assemblage is considered to be moderately rich, due to the range of substrates within the study area, but would be richer still if spinifex (*Triodia*) was present.

Table 8. Composition of the vertebrate fauna assemblage in the survey area; number of species confirmed in brackets.

Taxon	Number of species	Number of species in each status category				
		Resident	Migrant or regular visitor	Irregular visitor	Vagrant	Locally extinct
Frogs	10 (1)	10 (1)	-	-	-	-
Reptiles	70 (32)	69 (32)	1	-	-	-
Birds	153 (64)	72 (46)	34 (13)	32 (5)	15	-
Native Mammals	28 (excluding locally extinct) (9, including 5 bats)	24 (6)	2 (2)	2	1	9
Introduced Mammals	8 (4)	6 (4)	1	-	-	-
Total	269 (110)	181 (90)	38 (16)	34 (5)	16	-

3.2.2 Fauna of conservation significance

Thirty-five vertebrate species of conservation significance may occur in the survey area, with the majority of these being wetland birds classed as CS1 (Table 9 and Appendix 5). Note that the expected species assemblage is based largely on database records and on a greater than 20 km radial buffer zone, which can include environments not represented within the survey area. Species for which there is no habitat in the survey area have not been included, but could be very rare vagrants (and could include birds that overfly the site).

Species classed as CS1 are those listed under legislation (EPBC Act and WA Biodiversity Conservation Act), while those classed as CS2 are listed as Priority by the Department of Biodiversity Conservation and Attractions (DBCA), but not listed under legislation. The CS3 class is more subjective, but includes locally significant species that have declined extensively in an area due to natural or human-induced impacts, and species that occur at the edge of their range. This makes their presence in the survey area significant as populations on the edge of a species' range are often less abundant and more vulnerable to extinction than populations at the centre of the range (Curnutt *et al.* 1996).

A summary of the conservation significant species and their predicted occurrence in the survey area is provided in Table 10. Species or groups of species which are at least irregular visitors are discussed below. The only conservation significant species actually recorded during field investigations were the Common Greenshank (CS1), Sharp-tailed Sandpiper (CS1), and three species of local significance (CS3): Sandplain worm-Lizard, Australian Bustard and Bush Stone-curlew.

Table 9. Composition of extant conservation significance of the vertebrate fauna assemblage expected and recorded in the project area; number of species confirmed are in brackets.

Taxon	Conservation Significant fauna			
	CS1	CS2	CS3	Total
Frogs	-	-	-	0
Reptiles	1(0)	-	2(0)	3 (0)
Birds	18(2)	1(0)	8 (2)	27 (4)
Native Mammals	1(0)	2(0)	2(0)	5
Introduced Mammals	-	-	-	-
Total	20	3	12	35

Table 10. Conservation significant species expected to occur in the survey area.

Species	Common Name	Conservation significance	Recorded	Predicted status
Reptiles				
Liopholis kintorei	Great Desert Skink	CS1 (V,S3[v])		Vagrant
Aprasia picturata	Black-headed Worm-Lizard	CS3		Vagrant
Aprasia repens	Sandplain Worm-Lizard	CS3	X	Resident
Birds				
Leipoa ocellata	Malleefowl	CS1 (V,S3[v])		Irregular, non-breeding Visitor
Lophoictinia isura	Square-tailed Kite	CS3		Irregular visitor
Falco hypoleucos	Grey Falcon	CS1 (S3[v])		Vagrant
Falco peregrinus	Peregrine Falcon	CS1 (S7)		Irregular Visitor
Ardeotis australis	Australian Bustard	CS3	X	Regular visitor
Up to 10 waterbird species	See Appendix 5.	CS1 (M)	X*	Regular/Irregular Visitors, Vagrants
Burhinus grallarius	Bush Stone-curlew	CS3		Regular Visitor
Cacatua leadbeateri	Major Mitchell's Cockatoo	CS3		Vagrant
Neophema splendida	Scarlet-chested Parrot	CS3		Irregular Visitor
Polytelis anthopeplus	Regent Parrot	CS3		Irregular Visitor
Polytelis alexandrae	Princess Parrot	CS1 (V,P4)		Irregular Visitor
Pezoporus occidentalis	Night Parrot	CS1 E,S1 [ce]		Vagrant
Apus pacificus	Fork-tailed Swift	CS1 (M)		Regular Visitor
Amytornis striatus striatus	Striated Grasswren	CS2 (P4)		Vagrant

Acanthiza iredalei iredalei	Slender-billed Thornbill (Western)	CS3		Regular Visitor
Stipiturus ruficeps	Rufous-crowned Emu wren	CS3		Vagrant
Conopophila whitei	Grey Honeyeater	CS3		Irregular Visitor
Mammals				
Dasycercus blythi	Brush-tailed Mulgara	CS2 (P4)		Irregular Visitor
Antechinomys laniger	Kultarr	CS3		Resident
Sminthopsis longicaudata	Long-tailed Dunnart	CS2 (P4)		Resident
Petrogale lateralis	Black-flanked Rock-Wallaby	CS1 (E,S2[e])		Vagrant
Nyctophilus major tor	Central Long-eared Bat	CS2 (P3)		Resident
Pseudomys desertor	Desert Mouse	CS3		Irregular visitor
Invertebrates				
Kwonkan moriartii	Moriarty's Trapdoor Spider	CS3 (P2)		Resident

*Common Greenshank (August 2018) and Sharp-tailed Sandpiper (October 2019).

Conservation Significance codes:

- CS1, CS2, CS3 = (summary) levels of conservation significance. See Appendix 1 for full explanation.
- EPBC Act listings (CS1 species): E = Endangered, V = Vulnerable, M = Migratory, Mar = Marine (Appendix 3).
- Wildlife Conservation Act listings (CS1 species): for all CS1 species S1 to 7 = Schedules 1 to 7 respectively, (Appendix 3) with IUCN listing in square parentheses: [e] = endangered, [v] = vulnerable, [ce] = critically endangered.
- DBCA Priority species (CS2 species): P1 to P5 = Priority 1 to 5 (Appendix 3).
- Species considered to be of local significance (CS3).

Conservation Significance Level 1

One reptile, 18 birds and one mammal are listed as conservation significance level 1.

Great Desert Skink

The Great Desert Skink is a large burrowing lizard, with a scattered distribution and is restricted to sandplain and gravelly habitats in the western desert's region of central Australia (DEE 2018b). It is known to have disappeared from former habitats, particularly in the Gibson Desert and Great Sandy Desert regions.

The Great Desert Skink occupies a variety of habitat types within the Western Desert region. They generally occur on hummock grass sandplains characterised by a dominant cover of Spinifex grasses e.g. *Triodia basedowii*. In the Tanami Desert and parts of the Great Sandy Desert, the Great Desert Skink also inhabits paleodrainage lines characterised by giant termite mounds and *Melaleuca* shrubs. The decline of the Great Desert Skink has been attributed to altered fire regimes and predation by introduced predators (DEE 2018b). The species has a clumped distribution which is influenced by fire regimes (McAlpin 1997) and is near the south-western extreme of its distribution (DBCA 2018).

The Great Desert Skink is probably absent from the project area as no evidence of the species was recorded during field investigations and no spinifex grassland is present. However, an old historical

record exists approximately 30km north-east of the survey area at Wanjarri Nature Reserve (DBCA 2018).

Malleefowl

In Western Australia, Malleefowl occur mainly in scrubs and thickets of Mallee (*Eucalyptus* spp.), Boree (*Melaleuca pauperiflora M. sheathiana*), Bowgada (*Acacia ramulosa var. linophylla*) and also in other dense litter-forming shrublands including Mulga shrublands (*Acacia aneura*) (Johnstone and Storr 2004). The species is threatened by the widespread clearing of habitat, habitat degradation (by fire and livestock) and fox predation (Benshemesh 2007).

Malleefowl have been recorded both north and south of the project area, including at Wanjarri Nature Reserve, Mt Keith, Wiluna and at Yeelirrie by BCE. At Yeelirrie Station, 10 to 20 breeding pairs are estimated to occur on the property (Benshemesh *et al.* 2008) and it is considered to be of high importance because it is one of the few examples known of a Malleefowl population in a low rainfall area.

Malleefowl habitat is present in the project area, but searching did not find any recent or even old mounds, and previous experience indicates that more than enough habitat was searched for mounds to be detected had they been present. It therefore seems likely that the species is not and has not been (at least in recent decades) a breeding resident, but it could still be at least an irregular visitor.

Grey Falcon

The species is infrequently recorded over much of arid and semi-arid Australia and occurs at low densities (BirdLife International 2018). The distribution of the Grey Falcon is centred on inland drainage systems and nests are usually in the tallest trees along watercourses (Garnett and Crowley 2000). Regional records occur at Wiluna, Lorna Glen and Wanjarri Nature Reserve (DBCA 2018). It is likely to occur as a vagrant to the project area but there is none of its favoured habitat present.

Peregrine Falcon

The Peregrine Falcon is classified as Specially Protected Fauna under Schedule 7 (Other Specially Protected Fauna) of the Wildlife Conservation Act. Blakers *et al*. (1984) consider that Australia is one of the strongholds of the species, since it has declined in many other parts of the world. The species is found in a wide variety of habitats, with its distribution often linked to the abundance of prey. The Peregrine Falcon lays its eggs in recesses of cliff faces, tree hollows or in large abandoned nests of other birds and pairs maintain a home range of about 20 to 30 km^2 throughout the year (BirdLife Australia 2018).

The Peregrine Falcon has been recorded at Wanjarri Nature Reserve (DBCA 2018) and along a cliff ledge in the Barr Smith Range (Bamford *et al.* 2011). The study area is likely to lie within the foraging territory of a pair but breeding is very unlikely due to the lack of substantial cliffs or large trees.

Migratory Wetland Birds – up to 10 species

This group includes several shorebird species such as plovers, sandpipers, Common Greenshank, and others known to occur locally and regionally over a wide variety of wetland habitats. All the shorebird species listed in Appendix 5 potentially occur within the survey area and/or Lake Miranda as a regular visitor, irregular visitor or vagrant. The Common Greenshank (one bird) was present in August 2018 and the Sharp-tailed Sandpiper was seen in dry chenopod shrubland in October 2019. Under ideal conditions, numbers of migratory waterbirds could be very high, although at such times many lakes in the greater region would be flooded and thus the birds could be widely dispersed. Species include:

Black-tailed Godwit	*Limosa limosa*	Vagrant
Common Greenshank	*Tringa nebularia*	Regular Visitor
Marsh Sandpiper	*Tringa stagnatalis*	Regular Visitor
Common Sandpiper	*Tringa hypoleucos*	Regular Visitor
Wood Sandpiper	*Tringa glareola*	Regular Visitor
Red-necked Stint	*Calidris ruficollis*	Regular Visitor
Pectoral Sandpiper	*Calidris melanotos*	Irregular Visitor
Sharp-tailed Sandpiper	*Calidris acuminata*	Irregular Visitor
Curlew Sandpiper	*Calidris ferruginea*	Vagrant
Oriental Plover	*Charadrius veredus*	Vagrant

Princess Parrot

The Princess Parrot occurs on red desert sandplains, dunes, along tree-lined watercourses and arid woodlands (DEE 2018b). The Princess Parrot is highly nomadic, with its occurrence sporadic through the arid interior. A specimen was collected in 1964 from Wanjarri Nature Reserve (DBCA 2018), and Biota (2017a) report an unconfirmed sighting in 2005 from environmental personnel at Mount Keith. The species is likely to be an irregular visitor to the survey area. It is an irregular visitor (sometimes at intervals of more than 20 years) to most sites in its range (Garnett and Crowley 2000), and movements are largely unknown (Higgins 1999).

Night Parrot

The Night Parrot is listed as Endangered under the EPBC Act and Critically Endangered under the WA Biodiversity Conservation Act. Habitat requirements for the species include areas of old-growth spinifex (*Triodia spp.*) for roosting and nesting, together with foraging habitats that are likely to include various native grasses and herbs, including around salt lakes, and that may or may not contain shrubs or low trees (DPaW 2017).

A targeted Night Parrot survey was conducted for BHP Billiton's Mount Keith Satellite Proposal (approximately 20 km north of the survey area) and adjacent Wanjarri Nature Reserve but did not record the species (Biota 2017b). The detection of Night Parrot calls was the main objective for establishing Solo audio recorders in the project area in October 2018. These were set up for 11 nights and no calls were recorded. The virtual lack of spinifex around Lake Miranda makes it unlikely the species is present, but the Night Parrot may potentially occur as a vagrant in the survey area.

Fork-tailed Swift
The Fork-tailed Swift is a non-breeding summer visitor to Australia. It is a largely aerial species of unpredictable occurrence and mostly independent of terrestrial environments.

Black-flanked Rock-Wallaby
The Black-flanked Rock-Wallaby has declined over much of its range and now occurs in only a few scattered populations across Western Australia, with very few known from the arid zone. The main factors threatening Rock-Wallaby populations are competition/habitat degradation due to introduced herbivores and over-abundant native herbivores, predation from introduced predators and habitat degradation (Pearson 2013).

Scats collected from a cave within the Barr Smith Range by Bamford and Turpin (2015) were confirmed as the Black-flanked Rock-Wallaby (*Petrogale lateralis*), and most likely the sub-species *P. l. lateralis*. Scats were also collected and camera trapping conducted at the Mt Keith Satellite Proposal situated north of the survey area but did not identify the species (Biota 2017a).

The Black-flanked Rock-Wallaby relies on behavioural (occupying caves and exhibiting nocturnal foraging activity) rather than physiological responses for survival during adverse conditions (Bradshaw *et al*. 2001; King and Bradshaw 2008). As a result, sites containing permanent water (such as along the Barr Smith Range) can be important for the species in the arid zone, allowing animals to occupy sub-optimal habitat with inferior thermal refuge (Pearson 2013). While much of the rocky habitat along the Barr Smith Range appears marginal, the presence of scattered waterholes in association with caves and rock crevices may allow the species to persist.

While not expected to be resident in the survey area (due to the lack of rocky and breakaway environments), the species may persist in the rocky habitats of the southern Barr Smith Range (south of Mount Keith) and south of Wanjarri Nature Reserve, so could be a vagrant in the project area.

<u>Conservation Significance Level 2</u>

Striated Grasswren
The sandplain sub-species of the Striated Grass- has disappeared from the southern fringes of its historical range (Western Central and Southern Inland Australia (BirdLife International 2018) and has declined in density over the remainder of its range (Garnett and Crowley 2000). Striated Grasswrens occur on sandplains dominated by mature *Triodia* hummock grassland with an overstorey of shrubs, usually mallee Eucalypts. Fire is recognised as a major threat throughout this sub-species' range (Garnett and Crowley 2000). The Striated Grasswren has been recorded from the Wanjarri Nature Reserve and while the project area lacks suitable spinifex, the species could still occur as a vagrant.

Brush-tailed Mulgara
The Brush-tailed Mulgara has recently been separated from the similar Crest-tailed Mulgara which is known from the desert regions along the border between the Northern Territory and South Australia. The species is widely distributed in arid regions of the central and western parts of the

country (Woolley 2008). It occurs in scattered populations at fairly low density, but may be locally abundant. The density of Brush-tailed Mulgara populations fluctuates depending on long-term climatic conditions and is also sensitive to fire (Woolley 2008). The species occupies spinifex (*Triodia spp.)* grasslands, and burrows in flats between sand dunes.
The Brush-tailed Mulgara was recorded extensively at Yeelirrie in spinifex sandplains (Bamford *et al.* 2011; Bamford and Turpin 2015). The species has also been recorded at Mount Keith and Wanjarri Nature Reserve. Spinifex grassland is not present in the survey area and therefore the species may only be an irregular visitor.

