Salt Lake Potash Limited Lake Way Project
Level 2 Fauna Assessment of the
Expansion Project Area

Shrubland over spinifex hummock grassland on sandy loam flat east of Lake Way (M. Bamford).

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Executive Summary

Introduction

Salt Lake Potash Ltd is proposing to develop a potash extraction project on Lake Way, south of Wiluna. Bamford Consulting Ecologists (BCE) contributed to the fauna component of the assessment of a demonstration project in early 2019, and was then commissioned to undertake a fauna assessment for the 200 ktpa expansion project, including a comprehensive (level 2) field investigation. The focus of this assessment is vertebrate fauna and the environments that support these species. Aquatic and subterranean fauna are being addressed elsewhere. This report presents the results of this assessment, incorporating desktop review, observations from the brief site visit in early 2019 (31st January and 1st February), and observations and results from the level 2 investigations carried out 4th to 11th October 2019.

The purposes of this report are to provide information on the fauna values of the survey area, particularly for significant species, to present 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.

Summary of fauna values

Overview

The desktop study identified 286 vertebrate fauna species as potentially occurring in the project area: 8 frogs, 79 reptiles, 161 birds and 38 mammals (28 native and 10 introduced species). The assemblage includes up to 22 species of conservation significance. Field investigations confirmed the presence of 104 vertebrate fauna species including: one frog, 28 reptiles, 55 birds and 18 mammals (13 native and five introduced). Confirmed species included a number of conservation significance, while poor seasonal and annual conditions affected the field results.

Fauna assemblage.

Rich and substantially intact except for the loss of some, mostly medium-sized, mammal species and possibly some birds. The assemblage is likely to be typical of a very broad region of the Eastern Murchison and adjacent subregions, although the juxtaposition of VSAs and particularly the presence of sandy soils, gypsum soils and Lake Way itself may give an unusual combination of species for a small area.

Species of conservation significance.

This list includes up to 22 species. Most notable is the presence of a possibly undescribed lizard (*Lerista* 'Lake Way') in the gypsum soils close to Lake Way (VSA 3), the presence of a moderately dense population of the Brush-tailed Mulgara on sandy soils (VSA 5) east of Lake Way, and the occasional presence of migratory and other waterbirds on Lake Way when conditions are suitable.

Patterns of biodiversity.

These are poorly defined on available information, and no one VSA stands out, but the Mulga areas (VSA 4) were notable at least during the October 2019 investigations.

Significant species are most closely linked to Lake Way itself (waterbirds), the gypsum soils on the margins of the lake (VSA 3, some reptiles) and spinifex sandplain (VSA5; Brush-tailed Mulgara.

Key ecological processes.
Fire, feral species and hydrology are the key ecological processes affecting the fauna assemblage. 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 large 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). The vegetation in the area is affected by feral herbivores, most notable Rabbits and domestic livestock.

Vegetation and Substrate Associations
These provide habitat for fauna and the project area is characterised by a wide range of VSAs across a relatively small area. Key VSAs are:

- Open playa of Lake Way (north). Bare ground that floods intermittently after major rainfall events.
- Salt marsh (chenopod shrublands) of Lake Way. Chenopod shrublands on margins and across much of the south of Lake Way that flood after major rainfall events.
- Very open Mallee and scattered tall shrubs on gypsum/calcrete rises around the south of the lake; also present on islands in the south of the lake.
- Mulga over scattered shrubs and generally scattered spinifex on loam to loamy-sand flats. Forms a broad and variable band of vegetation east and north of the lake. Also present in West Creek borefield area.
- Scattered low Mallee with moderately dense Acacia shrubland over spinifex on sandy loam plain. Very extensive away from lake to east.
- Open shrubland and spinifex on sandy dune ridge. East of Lake Way.
- Very open Acacia shrubland with occasional thickets over sparse grasses and herbs on gravelly rises. Generally west of Lake Way including part of the pipeline route from the West Creek borefield.

Impacting processes
Overall, impacts of greatest concern are related to:

- Disruption of patterns of movement due to linear infrastructure (trenches, pipelines and roads);
- Species interactions due to changes in abundance of large predators (Dingo/wild dog, Cat and Fox) and potentially increase in abundance of predatory native birds around the project;
- Hydrological change from on-lake and off-lake earthworks, 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

- Ongoing mortality, notably light causing local mortality of invertebrates and increases in abundance of predatory species.