Long-tailed Dunnart
The Long-tailed Dunnart appears to be a specialist of rocky habitats and has a probably fragmented distribution from the Pilbara and northern Murchison into the southern Northern Territory and northern South Australia (van Dyck and Strahan 2008). Possible threats include habitat alteration due to introduced herbivores e.g. cattle and rabbits, inappropriate fire regimes, invasion by Buffel Grass, and predation by cats and foxes (Pavey 2006). Although associated with rocky environments, it has been recorded near Wiluna by BCE in an area of small rocky hills similar to those of the Violet Range, and thus can be considered a potential resident in the project area.

Central Long-eared Bat
The distribution, the Central Long-eared Bat is poorly-known but populations occur in the Dundas, Jilbadji and Mt Manning Nature Reserves in Western Australia (DBCA 2018). The Central Long-eared Bat was recorded during field surveys at Yeelirrie (c.a. 60 km north-west) (Bamford *et al.* 2011). The Central Long-eared Bat is likely to be resident in the survey area, probably favouring Mulga areas where suitable tree hollows provide shelter.

Moriarty's Trapdoor Spider
Documenting the invertebrate assemblage is beyond the scope of a level 2 investigation, but one invertebrate species of conservation significance (CS2, Priority 2 by DBCA) has been documented in the general area, Moriarty's Trapdoor Spider *Kwonkan moriartii*. The species was recorded approximately 15 km north of the survey area and Wanjarri Nature Reserve (DBCA 2018), it was not recorded during the field investigation and site inspection but is assumed to be resident in the absence of other information.

<u>Conservation Significance Level 3</u>

One reptile, nine birds and two mammals are listed as conservation significance level 3.

Black-headed Worm-Lizard *Aprasia picturata*
This pygopod species has been collected and described by Smith and Henry (1999) and is known from the vicinity of Leonora and Wiluna. *Aprasia picturata* has been recorded 35 km east of Leonora, and three and a half kilometres south of Minara homestead (Smith and Henry 1999). At these locations, Smith and Henry (1999) recorded the species from a low greenstone ridge with pockets of sandy loam supporting a mixed *Acacia* shrubland and a low rocky ridge with sparse *Acacia* and *Eremophila* shrubs. It is considered to be locally conservation significant due to its limited distribution and specialised habitat requirements (Wells 2007). Although the environments

where it has been recorded do not completely fit those of the project area, it is considered that it may occur nearby and individuals may occasionally be present.

Sandplain Worm-Lizard ***Aprasia repens***

Several specimens of this small legless-lizard were caught in pitfalls set near bushes in VSA3 (open shrubland on calcrete/gypsum soils on the margin of Lake Miranda). This is a range extension of several hundred kilometres and an atypical habitat for the species, which is usually on near-coastal sands of the South-West, so the population can be considered locally significant. One specimen was sent to the WA Museum for further analysis and initial feedback returned a positive identification for *A. repens,* with a note that genetic analysis may be required in future as several other inland specimens have been recorded and may represent an undescribed taxon.

Square-tailed Kite

The Square-tailed Kite is sparsely distributed over much of Australian mainland, with a few scattered records from Wanjarri Nature Reserve and Lake Mason (BirdLife Australia 2018) and Yeelirrie Station (Bamford and Turpin 2015). The species is a specialised predator of small birds taken from the canopy, foraging primarily over forest, woodland, mallee and heath (Garnett and Crowley 2000). It is likely to be an irregular visitor to the project area.

Australian Bustard

The Australian Bustard is associated with a variety of grassland, grassy woodland and shrubland habitats across Australia, but has declined in the south. It was formally listed as a priority species by the DBCA. The main threats to its survival are a combination of habitat loss/degradation and predation by introduced fauna (e.g. feral Cats and Foxes). The Australian Bustard has been previously recorded from Yeelirrie Station, Wanjarri Nature Reserve and Cosmos (BirdLife Australia 2018) and one sighting in the project area was made in October 2019.

Bush Stone-curlew

The ground-dwelling Bush Stone-curlew inhabits lightly timbered open woodlands and dense *Acacia* shrublands including along drainage lines (J. Turpin, pers. obs.). It is also known to occur in dense *Acacia* shrublands on Banded Ironstone ridges such as at Weld Range (J. Turpin and M. Bamford, pers. obs.). This species has suffered significant declines and is now sparsely distributed in the southern parts of Western Australia; it was formerly listed as a priority species by the DBCA and records in the south of its range are still very unusual. It has been recorded at Wanjarri Nature Reserve (BirdLife Australia 2018) and is likely to be a regular visitor in the survey area.

Bellevue staff members reported the wailing nocturnal calls of Bush Stone-curlew a few weeks prior to the field investigation in 2018. The observations were made at the accommodation quarters on site.

Major Mitchell's Cockatoo

The Major Mitchell's Cockatoo was formerly more widespread and is patchily distributed across its range. It may occur in woodland, sparsely timbered grasslands and shrublands, and rocky outcrops (BirdLife Australia 2018). It has previously been recorded at Yeelirrie Station, with a small flock seen in Mulga shrubland (anon. 1978). The species is likely to be a vagrant to the project area.

Scarlet-chested Parrot

The Major Mitchell's Cockatoo was formerly more widespread and is patchily distributed across its range. It may occur in woodland, sparsely timbered grasslands and shrublands, and rocky outcrops (BirdLife Australia 2018). It has previously been recorded at Yeelirrie Station, with a small flock seen in Mulga shrubland (anon. 1978). The species is likely to be a vagrant to the project area.

Scarlet-chested Parrot

The Scarlet-chested Parrot has declined over much of its range, formerly occurring across the Murchison and into the south-west of Western Australia. This species has also declined in the Goldfields (Garnet and Crowley 2000). Most recent records for the Scarlet-chested Parrot come from arid inland Australia including the Great Victoria Desert. This species has been recorded from the Wanjarri Nature Reserve and is likely to be an irregular visitor to the survey area.

Regent Parrot

The Regent Parrot has been identified by Saunders and Ingram (1995) as one of a number of south-west Australian woodland bird species recognized as declining. It is at the extreme north of its range in the region and is a rare visitor to Wanjarri Nature Reserve. The species is likely to be an irregular visitor to the survey area.

Slender-billed Thornbill

The western sub-species of the Slender-billed Thornbill was formerly listed as Vulnerable under the EPBC Act, however, in 2013 it was removed from the list of threatened taxa. A South Australian sub-species remains listed. The Slender-billed Thornbill occurs in shrubland, typically in areas of saltmarsh dominated by samphire, bluebush (*Maireana spp*.) or saltbush (*Atriplex spp*.) around salt lakes, or in low heath on sandplain. The species occurs in a number of disjunct populations in Western Australia, from Shark Bay to the Nullarbor (Johnstone and Storr 2004). The species is declining in much of its range owing to the degradation of chenopod vegetation by livestock and rabbits (Johnstone and Storr 2004).

The Slender-billed Thornbill has been recorded to the west of the survey area near Cue and Mount Magnet (BirdLife Australia 2018). The species was recorded in 1978 at a salt lake near Sir Samuel, in low, dense samphire shrubland with occasional taller patches. The fringes of Lake Miranda contain Chenopod shrubland and provide ideal habitat for Slender-billed Thornbill, with low, dense samphire and occasional taller patches. Targeted transects undertaken during the field investigation in 2018 and 2019 (Figures 3 and 4) did not confirm their presence in saltmarsh fringes of Lake Miranda. The species may still be a regular visitor at the site.

Rufous-crowned Emu wren

The Rufous-crowned Emu-wren has a fragmented population in northern and central Australia and is generally uncommon. It is patchily distributed, with Wanjarri, where it has been recorded (DBCA 2018), near the limit of its range. The Rufous-crowned Emu-wren is associated with tall, dense spinifex and long-unburnt mature hummock grasslands, which are not present in the survey area. The species is considered to be a vagrant in the area.

Grey Honeyeater

The Grey Honeyeater is uncommon throughout the Murchison and Pilbara, being recorded from a few, scattered localities (BirdLife Australia 2018). This species inhabits *Acacia* woodlands and shrublands, particularly those dominated by Mulga (*Acacia aneura*), across arid central Australia. The Grey Honeyeater has been recorded at Wanjarri Nature Reserve and north of the survey area (ATA 2005). It is likely to be at least an irregular visitor to the survey area as there is extensive suitable habitat.

Kultarr

The Kultarr occurs across central Australia extending into the Murchison. It prefers stony, granitic plains dominated by *Acacia*, *Eremophila* and *Senna* shrublands (Strahan 1995). The Kultarr is uncommon over most of its range, and populations appear to fluctuate seasonally (Strahan 1995). Some eastern populations are now considered extinct. The Kultarr appears to occur sporadically across the Murchison and has been recorded at Mount Keith and Wanjarri Nature Reserve (DBCA 2018). The Kultarr is considered resident in the project area as habitats appear suitable.

Desert Mouse

The Desert Mouse is a medium sized rodent (15–30 gram) that has a widespread distribution throughout the arid zone of Australia (Menkhorst and Knight 2010). It is considered locally abundant in habitats containing samphire, sedge, nitrebush or mature Spinifex grasslands (Alpers *et al.* 2003). The distribution of the species once extended from the Murray-Darling through the Flinders Ranges to the Gibson and Great Sandy Deserts, to the west coast and onto Bernier Island (Read *et al*. 1999, Menkhorst and Knight 2010). Since European colonisation there has been a contraction of the species' range to the central deserts (Kerle 1995, Read *et al*. 1999). In Western Australia, the Desert Mouse occurs in the Pilbara and the Central Deserts. The Desert Mouse is at the south-western extreme of its distribution, records come from near Wanjarri Nature Reserve and Mount Keith (DBCA 2018). The Desert Mouse is considered locally significant and may be resident.

SRE Invertebrates

The majority of invertebrates that were considered potentially SREs were collected in pitfall traps as bycatch. Several specimens were collected and sent to specialists (S. Judd for slaters, E. Volschenk for scorpions and Framenau for trapdoor spiders) for identification, and the results are presented in table 11. A different slater species was collected in each of the major VSAs, corresponding to rocky substrate (Site 2), sandy loam (Site 4) and gypsum (Site 8). One of these species, *Buddelundia labiata,* may be an SRE as it has only previously been collected in the Lake Miranda area and very recently (spring 2019; Bamford Consulting) Lake Way. In contrast, *Buddelundia* 45 and *Buddelundia* 96 have been collected 20-30km further north, and in the case of *Buddelundia* 96, also at a series of sites 50-105km further north.

The five scorpion species collected in 2018 are also mostly widespread, and also showed patterns related to VSA type. *Urodacus* sp. was noted as a possible SRE but in the absence of identification to species level additional specimens would be needed. This came from site 1 (VSA1) which is widespread in the region.

The single trapdoor spider (*Aname* sp.) was of a widespread genus which is undergoing taxonomic review and could not be identified to species.

No collection of subterranean fauna was undertaken, but two Priority Ecological Communities containing unique assemblages of invertebrates are documented in the area: the Lake Miranda east and Lake Miranda west calcrete groundwater assemblage types on Carey palaeodrainage on Yakabindie Station (DBCA 2019).

Table 11. Invertebrates collected.

Family	Species	Site	Easting	Northing	Comments
Isopods (slaters)					
Armadillidae	*Buddelundia labiate*	Site 2	258575	6943123	3 Males possible SRE
Armadillidae	*Buddelundia 45*	Site 4	258226	6939706	1 Male, 1 Female
Armadillidae	*Buddelundia 96*	Site 8	258001	6939566	7 Males, 1 Female
Scorpions					
Buthidae	*Isometroides* 'goldfields 1'	Site 1	257579	6943478	1 Male, not SRE
Buthidae	*Isometroides* 'goldfields 1'	Site 9	259910	6941265	1 Male, Considered widespread
Buthidae	*Lychas 'adonis'*	Site 1	257579	6943478	1 Male, Considered widespread
Buthidae	*Lychas jonesae*	Site 1	257579	6943478	1 Female, 1 Male, Considered widespread
Buthidae	*Lychas 'splendens'*	Site 7	258000	6939566	1 Male, Considered widespread
Buthidae	*Lychas 'splendens'*	Site 8	257760	6939820	2 Males, Considered widespread
Urodacidae	*Urodacus sp.*	Site 1	257579	6943478	1 Male, Possible SRE
Nemesiidae	*Aname sp.*	Site 3	258575	6943123	Adult male. Unlikely to be an SRE

3.2.3 Introduced Species

The desktop study identified eight introduced fauna species as potentially occurring in the project area (Table 12). The field investigations confirmed four of these species, with Rabbits particularly abundant on the margins of Lake Miranda.

Table 12. Introduced fauna species expected to occur in survey area.

Common Name	Latin Name	Expected Status	Recorded
MAMMALS			
House Mouse	*Mus musculus*	Resident	
Rabbit	*Oryctolagus cuniculus*	Resident	Y
Dog	*Canis lupus*	Resident	Y
European Red Fox	*Vulpes vulpes*	Resident	
Feral Cat	*Felis catus*	Resident	Y
Goat	*Capra hircus*	Resident	
Cow	*Bos taurus*	Resident	Y
Camel	*Camelus dromedarius*	Regular Visitor	

3.2.4 Patterns of biodiversity

Reptiles and birds

Investigating patterns of biodiversity can be complex and are often beyond the scope even of level 2 investigations, but it is possible to draw some general conclusions based upon the size of the study area, the trapping and censussing results, and the patterns of soils and vegetation across the landscape. Important patterns of biodiversity indicated by sampling data (discussed further below) are:

- High reptile species richness and abundance in the Broad-leaf Mulga over shrubs and tussock grass on sandy-loam plains (VSA 2);
- High bird species richness and abundance in VSAs including Mulga (VSAs 1 and 2);
- High bird species richness and abundance, when conditions suitable, in and around the margins of Lake Miranda; and
- High reptile species richness and abundance in low shrubland over gypsum dunes (VSA 3).

Remnant native vegetation across the site is patchy and fragmented in structure and composition. The fauna assemblage is likely to reflect this and vary across the VSA types. There are some areas of native vegetation in good condition, mostly west of the Goldfields Highway and in the north, along the Cosmos Haul Road and towards Kathleen Valley (although some degradation due to cattle in this area). Large parts of the project area where mining has taken place in the past are degraded with scattered vegetation over mine overburden. Clearly, degraded areas will be lower in biodiversity. Lake Miranda will attract a large number of waterbird species following major rains.

Some patterns of biodiversity between sites and VSAs can be interpreted from capture data for reptile and mammal trapping, bird censussing and opportunistic observations. Tables 13 and 14

provides a summary of capture data for each systematic sampling transect, while Tables 15 and 16 presents bird data. The fauna assemblage and associated VSA are discussed below.

Table 13. Trapping data from systematic sampling sites, October 2018.

VSA	2	1	1	2	2	6	3	3	4	**Total captures**
Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	
Diplodactylus granariensis rex			1				1			**2**
Diplodactylus pulcher			1			2				**3**
Gehyra variegata		1					1	1		**3**
Heteronotia binoei							3	7		**10**
Nephrurus vertebralis	1				2					**3**
Strophurus strophurus			1	2			3			**6**
Underwoodisaurus milii							5	2		**7**
Aprasia repens							1	1		**2**
Pygopus nigriceps	1									**1**
Ctenophorus nuchalis				1						**1**
Ctenotus leonhardi	1			4		1				**6**
Eremiascincus richardsonii								3		**3**
Lerista desertorum	3			1			1	1		**6**
Lerista timida	2	2	1		8		3	1		**17**
Menetia greyii		1			2		10	2		**15**
Anilios hamatus					1					**1**
Anilios waitii								1		**1**
Total species	**5**	**3**	**4**	**4**	**4**	**2**	**9**	**9**	**0**	
Total captures	**8**	**4**	**4**	**8**	**17**	**3**	**37**	**28**	**0**	**109**

Table 14. Trapping data from systematic sampling sites, October 2019.

VSA	2	2	2	1	2	1	**Total captures**
Species	Site 10	Site 11	Site 12	Site 13	Site 14	Site 15	
Gehyra variegata		1	1				2
Heteronotia binoei						2	2
Nephrurus vertebralis		1			8		9
Strophurus strophurus	1	1					2
Rhynchoedura ornata		2	2			1	5
Ctenotus leonhardi		1	1				2
Lerista desertorum			1				1
Lerista timida	4	6		1	1		12
Menetia greyii				1			1
Total species	**2**	**6**	**4**	**2**	**2**	**2**	
Total captures	**5**	**12**	**5**	**2**	**9**	**3**	**36**

The trapping data (Table 13) provide a measure of species richness and abundance of small reptiles across the sites. No mammals were captured; in our experience of many decades of conducting this sort of sampling, such an outcome is unique. As a group the small mammal ground fauna is clearly depauperate. This is presumably due to current dry conditions, but the lack of spinifex may reduce richness and abundance. There was a single record of a small mammal, the Spinifex Hopping Mouse *Notomys* alexis, but only from an active burrow (Figure 4).

Numbers of species and captures in 2018 were generally higher than in 2019, suggesting an ongoing decline in abundance, but some VSAs consistently had richer and more abundant reptile assemblages than others. The richest reptile assemblage with the highest levels of abundance was the Gypsum dunes (Sites 7 and 8; VSA 3). In combination, these two sites recorded 11 reptile species, of which five were not recorded elsewhere. In addition, nocturnal searching at this site recorded one gecko species, *Diplodactylus conspicillatus,* and Rosen's Snake *Suta fasciata*, that were not found elsewhere. The Salt Lake Dragon *Ctenophorus salinarium* was captured in samphire on the edge of the gypsum dunes west of site 8. This dragon species exclusively inhabits samphire habitats adjacent to salt lakes and clay pans in arid and semi-arid environments (Wilson and Swan 2013. Among the species recorded only in this VSA was the Sandplain Worm-Lizard which may represent an undescribed taxon.

Heavy red sandy soils with an overstorey of broad-leaf mulga (VSA2; Sites 1, 4 and 5 in 2018; Sites 10. 11, 12 and 14 in 2019) were also rich in species except where there was degradation by cattle (particularly site 10). Among reptiles confined or largely confined to this VSA were fossorial species adapted to move through soil and leaf litter. Short limbed skinks *Lerista desertorum, L. timida* and the legless lizard *Pygopus nigriceps* are adapted to loams and sands with a Mulga overstory (Wilson and Swan 2013) and were confirmed present in this VSA. It was also the only VSA where the gecko *Nephrurus vertebralis,* also a sand specialist, was recorded. *Ctenophorus isolepis* and *Varanus gouldii* are also associated with sandy substrates and were opportunistic observations in this VSA at site 1.

Rocky hills with narrow-leaf mulga and sparse tussock grass (VSA1; Sites 2, 3 and 6 in 2018; Sites 13 and 15 in 2019) generally had low numbers of captures and species. Several geckoes appeared to be restricted to this VSA. Sampling in creeklines within this VSA (parts of sites 13 and 15) did not result in unusual captures, but this may reflect the poor conditions. The larger vegetation along minor creek lines within this VSA may provide habitat for small vertebrates and invertebrates, and small hollows and cracks in mature Mulga provide refuge for several species. Moreover, water will pool and persist in these creek lines after rainfall, creating important localised water points.

Samphire adjacent to Lake Miranda (VSA 4) was represented by one trapping location at site 9 in 2018. The samphire habitat was very exposed with a shrubland height of approximately 30cm. This trap site yielded no vertebrate captures which in our experience of many decades of conducting this sort of sampling, is extremely unusual. It suggests a very depauperate ground fauna.

Degraded areas (VSA 6) covered large expanses through the central part of the project area. Site 6 in 2018 was a typical representation of the degraded rocky hill environment with trapping

resulting in small numbers of captures of just two species: *Ctenotus leonhardi* and *Diplodactylus pulcher.* Nocturnal searches were undertaken in several degraded locations and found a few additional species. For example, the geckoes *Lucasium squarossum*, *Underwoodisaurus milii*, *Heteronotia binoei* and *Gehyra variegata* were recorded around Vanguard pit. This nocturnal searching was more successful in 2018 than 2019, further suggesting a decline in overall abundance.

Table 15. Bird census results from systematic sampling transects, October 2018.

VSA	2	1	1	2	2	6	3	3	4	**Total N records**
Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	
Crested Pigeon								1		1
Red-backed Kingfisher				3						3
Splendid Fairy-wren			3							3
White-winged Fairy-wren				3			1	5		9
Inland Thornbill					2					2
Chestnut-rumped Thornbill	4	4	11		7					26
Yellow-rumped Thornbill					3					3
Spiny-cheeked Honeyeater					1					1
Yellow-throated Miner	4			12	4	12	29	23	4	88
Singing Honeyeater	2			9	7	6	11	3		38
Crimson Chat								3		3
Crested Bellbird				1						1
Grey Shrike-thrush			1							1
Black-faced Woodswallow						4				4
Pied Butcherbird				2						2
Little Crow				2						2
Torresian Crow				7						7
Australasian Pipit								1		1
Red-capped Robin	1									1
Zebra Finch				5	4			27		36
Welcome Swallow						1			1	2
Total species	4	1	3	9	7	4	3	7	2	
Total birds/abundance	11	4	15	44	28	23	41	63	5	**234**

Table 16. Bird census results from systematic sampling transects, October 2019.

VSA	2	2	2	1	2	1	Total N Records
Species	Site 10	Site 11	Site 12	Site 13	Site 14	Site 15	
Crested Pigeon	1						1
Red-backed Kingfisher			1				1
Australian Ringneck	2						2
White-winged Fairy-wren	2	5					7
Chestnut-rumped Thornbill			4		2	5	11
Spiny-cheeked Honeyeater	2		1				3

VSA	2	2	2	1	2	1	Total N Records
Species	Site 10	Site 11	Site 12	Site 13	Site 14	Site 15	
Yellow-throated Miner	1	2	6	1			10
Singing Honeyeater	5	2	4				11
Willy Wagtail	1						1
Torresian Crow		2					2
Red-capped Robin						2	2
Zebra Finch			6				6
Total species	**7**	**4**	**5**	**1**	**1**	**2**	**12**
Total birds/abundance	14	11	22	1	2	7	**57**

Bird censussing on the systematic sampling transects recorded 21 species with a total number of records of 234 in 2018 (Table 15), with just 12 species and 57 records in total in 2019 (Table 16). This is a marked difference even with fewer sites in 2019 (five compared with nine sites in 2018), with much of the difference due to no sampling in VSA3 where a few species were very abundant. However, some species were less abundant in 2019 than in 2018 in the same VSA. For example, the Chestnut-rumped Thornbill was more abundant in VSAs 1 and 2 in 2018 than in 2019.

The abundance of Yellow-throated Miner and Singing Honeyeater was notable in sites 7 and 8 (VSA3) in 2018; they were observed feeding on nectar, with one Miner observed feeding on seed pods from flowering *Grevillia sarissa*. The low, open vegetation of VSA3 also provided suitable habitat for Crimson Chat and Australasian Pipit. Site 9 (VSA 4) recorded very low numbers of birds, but in areas of larger clumped samphire further to the south and west, several groups of White-winged Fairy-wrens were observed. In 2019, Site 10 was the only transect that included a small amount of VSA3 and it was the richest in bird species in that year.

Mulga woodlands (VSA 1 and 2) recorded several arid interior species expected to be seen in the region during censusing and opportunistic observations, including Chestnut-rumped Thornbill, Western Bowerbird, Mulga Parrot, Western Quail-thrush, White-plumed Honeyeater, Redthroat and Southern Whiteface. The Violet Range in the northern areas of the site recorded Hooded Robin, and both Grey-crowned and White-browed Babblers. Despite this, there was a lot of variation in species richness and abundance between sites in the same VSA. Some sites in either VSA1 or VSA2 were very poor in species and abundance, but the site with the highest bird richness and second highest abundance overall was Site 4 (VSA 2). This may be partly explained by the fact site 4 is surrounded by a range of different environments within close proximity: gypsum dunes (VSA 3) to the west; samphire shrubland (VSA 4) directly south, the aboriginal sacred site near Tribune (VSA 1) and degraded areas (VSA 6) to the north. This combination may have offered a variety of resources for bird species and transitions between environment are often important for birds.

Vanguard Pit consistently displayed large numbers of birds in areas above and in bushland directly to the north. White-backed Swallow, Fairy Martin, Black-faced Woodswallow and Little Woodswallow were regularly observed over the pit, while Zebra Finch, Crimson Chat, Variegated Fairy-wren and Mulga Parrot amongst others, were seen in dense vegetation north of Vanguard. The pit is saline so the attraction was not freshwater; at least some of the species utilise the rocky

structures and it is possible that the earthworks around the pit have dammed subsoil water movement as some of the acacias in the area were unusual in that they were flowering and seeding, whereas elsewhere these species were not.

Bats

In 2018, bat species were detected by call frequency using two echolocation devices: Anabat Swift and Echo Meter 2 Pro. A total of 82 audio files was obtained containing at least one call sequence each of bats. Five species of bat were recorded from the Bellevue study area (see Tables 15 to 17). All are common and widespread in the region.

The Bellevue project area provides a range of natural and artificial environments for bats to roost. Old and disused mine shafts provide a suitable microclimate (humidity) for some bats (Moro 2018). Of the bats recorded, *Vespadelus finlaysoni* are known to roost in twilight areas of caves and rock crevices, and have been recorded in disused mines in mulga shrubland (Churchill 2008, Moro 2018). *Chalinolobus gouldii, Nyctophilus geoffroyi* and *Ozimops planiceps* are widespread and will roost in a variety of locations such as tree hollows, as well as human environments such as buildings (Churchill, 2008). *C. gouldii* was heard feeding several times in the late evening. The large *Austronomus australis* is also widespread and roosts in trees in a wide variety of environments. None of the species recorded is of conservation significance. Figures of Sonograms for species of bats recorded on site are presented in Appendix 6.

Table 17. Bat species recorded and call characteristics.

Parameters	Species				
	Chalinolobus gouldii	*Vespadelus finlaysoni*	*Nyctophilus geoffroyi*	*Ozimops planiceps*	*Austronomus australis*
Fmax (kHz)	41.8	78.9	68	26	14.0
Fpeak (kHz)	28.2	58.2	56.5	24.7	11
Fmin (kHz)	25.6	55.1	43.9	23	10
Dur (ms)	7.03	4.3	3.1	7.1	7.6

Table 18. Species recorded on the Anabat Swift and record dates

Night of	Location	Species				
		C. gouldii	*V. finlaysoni*	*N. geoffroyi*	*O. planiceps*	*A. australis*
26th Oct	Camp	✓	-	-	-	-
27th Oct	Vanguard Pit	No Calls				
28th Oct	Old mine workings	✓	-	-	✓	-

Table 19. Bat species recorded on the Echo Meter Pro and record dates

Night of	Location	Species				
		C.gouldii	*V.finlaysoni*	*N.geoffroyi*	*O.planiceps*	*A.australis*
23nd Oct	Camp	✓	✓	✓	✓	✓
25th Oct	Old mine workings	No Calls				
27th Oct	Vanguard Pit	✓	✓		✓	
31st Oct	Throughout site & along Goldfields Hwy	✓				

3.2.4 Ecological processes

The nature of the landscape and the fauna assemblage indicate some of the ecological processes that may be important for ecosystem function (see Appendix 4 for descriptions and other ecological processes). These include:

Fire. Fire is an integral part of regional ecosystems and is recognised as a factor in the dynamics of fauna populations in Western Australia (Bamford and Roberts 2003). 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 and leave pockets of unburnt vegetation can enhance biodiversity. Note that fire regime can interact with feral species in providing greater access to habitats and native fauna hence impacting on native fauna populations.

In the survey area, tussock grasslands are highly flammable and Mulga communities are fire sensitive. Grasses are highly flammable and are able to withstand high intensity fires by regenerating quickly from seed and rootstock following a fire event (Latz 1995). Mulga, however, is highly sensitive to fire and can be permanently removed by high intensity fires (mature Mulga trees and seedlings readily succumb to moderately intense fire and generally do not resprout). High intensity fires, repeat fire events or the lack of rainfall following a fire can deplete Mulga seed supply and cause long-term change (Bradstock *et al*. 2012). In the absence of traditional burning regimes adopted by indigenous Australians, large areas of fire-sensitive Mulga (including the associated animals and plants) can be replaced by grassland dominated communities (Bradstock *et al*. 2012).

The project area currently supports large areas of intact Mulga, suggesting fire have not been too-frequent in recent decades. It is important to maintain this. Some animal species are particularly sensitive to wildfires and altered fire regimes as they rely on long-unburnt environments to survive. Fauna in small and isolated reserves can be vulnerable to local extinction due to an inappropriate fire regime, and this may be a concern for the study area. Fire regimes post European settlement may have affected the abundance of the Greater Bilby, Brush-tailed Mulgara and Great Desert Skink, as they are known to be sensitive to changed fire regimes. The Striated Grasswren and Rufous-crowned Emu-wren are also sensitive to altered fire regimes and fire may also have an effect on reptile species richness and abundance in the area.

Feral species and interactions with over-abundant native species. The fauna assemblage of the survey area includes a range of feral species and the mammal fauna in particular has suffered as a result. Predation by feral species is a major factor in the decline of Australian mammals, including Bilby, Boodie and rock-wallabies (Burbidge and McKenzie 1989). There was clear evidence that the Boodie had formerly been abundant in the project area. The Fox is of greatest concern; Bilbies coexist with feral Cats in the Great Sandy Desert (M. Bamford pers. obs) and rock-wallabies persist with Cats in the Pilbara, but feral Cats have been implicated in the failure of attempts to reintroduce the Bilby (Miller *et al*. 2010). The Fox is likely to be present in the survey area and cats were recorded. Any management programme to improve the condition of the environment in the region for rare mammals would need to include a feral predator control strategy. Management of Dingoes (also recorded) would need to be included in this plan, as the presence of Dingoes in the survey area can suppress the numbers of Foxes and feral Cats, but the Dingo is also an efficient predator. Rabbits and cattle were recorded however Goats and Camels may occur in the survey area and also cause widespread damage to vegetation and habitat.

Local hydrology. Surface and sub-surface hydrology may be complex at the site, particularly the interaction with Lake Miranda. There are also two subterranean fauna assemblages (Lake Miranda east and west calcrete groundwater assemblage types on Carey palaeodrainage on Yakabindie Station) that are likely to be supported by current hydrological patterns. Drainage patterns in the rocky hills (Violet Range) and Kathleen Valley support dense vegetation in valleys and where drainage moves out onto sandier soils, and these patterns are likely to support local concentrations of fauna.

Connectivity and landscape permeability. The project area lies in a largely intact landscape despite a long history of mining and degradation in some areas. For fauna, connectivity may be important where there are linear VSAs such as the gypsum dunes around Lake Miranda. Drainage lines in the rocky hills such as around Kathleen Valley may also facilitate fauna movement across the landscape.

3.2.5 Summary of fauna values

The desktop study identified 269 vertebrate fauna species as potentially occurring in the survey area (see Table 10 and Appendix 5): 10 frogs, 70 reptiles, 153 birds and 36 mammals (28 native and eight introduced species). The assemblage includes up to 35 species of conservation significance. The field investigations in 2018 and 2019 confirmed the presence of 110 species: one frog, 32 reptiles, 64 birds and 12 mammals (eight native and four introduced). Fauna values within the survey area can be summarised as follows:

Fauna assemblage.