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. Management will be required and 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.
- 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 Way flood.
- Check infrastructure where there may be a risk of fauna entrapment or where there is a strike risk (such as overhead powerlines and even mesh fences).
- 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 could 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. Managing hydrological change will require detailed monitoring.
- 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 Way should be monitored if flooding occurs to ensure that if birds are present and breeding, actions required to ensure that disturbance does not occur can be implemented.
- Monitor local groundwater levels.
- The Mulgara population appears to be substantial and may be worth monitoring as an indicator of ecosystem health.

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1 Introduction

Background

Salt Lake Potash Ltd is proposing to develop a potash extraction project on Lake Way, south of Wiluna. Potash extraction effectively involves a network of trenches to harvest brine across the lake bed, with the brine being concentrated in ponds before being processed and then trucked off-site. The initial development is a demonstration plant project, involving the construction/operation of drainage trenches to extract brine from the northern section of the lake, which would then be concentrated in a series of evaporation ponds. A fauna investigation for the demonstration phase of the project was carried out in early 2019, consisting of a site inspection and desktop review (Bamford and Metcalf 2019). Salt Lake Potash is now investigating an expanded project (the 200 ktpa project) that includes additional brine harvesting in the south-eastern section of the lake, pipeline access north of the lake, a borefield to the north-west of the lake along West Creek, and infrastructure between the lake and the Goldfields Highway (Figure 1).

Bamford Consulting Ecologists (BCE) was commissioned to undertake a fauna assessment for the expansion project, including a comprehensive (level 2) field investigation. The focus of this assessment is vertebrate fauna and the environments that support these species. Aquatic and subterranean fauna are being addressed elsewhere. This report presents the results of this assessment, incorporating desktop review, observations from the brief site visit in early 2019 (31st January and 1st February), and observations and results from the level 2 investigations carried out 4th to 11th October 2019. The purposes of this report are:

- to provide information on the fauna values of the project area (also referred to as the survey area), particularly for significant species,
- to present an overview of the ecological function of the site within the local and regional context, and
- to provide discussion on the interaction of the proposed expansion project on the site with these fauna values and functions.

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

    - 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.

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. Not all threatening processes are relevant to the current project.

1.2 Study objectives

The broad objectives of the investigations completed by BCE are to:

- identify fauna values;
- review impacting processes with respect to these values and the proposed activity; and
- provide recommendations to mitigate these impacts.

Key components of the approach to achieving these objectives 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. Brush-tailed Mulgara, Greater Bilby, migratory waterbirds, Malleefowl and Night Parrot. Because of the location of the project on and around a large salt lake with unusual and restricted soil and vegetation types (Botanica 2019), the investigations also aim to target unusual and/or restricted range species.
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.

7. Identify potential impacts upon fauna and make recommendations to minimise impacts.

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GDA 1994 MGA Zone 51

Lake Way

Figure 1
Lake Way, indicating general locations of areas investigated in the current investigation

Legend

- Gunbarrel Laager
- Fauna Investigation Area
- Assessment Area
- Demonstration Plant Indicative Infrastructure
- Full Project Indicative Infrastructure

SALT LAKE POTASH LTD

Date: 27/11/2019
Version: B

Drawn: L. Weggelaar
Author: J. Payne

1.3 Description of the survey area

The 200 ktpa potash project is located in the southern portion of Lake Way, with the demonstration project already under development in the north of the lake (Figure 1). The north of the lake is an open playa fringed with salt marsh vegetation, whereas the south of the lake is a complex of gypsum islands supporting low woodlands and shrublands, set in salt marsh flats. There are slight gypsum rises around much of the lake, with surrounding country consisting broadly of undulating gravelly hills (primarily west of the lake), and sandy to sandy loam flats, with a few sandy dunes (sandy and sandy loam areas primarily east of the lake). Vegetation ranges from spinifex hummock grassland on sand to tall Mulga woodland on loam, with distinctive vegetation types on gypsum soils near the lake. Vegetation and substrates are described in more detail below. Lake Way itself is dry for much of the time but floods infrequently and for varying periods of time after rain. Salinity in the lake varies with the stage in the flooding and drying cycle.

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), although the Lake Way area, in the north of the subregion, lies well within the Mulga/Spinifex country and is thus likely to have only a small south-western component in its biota. 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). Wanjarri Nature Reserve lies south of Lake Way 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).