Rich and substantially intact except for the loss of some, mostly medium-sized, mammal species and some birds, but the reptile assemblage may be almost intact. Overall, the fauna assemblage is likely to be well-represented in the region but is incomplete due to local species loss, and it is only moderately rich due to this extinction. The survey area is likely to contain only a subset of the fauna assemblage predicted for the entire region, particularly due to the absence of spinifex that

provides habitat for a number of species. The number of species confirmed is low due to dry conditions in the preceding two years.

Species of conservation significance.

This list includes up to 35 species (three reptile, 27 bird and five mammal species). Some of the significant species expected to be present are widespread and occur in very extensive regional landscapes. The majority of significant species recorded from the desktop review are probably not present, or at least occur only irregularly or as vagrants. This includes the Great Desert Skink, Malleefowl, Night Parrot and Black-footed Rock-Wallaby. Not even old Malleefowl mounds were found, suggesting the species has not recently (within half a century or more) been a breeding resident. Similarly, the Brush-tailed Mulgara, Peregrine Falcon and several CS3 parrot species are likely to be only irregular visitors to the survey area.

Up to 10 species of migratory waterbirds are likely to occur on an occasional basis on Lake Miranda, potentially in large numbers. Several CS3 bird species are certainly present in the survey area. These species are very mobile and populations can fluctuate, so even if not recorded at one time, these species may be present later. Up to nine mammal species are known to be extinct in the area, such as the Greater Bilby, Chuditch and Burrowing Bettong.

Patterns of biodiversity.

The gypsum soils surveyed in 2018 around Lake Miranda are rich in reptiles, while Mulga over clumped grasses and on sandy loams was moderately rich in reptiles and birds. The rocky hills are poorer in biodiversity by comparison, but dense vegetation along drainage lines in this area may support more species at that landscape scale. Lake Miranda will attract large numbers of waterbird and shorebird species following substantial rains.

Key ecological processes.

The main processes which may affect the fauna assemblage are likely to be the fire regime, the presence and abundance of feral species and to a lesser degree landscape connectivity and local hydrology. The current assemblage has been strongly influenced by feral predators and possibly also altered fire regimes, resulting in the local loss of a substantial proportion of the mammal fauna. The effect of feral predators (Dingo, Cat and Fox) is complicated as it interacts with the fire regime, and the feral species interact with each other. For example, the abundance of Cats and Foxes is suppressed by Dingoes and in some cases this has been found to be of benefit to native species (Southgate *et al*. 2007). Goats and camels may occur in the survey area and also cause widespread damage to vegetation and habitat. Rabbits cause damage and were recorded.

Overall, the survey area has a fauna species assemblage that has suffered some species loss and in a regional context it is only moderately rich due to the absence of spinifex that supports a rich assemblage of reptiles in particular. The assemblage does include some species of conservation significance, dominated by migratory waterbirds that will make intermittent use of Lake Miranda. There are some internal patterns of distribution that may be important for planning and the assemblage is sensitive to fire, feral species and landscape connectivity.

4 Impact Assessment

Impacting processes have to be considered in the context of fauna values and the nature of the proposed development, which in this case is assumed to involve some clearing of native vegetation. Predicted impacts are examined below; impacting processes are outlined in Appendix 2 and definitions of levels of impact significance are given in Table 4. Based on the impact assessment below, mitigation measures are presented in Section 5.

4.1 Impacting processes

Habitat loss leading to population decline.

The proposed development will result in some localised loss of native vegetation but it is intended to concentrate development in previously disturbed areas. The surface footprint is smaller than it might otherwise be due to operations being underground. The actual proportion of loss of native vegetation within the local area is small as there is extensive native vegetation outside of the survey area. Impacts largely avoid Mulga on sandy-loam, which is locally important for biodiversity. There will be little or no direct impact on Lake Miranda.

Some loss of habitat and population decline is inevitable in areas to be cleared but can be minimised through controls during clearing. Rehabilitation of disturbed areas may also be implemented as soon as possible after clearing. The small area of impact in relation to the surrounding landscape means that loss of habitat is unlikely to have long-term adverse impacts upon fauna populations in the region. Impact Minor.

Habitat loss leading to population fragmentation.

The proposed development is concentrated in previously disturbed areas. Linear environments around Lake Miranda and drainage lines elsewhere will be largely unaffected. Exploration has occurred close to Lake Miranda which could reduce connectivity along this side of the lake and therefore rehabilitation of Mulga on sand would minimise any fragmentation effect. Pipelines can cause population fragmentation for small species where pipes lie on the ground and create a barrier, but this can be avoided by burying a pipe or creating occasional earthen ramps over the pipe (see recommendations below). Impact Negligible to Minor.

Degradation of habitat due to weed invasion.

There is some weed invasion of the project area where it is already disturbed. Further impacts from weeds can be minimised by maintaining reasonable hygiene measures. This will be important as the current levels of weed invasion in disturbed locations provides a source of weed-seeds that can compromise rehabilitation. Impact Minor.

Ongoing mortality from operations.

Increased mortality is inevitable during clearing operations and from ongoing activities, such as roadkill due to animals being struck by vehicles, or birds striking infrastructure and fauna attracted into production areas (e.g. In search of food or water, insects attracted to lights). It is not known if waterbirds will be at risk from tailings storage facilities (either toxic or through entrapment in mud). In general, areas to be cleared are small within the context of the regional landscape so mortality during clearing is likely to represent only a small proportion of regional populations. For

common species, levels of mortality are unlikely to be significant in a conservation sense, but there are welfare issues. Risk of roadkill will be greatest if there is night movement of vehicles on roads that pass through native vegetation. Lighting may pose a risk to insects and this can affect the abundance of other species, with an increase in scavenging birds around buildings leading to a decline in some other bird species at remote mine sites (Read *et al.* 2015). Impact Minor with management.

Species interactions.

There are already concerns with impacts of feral species, including Cats and Foxes, but sensitive species have largely been exterminated. The abundance of feral species can increase around remote mining operations, often due to an increase in food supply. Tracks can improve access by these species into otherwise undisturbed areas. With several significant species in the area vulnerable to predation by these feral species, such impacts are a concern. There is also potential for increased abundance of some native species due to the provision of water or additional food supplies, and this can adversely impact other native species. Impact Minor to Moderate.

Hydrological change

Interruptions of hydroecological processes are a concern where habitat may be impacted, resulting in impacts to fauna species. Some habitats are likely to be reliant on surface and sub-surface flows that may be altered by clearing, earthworks and drainage management. As a result, habitat degradation may occur beyond the clearing footprint. Some increased runoff from development can be expected, and there may be mine de-watering. The sensitivity of subterranean assemblages is unknown. Similarly, the effect of groundwater abstraction in the Kathleen Valley area is unknown but can presumably be monitored and managed. Maintaining local hydrological flows is considered the key to managing impacts upon fauna in the survey area. It is likely that with standard operating procedures the impacts can be managed. Impact Minor.

Altered fire regimes

While the biota of the region is probably adapted to a particular fire regime, it is likely this regime has already been altered since European settlement. There is currently little evidence of recent fire and it is important for protecting fauna habitat that widespread or regular fires are avoided. Mulga in particular is sensitive to fire, while biodiversity in grassland environments can be altered by changes in the fire regime. Although not part of the mining process, mining activities can lead to a change in the fire regime and there may be a slight increase in the potential for fires as a result of the project. Impact Negligible assuming management.

Disturbance (dust, noise, light).

The level of dust, noise and light from the proposed development is uncertain but at a remote location, lighting can introduce a great change and lead to large numbers of insect deaths and to predatory species being attracted that then displace other species. Disturbance of waterbirds may be a concern in seasons when they are abundant, especially as some may bred on small islands in Lake Miranda. Impact could therefore be considered potentially Minor to Moderate.

Overall, impacts of greatest concern are related to:

- Vegetation clearing leading to direct mortality;
- Interference with population movement due to barriers such as pipelines on the surface;

- Species interactions due to changes in abundance of feral predators (Cat and Fox) and potentially increase in abundance of predatory native birds around the project;
- Hydrological change from groundwater abstraction, dewatering and altered surface flows,, as some vegetation types and fauna assemblages may be sensitive to such changes;
- Altered fire regimes (but could be beneficial as part of management); and
- Possibly light causing local mortality of invertebrates and increases in abundance of predatory species.

Note that some impacts are uncertain because of lack of data on the fauna assemblage. In particular, there is little information on the subterranean fauna assemblage.

5 Recommendations

The development footprint is small in the context of a very broad and continuous landscape, and development occurs largely on previously disturbed areas. Furthermore, the fauna assemblage is generally widespread and has lost most significant species, with key features being occasional use of Lake Miranda by waterbirds, , a rich and unusual reptile assemblage on gypsum soils close to the lake, a rich assemblage of fauna generally in Mulga on sandy-loam, and the presence of unusual subterranean fauna assemblages nearby. The composition of the fauna assemblage and the nature of the proposed development therefore ameliorate the significance of impacts, but there remains concern with risk to some parts of the environment, risks to significant species and concern with landscape-scale ecological processes that may be affected by the proposal. Mining projects can affect the abundance of fauna species but also provide opportunities for active conservation management, which may be assessed as offsets to development. Key management actions can be related to impacting processes as outlined below. Many of these strategies are now considered best practice at most mine sites. Although impacts are mostly expected to be minor, any reduction in impacts is desirable.

Habitat loss leading to population decline and fragmentation

- Minimise the disturbance footprint and maintain large trees where possible. Large eucalypt trees and even Mulga are important for fauna, including providing hollows for species.
- Ensure that pipelines lying on the ground do not obstruct the movement of small species, such as by burying or creating ramps.
- Clearly delineate areas to be cleared to minimise unnecessary vegetation loss.
- Maintain linkages to adjacent vegetation where possible.
- Rehabilitate (where possible) as soon as practical.

Habitat degradation due to weed invasion

- Develop and implement a weed management plan.

Ongoing mortality

- Restrict vehicle access to where this is necessary for project operation.
- Enforce maximum speed limits.
- Minimise night driving.
- Erect signage in areas of high wildlife activity, if required.
- Lighting should be directed to where it is needed and not into surrounding native vegetation. Unnecessary lighting should be avoided.
- Educate personnel with respect to fauna through the induction process, including avoiding disturbance of waterbirds should Lake Miranda flood.
- Check infrastructure where there may be a risk of fauna entrapment.
- Record and report all fauna incidents to the site supervisor and environment department.

Species interactions

- Rehabilitate access tracks as soon as possible to discourage access by feral fauna.
- Develop a predator management programme aimed at suppressing the abundance of the Fox and Cat and maintaining the Dingo population level at a natural density; this to be discussed and developed in consultation with the DBCA.
- Ensure appropriate waste disposal during construction activities to avoid attracting feral species to the area.
- Educate personnel not to feed (deliberately or inadvertently) feral species.

Hydrological changes

- Ensure local hydrology is not affected, including alterations to runoff through the landscape.
- Monitor groundwater levels where groundwater abstraction takes place.
- Avoid runoff to ensure sediment or any chemicals do not contaminate soil, groundwater and Lake Miranda and install appropriate erosion control, if required.
- Implement management actions if hydrological changes are likely to affect significant fauna habitats, if required.

Altered fire regimes

- Develop and implement a regional fire management plan during construction and operational activities to ensure wildfires do not occur as a result of activities and to ensure appropriate responses are in place should a wildfire occur. This could be developed as part of a cooperative fire management strategy with other key stakeholders.

Monitoring

- Waterbird abundance on Lake Miranda should be monitored to ensure that if birds are present and breeding, actions required to ensure that disturbance does not occur can be implemented. This does not require detailed counting; only observation of presence/ absence.
- Monitor local groundwater levels.

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7 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 rather 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 by other factors, for example, by the sorts of species present.

Vegetation and Substrate Associations

Vegetation and Substrate Associations (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, which VSAs will recognise. 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.

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* (Biodiversity Conservation 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 levels, schedules and priority levels mentioned below is provided in Appendix 3.

Conservation Significance (CS) level 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) and reviewed by Mace and Stuart (1994), 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 Biodiversity Conservation Act uses a series of Schedules to classify status, but also recognizes the IUCN categories and ranks species within the Schedules using the categories of Mace and Stuart (1994).

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

In Western Australia, the DBCA has produced a supplementary list of Priority Fauna, being species that are not considered threatened under the Biodiversity Conservation Act but for which the DBCA believes there is cause for concern. Some Priority species are also assigned to the Conservation Dependent category of the IUCN.

Conservation Significance (CS) level 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 and expert judgment, but is used here as it may have links to preserving biodiversity at the genetic level (EPA 2002). If a population is isolated but a subset of a widespread

(common) species, then it may not be recognised as threatened, but may have unique genetic characteristics. Conservation significance is applied to allow for the preservation of genetic richness at a population level, and not just at a species level. Species on the edge of their range, or that are sensitive to impacts such as habitat fragmentation, may also be classed as CS3, as may colonies of waterbirds. The Western Australian Department of Environmental Protection, now DBCA, used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of the Perth Bushplan (DEP 2000).

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 an area may be affected by processes such as fire regime, landscape patterns (such as fragmentation and/or linkage), the presence of feral species and hydrology. Impacts may be significant if processes are altered such that fauna populations are adversely affected, resulting in declines and even localised loss of species. Threatening processes as outlined below are effectively the ecological processes that can be altered to result in impacts upon fauna.

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Appendix 2. Explanation of threatening processes.

Potential impacts of proposed developments upon fauna values can be related to threatening processes. This is recognised in the literature (e.g. Gleeson and Gleeson 2012) and under the EPBC Act, in which threatening processes are listed. 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), SEWPaC (2013) and EPA (2016), 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 (2016) 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 (2016) 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.

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 (Gleeson and Gleeson 2012, Soule *et al.* 2004). 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, 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. 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, 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). 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.

<u>References specific to the above text:</u>

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Appendix 3. Categories used in the assessment of conservation status.

IUCN categories (based on review by Mace and Stuart 1994) as used for *the Environment Protection and Biodiversity Conservation Act 1999* and the *Western Australian Biodiversity Conservation Act 2016.*

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

Schedules used in the *WA Biodiversity Conservation Act 2016*

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

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

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

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

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

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

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

Threatening processes (EPBC Act)

Under the EPBC Act, a key threatening process is an ecological interaction that threatens or may threaten the survival, abundance or evolutionary development of a threatened species or ecological community. There are currently 20 key threatening processes listed by the federal Department of the Environment (DEE 2018c):

- Competition and land degradation by rabbits.
- Competition and land degradation by unmanaged goats.
- Dieback caused by the root-rot fungus (Phytophthora cinnamomi).
- Incidental catch (bycatch) of Sea Turtle during coastal otter-trawling operations within Australian waters north of 28 degrees South.
- Incidental catch (or bycatch) of seabirds during oceanic longline fishing operations.
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis.
- Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris.
- Invasion of northern Australia by Gamba Grass and other introduced grasses.
- Land clearance.
- Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants.
- Loss of biodiversity and ecosystem integrity following invasion by the Yellow Crazy Ant (*Anoplolepis gracilipes*) on Christmas Island, Indian Ocean.
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases.
- Novel biota and their impact on biodiversity.
- Predation by European red fox.
- Predation by exotic rats on Australian offshore islands of less than 1000 km^2 (100,000 ha).

- Predation by feral cats.
- Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs.
- Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species.
- The biological effects, including lethal toxic ingestion, caused by Cane Toads (Bufo marinus).
- The reduction in the biodiversity of Australian native fauna and flora due to the red imported fire ant, Solenopsis invicta (fire ant).

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

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

In addition to the above processes, DotE (2013) has produced Significant Impact Guidelines that provide criteria for the assessment of the significance of impacts. These criteria provide a framework for the assessment of significant impacts. The criteria are listed below.

Will the proposed action lead to a long-term decrease in the size of a population?

Will the proposed action reduce the area of occupancy of the species?

Will the proposed action fragment an existing population?

Will the proposed action adversely affect habitat critical to the survival of a species?

Will the proposed action disrupt the breeding cycle of a population?

Will the proposed action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

Will the proposed action result in introducing invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat?

Will the proposed action introduce disease that may cause the species to decline?

Will the proposed action interfere with the recovery of the species?

References for the above text:

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Appendix 4. Vertebrate fauna expected to occur in the survey area.

These lists are derived from the results of database and literature searches conducted in the general area.

Cons Sig = Conservation significance codes: CS1, CS2, CS3. See Appendix 1 for full explanation.

- EPBC Act listings: E = Endangered, V = Vulnerable, Mig = Migratory, Mar = Marine (see Appendix 3).
- Wildlife Conservation Act listings: for all CS1 species S1 to 7 = Schedules 1 to 7 respectively, (see Appendix 3) with rankings shown in square parentheses: [e] = endangered, [v] = vulnerable.
- DBCA Priority species: P1 to P5 = Priority 1 to 5 (see Appendix 3).
- CS3 species: are considered to be of local significance by Bamford Consulting Ecologists
- Int. Introduced species.

DB = Database Searches:

- NatureMap database (DBCA), searched August 2018;
- BirdLife Australia Atlas database, searched August 2018; and
- EPBC Protected Matters Search Tool, searched August 2018.

Regional Studies = Other studies conducted in the region:

- BCE = Past surveys at Yeelirrie (Bamford *et al.* 2011, Bamford and Turpin 2015);
- B = Biota 2017 Mt Keith Satellite survey (includes several studies; ATA 2005, Biota 2006a, 2006b); and
- WJ = Species recorded from Wanjarri Nature Reserve (DBCA).

Status = Status in survey area is based on the categories described in Section 2.2.4.

R = Resident; M = Migrant; RV = Regular Visitor; IV = Irregular Visitor; Va = Vagrant.

8 = Field investigation conducted by BCE in August and October 2018.

9 = Field investigation conducted by BCE in October 2019.

FROGS

Species		Cons Sig	DB	Regional studies	Status
HYLIDAE (Tree frogs)					
Cyclorana maini	Main's Frog			WJ,BCE,B	R
Cyclorana platycephala	Water-holding Frog			BCE,B	R
Litoria rubella	Desert Tree Frog			BCE	R8
LIMNODYNASTIDAE (Burrowing Frogs)					
Platyplectrum spenceri	Spencer's Frog			B	R
Neobatrachus aquilonius	Northern Burrowing Frog			WJ	R
Neobatrachus kunapalari	Kunapalari Frog				R
Neobatrachus sudellae	Desert Trilling Frog			WJ	R
Neobatrachus sutor	Shoemaker Frog				R
Neobatrachus wilsmorei	Wilsmore's Frog		x		R
MYOBATRACHIDAE (Ground frogs)					
Pseudophryne occidentalis	Western Toadlet			BCE	R
Total Species Expected: 10					

REPTILES

Species		Con Sig	DB	Regional studies	Status (BCE8,9)
Cheluidae (freshwater tortoises)					
Chelodina steindachneri	Flat-shelled Tortoise				RV
Gekkonidae (geckoes)					
Diplodactylus conspicillatus	Fat-tailed Gecko			BCE,B	R8,9
Diplodactylus granariensis rex	Goldfields Stone Gecko		x	BCE	R8,9
Diplodactylus pulcher	Western Saddled Ground Gecko		x	BCE,B	R8
Gehyra crpta	Western Cryptic Gehyra				R8,9
Gehyra purpurascens	Purple Arid Dtella				R
Gehyra variegata	Variegated Dtella		x	BCE,B	R8,9
Heteronotia binoei	Bynoe's Gecko		x	BCE,B	R8,9
Lucasium squarrosum	Mottled Ground Gecko		x	B	R8
Lucasium stenodactylus	Pale-snouted Ground Gecko				R
Nephrurus vertebralis	Midline Knob-tail		x	BCE	R8,9
Rhynchoedura ornata	Beaked Gecko			BCE,B	R8,9
Strophurus assimilis	Thorn-tailed Gecko				R
Strophurus strophurus	Western Ring-tailed Gecko			BCE,B	R8,9
Strophurus wellingtonae	Western Shield Spiny-tailed Gecko		x	BCE,B	R
Underwoodisaurus milii	Barking Gecko		x		R8,9
Pygopodidae (legless lizards)					
Aprasia picturata	Black-headed worm-lizard	CS3			R
Aprasia repens	Sand-plain Worm-lizard				R8
Lialis burtonis	Burton's Legless Lizard			BCE,B	R8
Pygopus nigriceps	Western Hooded Scaly-foot			BCE,B	R8
Agamidae (dragon lizards)					
Ctenophorus caudicinctus	Ring-tailed Dragon		x	BCE	R
Ctenophorus isolepis	Military Dragon			BCE,B	R8,9
Ctenophorus nuchalis	Central Netted Dragon		x	BCE	R8
Ctenophorus reticulatus	Western Netted Dragon			BCE	R
Ctenophorus salinarum	Claypan Dragon		x		R8
Ctenophorus scutulatus	Lozenge-marked Dragon			BCE	R9
Gowidon longirostris	Long-nosed Dragon				R
Moloch horridus	Thorny Devil			BCE	R
Pogona minor	Western Bearded Dragon			BCE	R9
Tympanocryptis cephala	Earless Pebble Dragon		x	B	R
Varanidae (monitors or goannas)					
Varanus caudolineatus	Stripe-tailed Monitor			BCE,B	R
Varanus eremius	Desert Pygmy Monitor			BCE	R
Varanus giganteus	Perentie			BCE,B	R
Varanus gouldii	Sand Goanna			BCE	R8
Varanus panoptes	Yellow-spotted Monitor			B	R8,9
Varanus tristis	Black-headed Monitor			BCE	R

Species		Con Sig	DB	Regional studies	Status (BCE8,9)
Scincidae (skink lizards)					
Cryptoblepharus buchananii	Buchanan's Snake-eyed Skink			BCE	R
Cryptoblepharus plagiocephalus	Peron's Fence Skink			BCE	R
Ctenotus helenae	Clay Soil Ctenotus			BCE,B	R
Ctenotus leonhardii	Leonhardi's Ctenotus			BCE,B	R8,9
Ctenotus pantherinus	Leopard Skink			BCE,B	R
Ctenotus quattuordecimlineatus			x	B	R
Ctenotus schomburgkii	Barred Wedge-snout Ctenotus			BCE	R
Ctenotus severus	Stern Rock Ctenotus				R
Ctenotus uber	Spotted Ctenotus			B	R
Egernia depressa	Pygmy Spiny-tailed Skink			BCE,B	R
Egernia formosa	Goldfields Crevice Skink			B	R
Liopholis inornata	Desert Skink			BCE,B	R
Liopholis kintorei	Great Desert Skink	CS1		WJ,B	IV
Eremiascincus richardsonii	Broad-banded Sand-swimmer			BCE,B	R8
Lerista bipes				B	R
Lerista desertorum			x	BCE,B	R8,9
Lerista rhodenoides				BCE	R
Lerista timida			x	B	R8,9
Menetia greyii	Common Dwarf Skink		x	BCE,B	R8,9
Morethia butleri	Woodland Dark-flecked Morethia		x	B	R
Tiliqua occipitalis	Western Blue-tongue			BCE	R
Typhlopidae (blind snakes)					
Anilios bicolor	Dark-spined blind snake			BCE	R
Anilios hamatus	Northern Hook-snouted Blind Snake			BCE	R8
Anilios waitii	Beaked Blind Snake				R8
Pythonidae (pythons)					
Antaresia stimsoni	Stimson's Python				R8
Elapidae (front-fanged snakes)					
Brachyurophis semifasciata	Southern Shovel-nosed Snake				R
Brachyurophis fasciolatus	Narrow-banded Shovel-nosed Snake				R
Demansia psammophis	Yellow-faced Whipsnake				R
Parasuta monachus	Monk Snake			B	R
Pseudechis australis	Mulga				R
Pseudechis butleri	Spotted Mulga Snake		x		R
Pseudonaja modesta	Ringed Brown Snake			BCE,B	R8,9
Pseudonaja mengdeni	Gwardar			BCE,B	R8
Simoselaps bertholdi	Jan's Banded Snake			BCE	R
Furina ornata	Moon Snake				R
Suta fasciata	Rosen's Snake		x	BCE	R8
Total Species Expected: 70					

BIRDS

Species		Cons Sig	DB	Regional studies	Status (BCE8,9)
CASUARIIDAE (Cassowaries and emus)					
Dromaius novaehollandiae	Emu		x	BCE, B	RV8,9
MEGAPODIIDAE (Megapodes)					
Leipoa ocellata	Malleefowl	CS1	x	BCE	RV?
PHASIANIDAE (Pheasants and allies)					
Coturnix pectoralis	Stubble Quail				IV
ANATIDAE (swans and ducks)					
Cygnus atratus	Black Swan		x		IV8,9
Tadorna tadornoides	Australian Shelduck		x	BCE, B	IV8
Anas superciliosa	Pacific Black Duck		x		IV
*Anas gracilis*l	Grey Teal		x	BCE	IV8
Chenonetta jubata	Australian Wood Duck			BCE	IV
Malacorhynchus membranaceus	Pink-eared Duck				IV
Aythya australis	Hardhead				IV
Podicipedidae (grebes)					
Tachybaptus novaehollandiae	Australasian Grebe				IV
Poliocephalus poliocephalus	Hoary-headed Grebe		x	BCE	IV
Phalacrocoracidae (cormorants)					
Phalacrocorax melanoleucos	Little Pied Cormorant				Va
Phalacrocorax sulcirostris	Little Black Cormorant			B	Va
Ardeidae (herons and egrets)					
Egretta novaehollandiae	White-faced Heron		x		IV
Ardea pacifica	White-necked Heron		x		IV
Ardea modesta	Eastern Great Egret	CS1	x		Va
Threskiornithidae (ibis and spoonbills)					
Threskiornis molucca	Australian White Ibis				IV
Threskiornis spinicollis	Straw-necked Ibis				IV
ACCIPITRIDAE (Osprey, hawks and eagles)					
Elanus axillaris	Black-shouldered Kite				Va
Lophoictinia isura	Square-tailed Kite	CS3	x	BCE	Va
Hamirostra melanosternon	Black-breasted Buzzard				IV8
Milvus migrans	Black Kite		x		IV
Haliastur sphenurus	Whistling Kite		x	BCE,B	R8,9
Circus assimilis	Spotted Harrier		x	BCE	RV
Accipiter fasciatus	Brown Goshawk		x	B	R
Accipiter cirrhocephalus	Collared Sparrowhawk		x	BCE,B	R
Aquila audax	Wedge-tailed Eagle		x	BCE,B	R8,9
Hieraaetus morphnoides	Little Eagle		x	BCE,B	R
FALCONIDAE (Falcons)					
Falco berigora	Brown Falcon		x	BCE,B	R8,9
Falco longipennis	Australian Hobby		x	BCE	R8,9
Falco hypoleucos	Grey Falcon	CS1		WJ	Va
Falco subniger	Black Falcon				Va

Species		Cons Sig	DB	Regional studies	Status (BCE8,9)
Falco peregrinus	Peregrine Falcon	CS1		BCE	IV
Falco cenchroides	Nankeen Kestrel		x	BCE,B	R8,9
RALLIDAE (Rails, gallinules and coots)					
Gallinula ventralis	Black-tailed Native-hen				IV
Fulica atra	Eurasian Coot				IV
OTIDIDAE (Bustards)					
Ardeotis australis	Australian Bustard	CS3	x	BCE	R9
TURNICIDAE (Button-quails)					
Turnix velox	Little Button-quail		x		R
SCOLOPACIDAE (sandpipers)					
Limosa limosa	Black-tailed Godwit	CS1			Va
Tringa nebularia	Common Greenshank	CS1			RV8
Tringa stagnatalis	Marsh Sandpiper	CS1			IV
Tringa hypoleucos	Common Sandpiper	CS1	x		RV
Tringa glareola	Wood Sandpiper	CS1			RV
Calidris ruficollis	Red-necked Stint	CS1			RV
Calidris melanotos	Pectoral Sandpiper	CS1	x		IV
Calidris acuminata	Sharp-tailed Sandpiper	CS1	x		IV9
Calidris ferruginea	Curlew Sandpiper	CS1			Va
BURHINIDAE (Stone-curlews)					
Burhinus grallarius	Bush Stone-curlew	CS3	x	BCE	RV8
RECURVIROSTRIDAE (stilts and avocets)					
Himantopus himantopus	Black-winged Stilt		x		RV
CHARADRIIDAE (Lapwings, plovers and dotterels)					
Erythrogonys cinctus	Red-kneed Dotterel			B	RV
Charadrius ruficapillus	Red-capped Plover		x	BCE	RV8
Charadrius veredus	Oriental Plover	CS1	x		Va
Charadrius melanops	Black-fronted Dotterel			B	RV
Charadrius australis	Inland Dotterel				IV
Vanellus tricolor	Banded Lapwing		x	BCE	IV
COLUMBIDAE (Pigeons and doves)					
Phaps chalcoptera	Common Bronzewing		x	BCE,B	R9
Ocyphaps lophotes	Crested Pigeon		x	BCE,B	R8,9
Geopelia cuneata	Diamond Dove		x	BCE	R8
CACATUIDAE (Cockatoos)					
Eolophus roseicapilla	Galah		x	BCE,B	R
Cacatua sanguinea	Little Corella				R
Cacatua leadbeateri	Major Mitchell's Cockatoo	CS3			Va
Nymphicus hollandicus	Cockatiel		x	BCE,B	R
PSITTACIDAE (Parrots)					
Barnardius zonarius	Australian Ringneck		x	BCE,B	R8,9
Psephotus varius	Mulga Parrot		x	BCE,B	R8,9
Melopsittacus undulatus	Budgerigar		x	BCE,B	RV
Neosephotus bourkii	Bourke's Parrot		x		RV