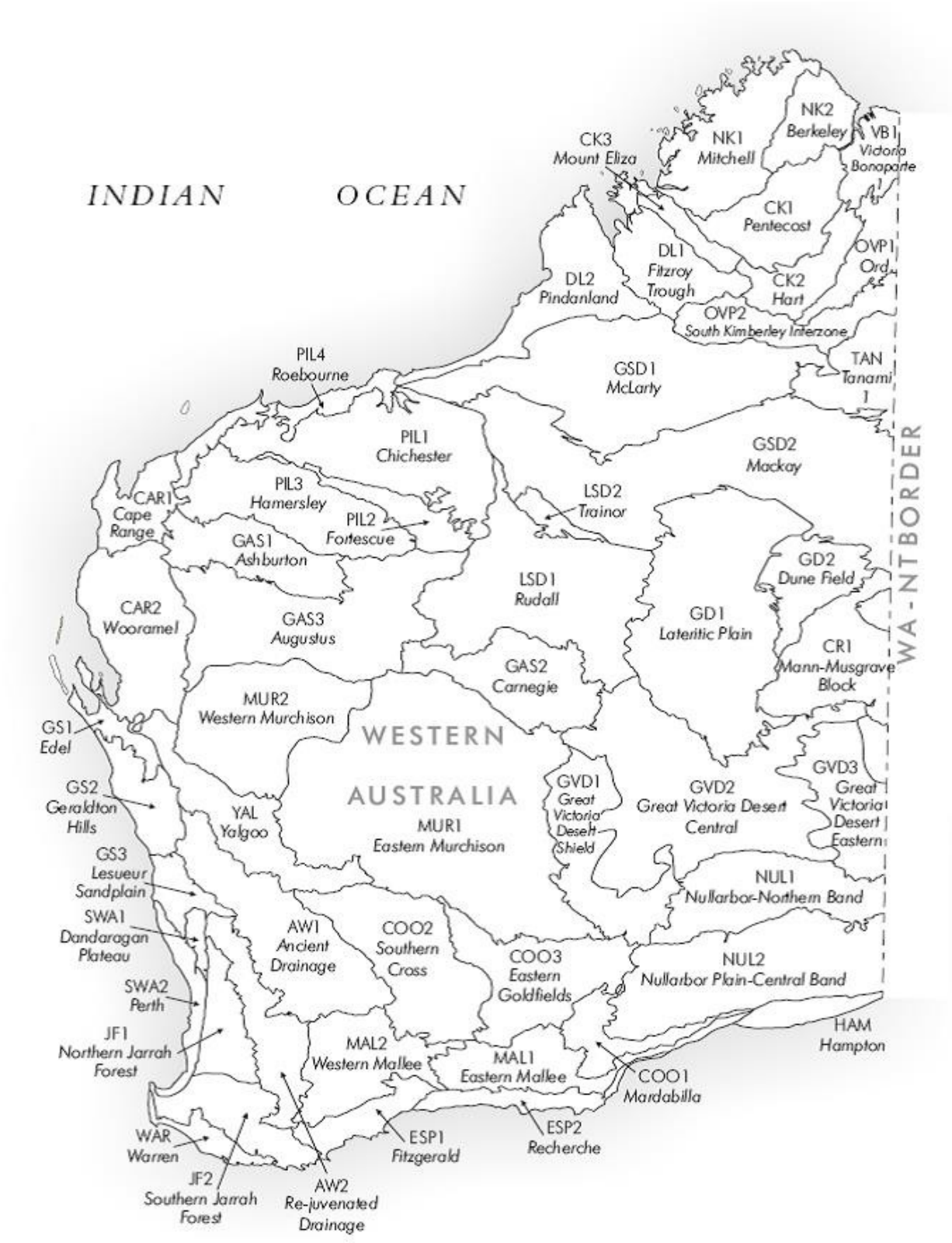


Figure 2. IBRA Subregions in Western Australia.

Note the survey area lies in the north of MUR1 Eastern Murchison IBRA subregion.

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, and Commonwealth biodiversity legislation (EPA 2002; EPA 2004). The EPA proposes two levels of investigation that differ in the approach to field investigations, Level 1 being a review of data and 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.