Species		Cons Sig	DB	Regional studies	Status (BCE8,9)
Neophema elegans	Elegant Parrot			BCE	IV
Neophema splendida	Scarlet-chested Parrot	CS3		WJ	IV
Polytelis alexandrae	Princess Parrot	CS1	x	WJ	IV
Polytelis anthopeplus	Regent Parrot	CS3	x	WJ	IV
Pezoporus occidentalis	Night Parrot	CS1	x		Va?
CUCULIDAE (Old world cuckoos)					
Cuculus pallidus	Pallid Cuckoo		x	BCE,B	RV
Chrysococcyx osculans	Black-eared Cuckoo		x	BCE	RV
Chrysococcyx basalis	Horsfield's Bronze-Cuckoo		x	BCE,B	RV
STRIGIDAE (Hawk owls)					
Ninox novaeseelandiae	Southern Boobook		x	BCE	R
TYTONIDAE (Barn owls)					
Tyto alba	Barn Owl		x		RV
PODARGIDAE (Australian frogmouths)					
Podargus strigoides	Tawny Frogmouth		x	BCE	R9
CAPRIMULGIDAE (Nightjars and allies)					
Eurostopodus argus	Spotted Nightjar		x	BCE	RV
AEGOTHELIDAE (Owlet-nightjars)					
Aegotheles cristatus	Australian Owlet-nightjar		x	BCE,B	R
APODIDAE (Typical swifts)					
Apus pacificus	Fork-tailed Swift	CS1		BCE	RV
HALCYONIDAE (Kingfishers)					
Todiramphus pyrrhopygia	Red-backed Kingfisher		x	BCE,B	R8,9
Todiramphus sanctus	Sacred Kingfisher				RV
MEROPIDAE (Bee-eaters)					
Merops ornatus	Rainbow Bee-eater		x	BCE,B	RV8,9
CLIMACTERIDAE (Australo-Papuan treecreepers)					
Climacteris affinis	White-browed Treecreeper		x	B	IV
MALURIDAE (Fairy-wrens, emu-wrens and grasswrens)					
Malurus splendens	Splendid Fairy-wren		x	BCE,B	R8,9
Malurus lamberti	Variegated Fairy-wren		x	BCE,B	R8,9
Malurus leucopterus	White-winged Fairy-wren		x	BCE,B	R8,9
Amytornis striatus striatus	Striated Grasswren	CS2	x	WJ	Va
Stipiturus ruficeps	Rufous-crowned Emu wren	CS3		WJ	Va
PARDALOTIDAE (Pardalotes, scrubwrens, thornbills and allies)					
Pardalotus rubricatus	Red-browed Pardalote		x		R
Pardalotus striatus	Striated Pardalote		x	BCE,B	R
Calamanthus campestris	Rufous Fieldwren		x	BCE	R
Pyrrholaemus brunneus	Redthroat		x	BCE	R8,9
Smicrornis brevirostris	Weebill		x	BCE,B	R
Gerygone fusca	Western Gerygone		x	BCE	R
Acanthiza apicalis	Inland Thornbill		x	BCE,B	R8
Acanthiza uropygialis	Chestnut-rumped Thornbill		x	BCE,B	R8,9
Acanthiza robustirostris	Slaty-backed Thornbill		x	BCE,B	R9

Species		Cons Sig	DB	Regional studies	Status (BCE8,9)
Acanthiza iredalei	Slender-billed Thornbill	CS1			R
Acanthiza chrysorrhoa	Yellow-rumped Thornbill		x	BCE,B	R8,9
Aphelocephala leucopsis	Southern Whiteface		x	BCE,B	R8
MELIPHAGIDAE (Honeyeaters)					
Acanthagenys rufogularis	Spiny-cheeked Honeyeater		x	BCE,B	R8,9
Anthochaera carunculata	Red Wattlebird		x		Va
Manorina flavigula	Yellow-throated Miner		x	BCE,B	R8,9
Lichenostomus virescens	Singing Honeyeater		x	BCE,B	R8,9
Lichenostomus penicillatus	White-plumed Honeyeater		x	BCE,B	R8
Lichenostomus plumulus	Grey-fronted Honeyeater		x	B	R
Lichmera indistincta	Brown Honeyeater		x	BCE	R8
Phylidonyris albifrons	White-fronted Honeyeater		x	BCE,B	R
Conopophila whitei	Grey Honeyeater	CS3		WJ,B	IV
Certhionyx niger	Black Honeyeater		x	B	R
Certhionyx variegatus	Pied Honeyeater		x	BCE,B	R
Epthianura tricolor	Crimson Chat		x	BCE	RV8,9
Epthianura aurifrons	Orange Chat		x		RV
Epthianura albifrons	White-fronted Chat		x		RV
PETROICIDAE (Robins)					
Microeca leucophaea	Jacky Winter		x	BCE	RV
Petroica goodenovii	Red-capped Robin		x	BCE,B	R8,9
Melanodryas cucullata	Hooded Robin		x	BCE,B	R8,9
POMATOSTOMIDAE (Babblers)				BCE	
Pomatostomus temporalis	Grey-crowned Babbler		x	BCE,B	R8,9
Pomatostomus superciliosus	White-browed Babbler		x	BCE,B	R8,9
CINCLOSOMATIDAE (Quail-thrushes and allies)					
Psophodes occidentalis	Chiming Wedgebill		x	B	R
Cinclosoma castanotum	Chestnut Quail-thrush		x	B	R
Cinclosoma casteneothorax	Western Quail-thrush		x	BCE	RV8
NEOSITTIDAE (Sitellas)					
Daphoenositta chrysoptera	Varied Sittella		x	BCE	R9
PACHYCEPHALIDAE (Whistlers, shrike-thrushes and allies)					
Oreoica gutturalis	Crested Bellbird		x	BCE,B	R8,9
Pachycephala rufiventris	Rufous Whistler		x	BCE,B	R8,9
Colluricincla harmonica	Grey Shrike-thrush		x	BCE,B	R8
DICRURIDAE (Monarchs, fantails and drongos)					
Grallina cyanoleuca	Magpie-lark		x	BCE,B	R8,9
Rhipidura f. albicauda	Grey (White-tailed) Fantail				R
Rhipidura leucophrys	Willie Wagtail		x	BCE,B	R8,9
CAMPEPHAGIDAE (Cuckoo-shrikes and trillers)					
Coracina novaehollandiae	Black-faced Cuckoo-shrike		x	BCE,B	R8,9
Coracina maxima	Ground Cuckoo-shrike		x	BCE,B	RV8
Lalage sueurii	White-winged Triller		x	BCE,B	R

Species		Cons Sig	DB	Regional studies	Status (BCE8,9)
ARTAMIDAE (Woodswallows, butcherbirds and currawongs)					
Artamus personatus	Masked Woodswallow		X	BCE,B	RV
Artamus cinereus	Black-faced Woodswallow		x	BCE,B	R8,9
Artamus minor	Little Woodswallow		x	BCE,B	IV8,9
Cracticus torquatus	Grey Butcherbird		x	BCE,B	R8,9
Cracticus nigrogularis	Pied Butcherbird		x	BCE,B	R8
Gymnorhina tibicen	Australian Magpie		x	BCE,B	R8
Strepera versicolor	Grey Currawong			WJ, BCE,B	IV
CORVIDAE (Crows and allies)					
Corvus bennetti	Little Crow		x	BCE	RV8
Corvus orru	Torresian Crow		x	BCE	RV8,9
Ptilonorhynchidae (Bowerbirds)					
Ptilonorhynchus guttatus	Western Bowerbird		x	BCE,B	R8,9
MOTACILIDAE (Old world wagtails and pipits)					
Anthus novaeseelandiae	Australasian Pipit		x	BCE,B	R8,9
PASSERIDAE (Sparrows, weaverbirds, waxbills and allies)					
Taeniopygia guttata	Zebra Finch		x	B	R8,9
DICAEIDAE (Flowerpeckers)					
Dicaeum hirundinaceum	Mistletoebird		x	B	R
HIRUNDINIDAE (Swallows and martins)					
Cheramoeca leucosternum	White-backed Swallow		x	BCE	R8
Hirundo neoxena	Welcome Swallow		x	BCE,B	RV8,9
Hirundo nigricans	Tree Martin		x	B	R
Hirundo ariel	Fairy Martin		x	BCE,B	R8
SYLVIIDAE (Old world warblers)					
Cinclorhamphus mathewsi	Rufous Songlark		x	B	RV
Cinclorhamphus cruralis	Brown Songlark		x		RV
Total Species Expected: 153					

Bird species recorded by trap line census and walking transects.

Date	Species	Survey type	Location; Site or Lease #	Count
22/10/2019	Singing Honeyeater	Census	11	1
22/10/2019	Yellow-throated Miner	Census	11	1
22/10/2019	Yellow-throated Miner	Census	10	1
22/10/2019	Singing Honeyeater	Census	10	1
22/10/2019	Crested Pigeon	Census	10	1
23/10/2019	Willie Wagtail	Census	10	1
23/10/2019	Singing Honeyeater	Census	10	1
23/10/2019	Spiny-cheeked Honeyeater	Census	10	1
23/10/2019	Grey-crowned Babbler	Census	10	out

23/10/2019	Australian Ringneck	Census	10	2
23/10/2019	White-winged Fairy-wren	Census	11	2
23/10/2019	Torresian Crow	Census	11	2
24/10/2019	Singing Honeyeater	Census	12	3
24/10/2019	Yellow-throated Miner	Census	12	6
24/10/2019	Zebra Finch	Census	12	6
24/10/2019	Chestnut-rumped Thornbill	Census	12	2
24/10/2019	Singing Honeyeater	Census	10	1
24/10/2019	White-winged Fairy-wren	Census	10	2
24/10/2019	Singing Honeyeater	Census	11	1
24/10/2019	Red-capped Robin	Census	15	2
24/10/2019	Chestnut-rumped Thornbill	Census	15	2
25/10/2019	Red-backed Kingfisher	Census	12	1
25/10/2019	Singing Honeyeater	Census	12	1
25/10/2019	Chestnut-rumped Thornbill	Census	12	2
25/10/2019	Spiny-cheeked Honeyeater	Census	12	1
25/10/2019	Chestnut-rumped Thornbill	Census	14	1
25/10/2019	Chestnut-rumped Thornbill	Census	15	3
25/10/2019	Singing Honeyeater	Census	10	2
25/10/2019	White-winged Fairy-wren	Census	11	3
25/10/2019	Yellow-throated Miner	Census	11	1
26/10/2019	Yellow-throated Miner	Census	13	1
26/10/2019	Spiny-cheeked Honeyeater	Census	10	1
27/10/2019	Singing Honeyeater	Census	14	1
25/10/2019	Crested Pigeon	Transect	M36-535 (Mulga woodland)	2
25/10/2019	White-browed Babbler	Transect	M36-535 (Mulga woodland)	2
25/10/2019	Variegated fairy-wren	Transect	M36-535 (Mulga woodland)	4
25/10/2019	Willy Wagtail	Transect	M36-535 (Mulga woodland)	1
25/10/2019	Red-capped Robin	Transect	M36-535 (Mulga woodland)	1
25/10/2019	Black-faced Cuckoo-shrike	Transect	M36-535 (Mulga woodland)	1
25/10/2019	Singing Honeyeater	Transect	M36-535 (Mulga woodland)	4
25/10/2019	Yellow-throated Miner	Transect	M36-535 (Mulga woodland)	9
25/10/2019	Chestnut-rumped Thornbill	Transect	M36-535 (Mulga woodland)	2
25/10/2019	Red-capped Robin	Transect	M36-535 (Mulga woodland)	3
25/10/2019	Slender-billed Thornbill	Transect	M36-535 (Mulga woodland)	1
25/10/2019	Welcome Swallow	Transect	M36-535 (Mulga woodland)	2
25/10/2019	Spiny-cheeked Honeyeater	Transect	M36-535 (Mulga woodland)	1
25/10/2019	White-winged fairy -wren	Transect	M36-535 (Mulga woodland)	2
25/10/2019	Chestnut-rumped Thornbill	Transect	M36-535 (Mulga woodland)	5
26/10/2019	Crimson Chat	Transect	M36-535 (Mulga woodland)	1
26/10/2019	Singing Honeyeater	Transect	M36-535 9 (Gypsum island)	4
26/10/2019	Spiney-cheeked Honeyeater	Transect	M36-535 9 (Gypsum island)	2
26/10/2019	Yellow-throated Miner	Transect	M36-535 9 (Gypsum island)	7

26/10/2019	Australian Ringneck	Transect	M36-535 9 (Gypsum island)	5
26/10/2019	Australian Ringneck	Transect	M36-24	4
26/10/2019	Chestnut-rumped Thornbill	Transect	M36-24	11
26/10/2019	White-browed Babbler	Transect	M36-24	2
26/10/2019	Mulga Parrot	Transect	M36-24	6
26/10/2019	Red-capped Robin	Transect	M36-24	4
26/10/2019	Singing Honeyeater	Transect	M36-24	3
26/10/2019	Willy Wagtail	Transect	M36-24	2
26/10/2019	Rainbow Bee-eater	Transect	M36-24	1
26/10/2019	Black-faced Woodswallow	Transect	M36-24	1
26/10/2019	Yellow-throated Miner	Transect	M36-24	1
26/10/2019	Australian Hobby	Transect	M36-24	1
27/10/2019	Sharp-tailed Sandpiper	Transect	M36-25 (SE Lake Miranda)	1

MAMMALS

Species		Cons Sig	DB	Regional studies	Status (BCE8,9)
TACHYGLOSSIDAE (Echidnas)					
Tachyglossus aculeatus	Echidna			BCE,B	R8,9
DASYURIDAE (Dasyurids)					
Dasycercus blythi	Brush-tailed Mulgara	CS2	x	MK, BCE,B	IV
Antechinomys laniger	Kultarr	CS3		MK,WJ	R
Ningaui ridei	Wongai Ningaui		x	MK, BCE,B	R
Pseudantechinus woolleyae	Woolley's Pseudantechinus			WJ,scats	R
Sminthopsis crassicaudata	Fat-tailed Dunnart			WJ,B	R
Sminthopsis dolichura	Little Long-tailed Dunnart			WJ,B	R
Sminthopsis hirtipes	Hairy-footed Dunnart			WJ, BCE	IV
Sminthopsis longicaudata	Long-tailed Dunnart	CS2			R
Sminthopsis macruora	Stripe-faced Dunnart		x	WJ, BCE,B	R
Sminthopsis ooldea	Ooldea Dunnart			WJ, BCE	R
MACROPODIDAE (Kangaroos, wallabies)					
Macropus robustus	Euro, Biggada			WJ, BCE,B	R8,9
Macropus rufus	Red Kangaroo, Marlu			WJ, BCE	R8,9
Petrogale lateralis	Black-flanked Rock-Wallaby	CS1		Scats BCE	Va?
EMBALLONURIDAE (Sheathtail bats)					
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat			BCE	R
Taphozous hillli	Hill`s Sheathtail-bat				R
VESPERTILIONIDAE (Vespertillionid bats)					
Chalinolobus gouldii	Gould's Wattled Bat		x	WJ, BCE	R8
Nyctophilus geoffroyi	Lesser Long-eared Bat		x	WJ, BCE	R8
Nyctophilus major tor	Central Long-eared Bat	CS2		BCE	R
Scotorepens balstoni	Inland Broad-nosed Bat		x	WJ, BCE,B	R
Vespadelus baverstocki	Inland Forest Bat			WJ, BCE	R
Vespadelus finlaysoni	Finlayson's Cave Bat			BCE	R8
Vespadelus regulus	Southern Forest Bat		x	WJ	R
MOLOSSIDAE (Freetail bats)					
Austronomus australis	White-striped Freetail-Bat			WJ, BCE	RV8
Mormopterus (*Ozimops*) *petersi*	Inland Freetail-Bat			BCE	RV8
MURIDAE (Rats and mice)					
Mus musculus	House Mouse	INT	x	MK,B	R
Notomys alexis	*Spinifex Hopping-Mouse*		X	MK,BCE	R9
Pseudomys bolami	Bolam's Mouse		x	B	R
Pseudomys desertor	Desert Mouse	CS3		MK,B	R
Pseudomys hermannsburgensis	Sandy Inland Mouse		x	MK,B	R

Species		Cons Sig	DB	Regional studies	Status (BCE8,9)
LEPORIDAE (Rabbits and hares)					
Oryctolagus cuniculus	Rabbit	INT	x	BCE	R8,9
CANIDAE (Dogs and foxes)					
Canis lupus dingo	Dingo	INT	x	BCE	R8,9
Vulpes vulpes	Red Fox	INT	x	BCE	R
FELIDAE (Cats)					
Felis catus	Cat	INT	x	BCE	R8,9
BOVIDAE (Horned ruminants)					
Capra hircus	Goat	INT	x		R
Bos Taurus	Cow	INT			R8,9
CAMELIDAE (camels)					
Camelus dromedarius	Camel	INT	x	BCE	RV
Native Species Expected: 28 **Introduced Species Expected: 8**					

Species present in database searches but considered unlikely due to habitat presence or clearly out of range. Some could be rare vagrants.

Species		Cons Sig	DB	Regional studies
Strophurus elderi	Jewelled Gecko			BCE,B
Delma butleri	Unbanded Delma			BCE
Delma nasuta	Long-nosed Delma			BCE
Delma petersoni				
Ctenotus ariadnae				BCE,B
Ctenotus calurus				B
Ctenotus grandis				BCE
Ctenotus hanloni				BCE
Liopholis striata	Night Skink			BCE,B
Tiliqua multifasciata	Centralian Blue-tongue			BCE,B
Acanthophis pyrrhus	Desert Death Adder			
Phalacrocorax varius	Pied Cormorant			
Nycticorax caledonicus	Nankeen Night Heron			
Elanus scriptus	Letter-winged Kite			

Species considered extinct in the survey area

Species Name	Common Name
Amytornis textilis	Thick-billed Grasswren
Dasyurus geoffroii	Chuditch
**Bettongia lesueur*	Boodie, *Burrowing Bettong- many old warrens recorded in 2018 and 2019 surveys.
Lagorchestes hirsutus	Rufous Hare-Wallaby
Macroderma gigas	Ghost Bat
Macrotis lagotis	Greater Bilby
Isoodon auratus	Golden Bandicoot
Chaeropus ecaudatus	Pig-footed Bandicoot
Leporillus apicalis	Lesser Stick-nest Rat

Note that this list is probably incomplete and the past status of some of these species in the area is uncertain.

Appendix 6. Sonograms of bat species recorded on site.

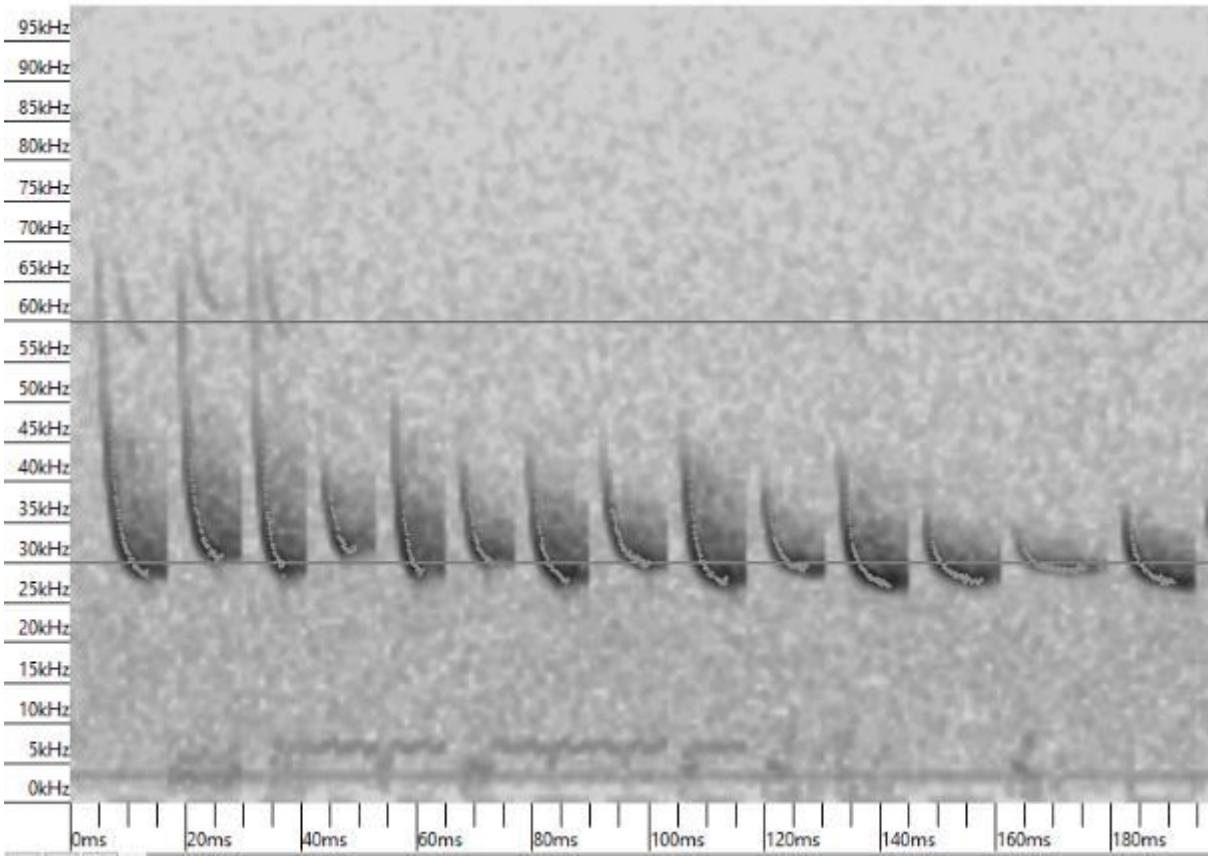

Figure 1: Sonogram of *Chalinolobus gouldii* showing characteristic alternating frequencies.

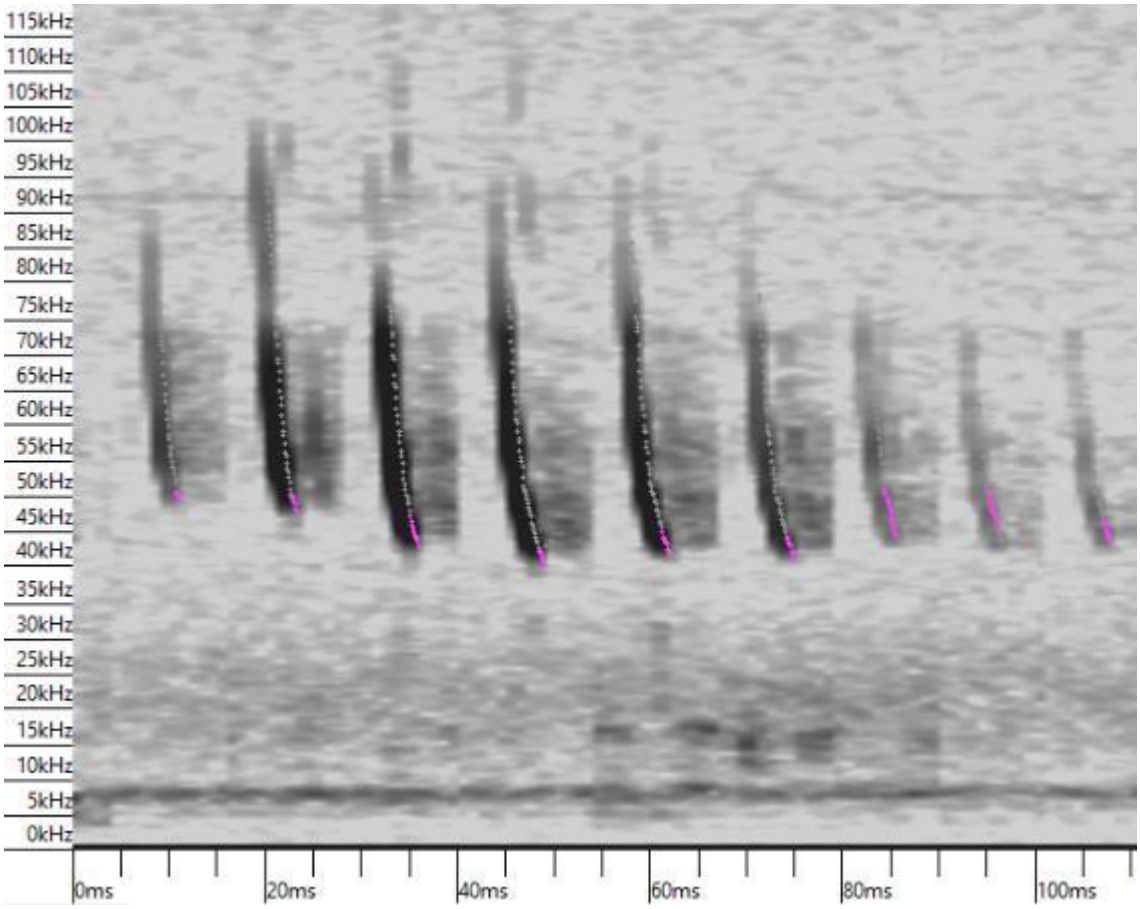

Figure 2: Sonogram of *Nyctophilus geoffroyi*.

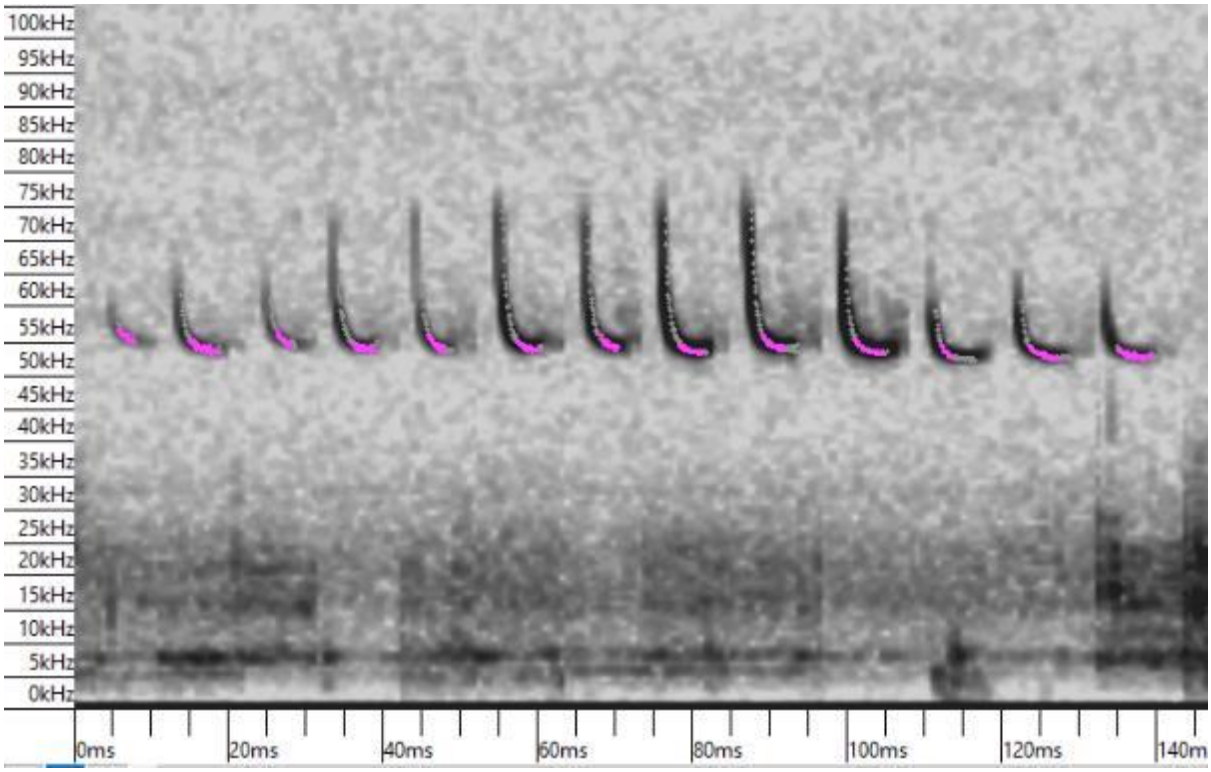

Figure 3: Sonogram of *Vespadelus finlaysoni*.

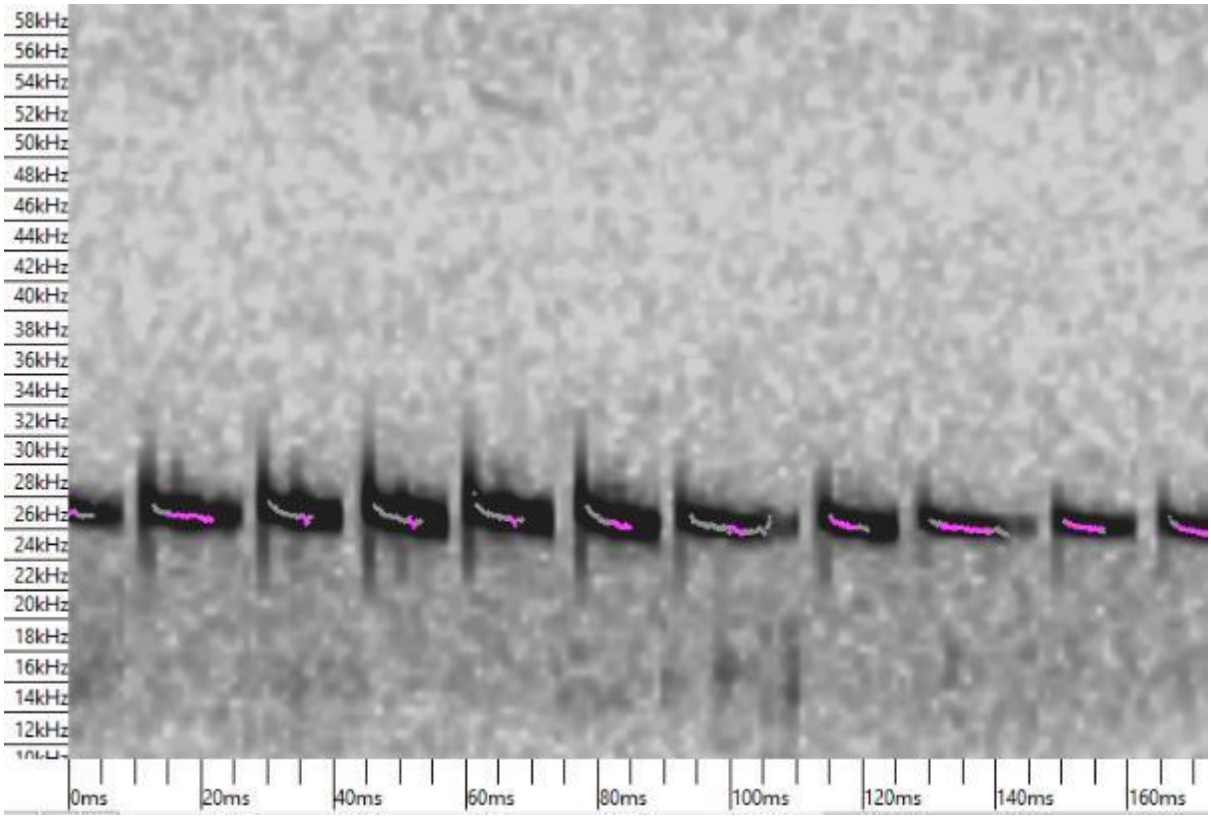

Figure 4: Sonogram of *Ozimops planiceps* (previously *Mormopterus* sp 3) echolocation sequence. Note harmonics just visible at around 55 kHz.