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. These included state and federal government databases and results of regional studies. Databases accessed were the Atlas of Living Australia (ALA), 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 Energy and the Environment (DEE) (Table 1). 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, 2005) and Barrett *et al.* (2003); and
Mammals: Menkhorst & Knight (2004); Armstrong (2011); 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
Atlas of Living Australia.	Records of biodiversity data from multiple sources across Australia.	Point search: 26.75°S, 120.32°E plus 10 km buffer. Searched: January 2019.
NatureMap (DBCA)	Records in the WAM and DBCA databases. Includes historical data and records on Threatened and Priority species in WA.	Point search: 26.75°S, 120.32°E plus 20 km buffer. Searched: January 2019.
BirdLife Australia Atlas Database (Birdlife Australia)	Records of bird observations in Australia, 1998-2019.	Point search: 26.75°S, 120.32°E plus 40 km buffer. Searched: January 2019.
EPBC Protected Matters (DEE)	Records on matters of national environmental significance protected under the EPBC Act.	Point search: 26.75°S, 120.32°E plus 40 km buffer. Searched: January 2019.

In addition, information on fauna and potential impacts was available from a number of previous studies in the area. These included:

- Bamford and Bancroft (2004). Review of the Wetland Avifauna of Lake Way. Unpublished report for Agincourt Resources.
- Outback Ecology Services (2005). Wiluna Gold Mine. Dewatering Discharge Licence Report (DDLR) Jan 2005 – Dec 2005. Unpublished report to Agincourt Resources.

- Outback Ecology Services (2006). Wiluna Gold. Monitoring of Lake Way during mining operations. Unpublished report to Agincourt Resources.
- Outback Ecology Services (2008). Toro Energy Ltd. Lake Way Baseline Environmental Survey. Salt Lake Ecology. Unpublished report to Nova Energy Ltd.
- EPA (2012). Report and Recommendations of the EPA: Wiluna Uranium Project, Toro Energy Ltd. Report 1437.
- Outback Ecology Services (2012a). Appendix E: Revision of "Toro Energy Ltd Wiluna Uranium Project Subterranean Fauna Assessment, March 2011". Unpublished report to Toro Energy Ltd.
- Outback Ecology Services (2012b). Wiluna Uranium Project Stygofauna May 2012. Memo to Toro Energy Ltd. 7th May 2012.
- Office of the Appeals Convener (2012). Statement that a proposal may be implemented; Wiluna Uranium Mine, 30km south and 15 km south-east of Wiluna, Shire of Wiluna. Ministerial Statement 913.
- MWH Australia (2015). Review of impacts to stygofauna from Wiluna Uranium Project. Letter to Toro Energy Ltd. 19th June 2015.
- Ecologia (2015). Extension to the Wiluna Uranium Project – Cumulative Impact Assessment. Unpublished report to Toro Energy Ltd.
- Toro Energy Ltd (2015). Extension to the Wiluna Uranium Project; Assessment No: 2002 (CMS14025): Public Environmental Review.
- Bennelongia Environmental Consultants (2017). Lake Wells Potash Project: Wetland Ecology Baseline Survey. Unpublished report for Australian Potash Ltd.
- Focused Vision Consulting (2017). Ecological Monitoring Program, Lake Way L5206/1987/10; Blackham Resources Ltd. – Matilda Operations Pty Ltd. Unpublished report by Focused Vision Consulting, in conjunction with Bennelongia Environmental Consultants, for Blackham Resources.

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 2016. The authorities used for each vertebrate group were: amphibians (Doughty *et al.* 2016a), reptiles (Doughty *et al*. 2016b), birds (Johnstone and Darnell 2016), 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). This includes the use of capital letters in English names. 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.

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 project area is of no importance. Species returned from databases but excluded from species lists due to lack of suitable habitat (and some database errors) are not presented.

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;
- **Migrant or regular visitor**: species that occur within the project 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 project area in at least moderate numbers and for some time;
- **Vagrant**: species that occur within the project area unpredictably, in small numbers and/or for very brief periods. Therefore, the project area is unlikely to be of importance for the species; and
- **Locally extinct**: species that would have been present but has not been recently recorded in the local area and therefore is almost certainly no longer present in the project area.

These status categories make it possible to distinguish between vagrant species, which may be recorded at any time but for which the site is not important in a conservation context, 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. It must be stressed that these status categories are predictions only and that often very intensive sampling would be required to confirm a species' status.