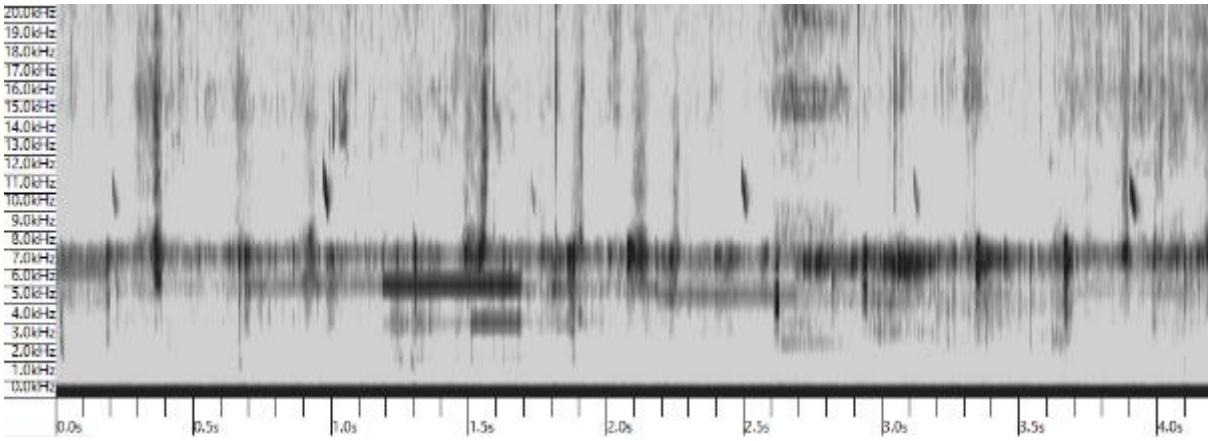

Figure 5: Weak sonogram of *Austronomus australis* call sequence. Characteristic low-frequency clicks are around 11 kHz.

Appendix 7. Annotated species list Bellevue Project Area, August and October 2018, October 2019.

Frogs and reptiles

1. *Litoria rubella*. 2018. Reported by staff and active some nights.
2. *Diplodactylus conspicillatus*. 2018. One found head-torching near site 8, on narrow clay flat with short grass between Mulga and Gypsum. Need to check current taxonomy. 2019. One caught in same area as in 2018.
3. *Diplodactylus granariensis rex*. 2018. One caught Site 3. Also one at site 8; very pale but appeared to be D.g. rex. 2019. A young animal (year 1) caught on flat (spotlighting) between dunes and gypsum ridge near site 12.
4. *Diplodactylus pulcher*. 2018. One caught at site 3.
5. *Gehyra variegata.* 2018. One caught at Site 2 and seen occasionally elsewhere. In this area, G. variegata has a dark reticulum tending to form two dark upper lateral lines. 2019. One caught site 11 and several spotlighting in south-west; on timber.
6. *Gehyra crypta*. 2018. Several caught spotlighting. In this area, lacks the dark reticulum, having just dark spots (not forming reticulum) and just behind and separate from these white spots; some quite free-standing white spots on back of head. 2019. One caught spotlighting near site 15. On rock which may be a feature of the species in the area. Several seen and caught when spotlighting on edge of rock heaps around Vanguard Pt.
7. *Heteronotia binoei*. 2018. Found at night at Boy's Well and Vanguard Pit, and caught sites 7 and 8. 2019. Seen around camp.
8. *Lucasium squarrosum*. 2018. One spotlighting near Vanguard pit (27/10). Specimen kept.
9. *Nephrurus vertebralis*. 2018. Caught site 1 (Mulga over sandy loam). 2019. Caught site 11 and site 13.
10. *Rhynchoedura ornata*. 2018. Active at night around camp. 2019. Caught site 10 and 11. Dead-torched near Vanguard Pit.
11. *Strophurus strophurus*. 2018. Caught at sites 3 and 4. 2019. Caught site 10 and when spotlighting near site 15.
12. *Underwoodisaurus milii*. 2018. Several caught Site 7 and 8. 2019. Head-torched near Vanguard Pit.
13. *Aprasia repens*. 2018. One caught at site 8 and one at site 7. One kept for WAM.
14. *Lialis burtonis*. 2018. A year 1 specimen hand-caught at Site 2.
15. *Pygopus nigriceps*. 2018. A year 1 trapped at site 1.
16. *Ctenophorus isopelis*. 2018. Seen in Site 1 on sandy soils.
17. *Ctenophorus nuchalis*. 2018. Caught site 4.
18. *Ctenophorus salinarum*. 2018. One caught in samphire on edge of gypsum dune west of site 8 (29/10).
19. *Ctenophorus scutullatus*. 2019. Caught sites 10 and 15.
20. *Pogona minor*. 2019. One juvenile seen site 15 (23/10).
21. *Ctenotus leonhardii*. 2018. One hand-caught at Site 1 (23/10) and seen regularly at sandy sites. Pitfalled at rocky and sandy sites. 2019. Few pitfalled.
22. *Eremiascincus richardsonii*. 2018. Caught at site 8 in pitfall near old Boodie warren.

23. *Lerista timida*. 2018. Caught site 5 and site 8. 2019. Caught at sites 10, 11 and 13. Some uncertainty about taxonomy but definitely fused frontoparietals.
24. *Lerista desertorum. 2018.* Caught sites 1 and 7. 2019. One caught site 12.
25. *Menetia greyii*. 2018. Several caught at sites 7 and 8, and one at site 2. All appeared to be female. 2019. One caught site 13.
26. *Varanus gouldii.* 2018. One seen at site 1.
27. *Varanus panoptes*. 2018. One checking pitfalls at site 3 (26/10). Roadkilled animal on highway: gravid female with 6 oviducal eggs. SVL: 390. Tot: 960. Good fat deposits. Stomach had a centipede (Scolopendra) scorpion (Urodacus), 4 cockroaches, a moth pupa and some bits of bone. 2019. One active at camp and one seen near site 13. One also using burrow in old Boodie warren near site 11. One caught on camera near burrow at site 15.
28. *Anilios hamatus*. 2018. One caught site 5.
29. *Anilios aff waitei*. 2018. One caught site 8; identification uncertain. Kept for WAM.
30. *Antaresia stimsoni*. 2018. Reported by staff around camp after summer rain. Eating *Litoria rubella*. Photo seen.
31. *Pseudonaja mengdeni*. 2018. One on night drive along highway (31/10).
32. *Pseudonaja modesta*. 2018. One reported by botanists. 2019. One seen during the day at site 14.
33. *Suta fasciata*. 2018. One found by head-torching at site 8.

Birds

1. Emu. 2018. Part skeleton near site 1. Tracks of single adult across part of Lake Miranda. 2019. Few feathers in fence near site 13. Tracks near cemetery.
2. Black Swan. August 2018. Dead bird on shore of Lake Miranda. Reported to have been common and breeding a few months earlier. 2019. Old nest found in samphire on Lake Way (SE).
3. Black-breasted Buzzard. 2018. One just south of Mt Keith on 23/10.
4. Wedge-tailed Eagle. 2018. Pair just north of cemetery (23/10). Pair over Tribune area (25/10). Few other sightings. 2019. Pair in south-west seen most days and a young male near site 13 (23/10).
5. Whistling Kite. 2019. One over north end of Lake Miranda (26/10). Also seen August 2018.
6. Nankeen Kestrel. 2018. One over Vanguard Pit (24/10) and one near 'chimney' (25/10). 2019. One in south-west area (21/10) and up to three around camp most days.
7. Brown Falcon. 2018. One in south near 'chimney' (25/10) and one near site 8 (29/10). 2019. One heard near site 11 (25/10).
8. Australian Hobby. 2018. One perched on power pole near Site 8 (29/10). 2019. One seen along Cosmos access road (23/10).
9. Diamond Dove. 2018. Seen once or twice; single birds.
10. Crested Pigeon. 2018. Seen occasionally in small numbers. 2019. Few seen around camp and occasionally elsewhere.
11. Common Bronzewing. 2019. Several seen in bushland including around Boyd's Well.
12. Australian Bustard. 2019. Feathers under powerline near site 12; possible powerline strike?
13. Common Greenshank. August 2018. Two on flooded arm of Lake Miranda.

14. Sharp-tailed Sandpiper. 2019. One in dry, sparse, low samphire of northern arm of Lake Miranda. Appeared to be a juvenile.
15. Red-capped Plover. August 2018. About 20 birds on flooded arm of Lake Miranda.
16. Bush Stone-curlew. 2018. Three birds reported near camp by staff early in October.
17. Tawny Frogmouth. 2019. One flushed near Cosmos Haul road (23/10).
18. Mulga Parrot. 2018. Three just north of Vanguard Pit (24/10) and up to 7 seen in this location regularly. 2019. Few pairs seen while doing walking transects.
19. Australian Ringneck. 2018. Two seen between sites 5 and 7 (28/10, 30/10 and 31/10). 2019. Seen occasionally around sites 10 to 12, and seen occasionally along walking transects.
20. Red-backed Kingfisher. 2018. Seen occasionally. 2019. Two seen near site 6 (25/10).
21. Rainbow Bee-eater. 2018. Heard near site 5 (31/10). 2019. Seen and heard occasionally throughout.
22. White-winged Fairy-wren. 2018. Parties in samphire and low shrublands; coloured males present. Very abundant, especially to west where samphire in good condition. 2019. Heard and seen regularly in chenopod shrubland around sites 10 and 11, and seen along highway near Kathleen Valley area.
23. Splendid Fairy-wren. 2018. Party in northern hills, including coloured male. Few other groups. 2019. Very few groups seen. One coloured male seen.
24. Variegated Fairy-wren. 2018. One party with a coloured male just north of Vanguard Pit (31/10). 2019. Presumably same party in same location; with coloured male. Party also seen near site 12 (25/10).
25. Redthroat. 2018. Several seen and heard in northern hills. 2019. Seen and heard occasionally in northern hills.
26. Inland Thornbill. 2018. Seen occasionally in Mulga areas.
27. Chestnut-rumped Thornbill. 2018. The common thornbill in Mulga country. 2019. The common thornbill in Mulga country.
28. Yellow-rumped Thornbill. 2019. Few groups around.
29. Slaty-backed Thornbill. 2019. One bird seen very clearly (streaks on forehead and dark eye distinct) near site 12 (25/10). Probably present throughout in small numbers.
30. Southern Whiteface. 2018. One party seen near Site 3.
31. Spiny-cheeked Honeyeater. 2018. Seen regularly in Mulga. 2019. Heard around site 12.
32. Yellow-throated Miner. 2018. Parties seen regularly. At sites 7 and 8, feeding on green seeds of acacia by biting into the green pods. Seeds are large (lentil-sized) with a fat arel. 2019. Seen and heard occasionally throughout.
33. Singing Honeyeater. 2018. Common in Mulga. 2019. Common in Mulga.
34. White-plumed Honeyeater. 2018. Two seen in Tribune area (24/10).
35. Brown Honeyeater. 2018. Single juvenile with yellow gape seen in shrubs west of Site 8 (29/10).
36. Crimson Chat. 2018. Few seen on open country near Vanguard Pit. 2019. Few on open ground near site 13 (24/10).
37. Orange Chat. 2019. Group of 6 on Samphire in south-east of lease area. UNCONFIRMED as not seen very well, but only species likely based on location, flight pattern and what colour was seen.
38. Grey Shrike-thrush. 2018. One calling at Site 3 (25/10).

39. Crested Bellbird. 2018. Seen and heard regularly. 2019. Two birds heard on 24/10 in north, and one heard near Vanguard Pit (27/10).
40. Rufous Whistler. 2018. Seen and heard regularly. 2019. One heard near Boyd's Well (23/10).
41. Red-capped Robin. 2018. Along drainage line near site 2 (26/10) and several seen in walk through rocky hills in the north, including recently-fledged young (27/10). 2019. Single birds and occasional pairs seen throughout; often associated with thornbills and/or fairy-wrens.
42. Hooded Robin. 2018. Seen in hills in north (27/10). 2019. Pair along walked transect in northern hills (24/10).
43. Varied Sittella. 2019. Group of about six birds near site 15 then re-sighted near site 13 an hour later (27/10).
44. Grey-crowned Babbler. 2018. Party near site 5 and in hills east of Site 2. Also party near Boyd's Well. 2019. Heard and seen near site 12 and site 13.
45. White-browed Babbler. 2018. Party just north of Vanguard Pit. 2019. Small group near Cosmos turnoff (23/10) and one seen near site 12 (25/10).
46. Western Quail-thrush. 2018. Party in northern hills (27/10) and single bird (but more nearby?) on bare ground of the blind hill along entrance road (29/10).
47. Willie Wagtail. 2018. Single birds seen occasionally. 2019. Single birds seen occasionally.
48. White-backed Swallow. 2018. Several regularly around pits.
49. Fairy Martin. 2018. Several regularly around pits.
50. Welcome Swallow. 2018. Two seen at Boyd's Well (23/10) and occasionally elsewhere. 2019. Two seen near Vanguard Pit, Site 12 and near Boyd's Well all on 23/10.
51. Black-faced Woodswallow. 2018. Seen regularly. 2019. Seen around site 11 (21/10) and small groups seen a few times elsewhere.
52. Little Woodswallow. 2018. Seen occasionally around Vanguard Pit. 2019. Two seen near Vanguard Pit (23/10).
53. Black-faced Cuckoo-shrike. 2018. Two over Tribune (25/10; 28/10). 2019. Few in site 10 to 12 area most days.
54. Ground Cuckoo-shrike. 2018. Two flying past near Vanguard Pit (30/10). 2019. Single bird near site 15 (23/10).
55. Magpie-lark. 2018. Pair around camp. 2019. Pair around camp.
56. Grey Butcherbird. 2018. Heard occasionally. 2019. One heard near site 10 and 11 mot days.
57. Pied Butcherbird. 2018. Seen and heard regularly. 2019. Several around camp each day, including a juvenile. One bird seen near site 11 (25/10).
58. Australian Magpie. 2018. One near Miranda Crossing (25/10). 2019. One again near Miranda Crossing (26/10).
59. Zebra Finch. 2018. Small group and occasionally up to about 50 in flocks near Vanguard Pit. 2019. Occasional small flocks. One big group (50+) near Vanguard Pit on one occasion.
60. Australasian Pipit. 2019. One on open ground near Vanguard (23/10). Several along road near Lake Miranda (24/10).
61. Western Bowerbird. 2018. One flying over Site 5 (25/10; 27/10. Old bower seen at western end of Miranda crossing. 2019. One in camp (morning of 25/10).
62. Torresian Crow. 2018. Heard and seen occasionally. Two seemed more or less regular close to camp. 2019. Two birds near site 11 (23/10); on 25/10 about 10 birds present. Calls and

appearance seemed ambiguous, but wings clearly same length as or slightly extending beyond tail.

63. Little Crow. 2018. Flocks up to 20 seen regularly. 2019. Two around camp; low grating call heard clearly (26/10).

Mammals

Echidna. 2018. Diggings at site 8. 2019. Fresh tracks on track into sites 10 to 12 (22/10).

Boodie. 2018 and 2019. Old warrens present in calcrete and in northern hills throughout.

Euro. 2018. Small numbers throughout. 2019. Two seen near old chimney (23/10) and one photographed at site 15.

Red Kangaroo. 2018. Three seen Site 4 (26/10) and group of three, including female with large pouch young, grazing on edge of samphire west of site 8 (29/10). 2019. About four animals near site 11; grazing in samphire and retreated into Mulga when we approached (22/10).

Rabbit. 2018 and 2019. Burrows and scats abundant on gypsum soils and chenopod shrublands; less common elsewhere.

Cat. 2018. Tracks in sand at site 1 and occasionally elsewhere. One seen near dense vegetation just north of Vanguard Pit. 2019. Tracks in sandy and other soft substrates. One dead animal found in south-east.

Dingo. 2018. Tracks of single animal across mud of Lake Miranda. Photo of one taken west of Site 8. 2019. Fresh tracks near cemetery (23/10) and near site 10 (24/10).

Notomys sp. 2018.Burrow systems in mulga on sandy loam but no tracks. One found drowned in a trough at the camp in September. Described as being 'large'. *N. mitchelli??*. 2019. Burrow system found near Kathleen Valley. Inactive and small so more likely *N. alexis*. An active burrow system found near old Sir Samuel townsite.

Austronomus australis. 2018. Heard over camp some nights; at least an hour after dark so travelled a long way.

Cows. Tracks occasionally throughout and a few seen.