2.3 Field Investigation

2.3.1 Survey overview

The site inspection carried out in January/February 2019 involved conducting brief visits (driving and walking) to areas around the northern and western shorelines and adjacent environments around Lake Way. Field survey in October 2019 incorporated a range of survey techniques so as to maximise sampling results and was concentrated in the east of Lake Way to inform the assessment for the 200ktpa project. In October, work was also undertaken in the West Creek borefield area north-west of Lake Way, in the accommodation/plant site area west of Like Way, and in the gas pipeline area north of Lake Way. Opportunistic observations were also made around the Gunbarrel Laager (see Figure 1 for general locations). The following techniques were used:

- Identification of Vegetation and Substrate Associations (VSAs);
- Systematic sampling transects;
    - Pit trapping;
    - Funnel trapping;
    - Bird censusing;
    - Targeted searching for Malleefowl mounds;
    - Targeted searching for evidence of Brush-tailed Mulgara, Greater Bilby and Marsupial Mole (mole trenches);
- Motion sensitive cameras;
- Bat echolocation devices;
- Audio recording devices;
- Nocturnal searching (head-torching and spotlighting);
- Opportunistic invertebrate collection, and
- Opportunistic observations.

Details on these methods are provided below and locations of sampling sites are given on Figure 3.

2.3.2 Dates and Personnel

The initial site visit around the demonstration project of 31st January to 1st February 2019 was carried out by Dr Mike Bamford (B.Sc. (Hons), Ph.D. (Biol.)) and Mr Brenden Metcalf (BSc. (Hons) Biol.)). The comprehensive field investigations (4th to 11th October 2019) were carried out by:

- Dr Mike Bamford (B.Sc. Hons. Ph.D.)
- Mr Peter Smith (As. Dip. Ag)
- Mrs Sarah Smith (B.Sc. Biol), and
- Mr Jamie Wadey (B.Sc. Hons; (Zool.)).

In addition to BCE personnel, Mr Josh Payne (Pendragon Consulting) assisted with field work and usually two members of the Martu community were present and assisted with activities from pitfall installation to transect walks and spotlighting. The field investigations

were carried out under Regulation 27 permit No BA27000133. This fauna assessment report was prepared by Dr Mike Bamford.

2.3.3 Vegetation and Substrate Associations

Vegetation and Substrate Associations (VSAs) in the survey area were assessed during both field trips. Within the project 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. VSAs were mapped through interpretation of vegetation mapping (Botanica 2019), with each VSA being an amalgamation of several vegetation types.

2.3.4 Systematic Fauna Sampling

Ten systematic sampling transects (pitfall, funnels and bird censusing) covered the major VSAs, with at least two replicates in each (Table 2). There were two transects in lake edge gypsum soils (sites 2 and 6), four transects on Mulga over sparse spinifex on loam flats which was the most widespread and variable VSA (sites 1, 3, 4 and 7), two sites on spinifex sandplain (sites 5 and 8) and two sites on sand ridges (sites 9 and 10). At each systematic sampling transect, 10 pitfalls (20 litre plastic buckets 28cm in diameter and 40cm deep) were installed at c. 20m spacing. Each pitfall was assisted with three driftfences (flywire 1.2m long and 20cm high on a lightweight metal frame) extending radially from the bucket to allow fauna to fall into the pit when following the fence line. On every second pitfall, one driftfence was extended to include a funnel trap with an additional 1.2m fence installed beyond the funnel. Fewer funnels were installed on some sites (see Table 2) due to exposed conditions. Pitfalls were operated for six nights (4th to 10th October for sites 1 to 5; 5th to 11th October for sites 6 to 10) but funnels for only five nights on sites 6 to 10 due to increasing temperatures towards the end of the sampling period (high temperatures lead to increased mortality of captured fauna in both funnel and pitfall traps). Transect locations, descriptions and trapping effort are displayed in Table 2 and Figure 3.

Bird censusing was conducted during each trap check for the length of the transect and 25m on either side of the transect line. This made the bird survey area about 200m long and 50m wide (ie c. 2ha). Birds were identified visually and acoustically. Birds were also noted outside the transect but were not counted.

Total sampling effort across the 10 sites was: 600 pitfall trapnights, 210 funnel trapnights and 60 bird census events.

Table 2. Systematic sampling transect locations, descriptions and trapping effort in the October 2019 field survey.

Site	Trap transect end coordinates		Description	Sampling effort
Site 1	Pit 1	51 J 248634, 7033075	Tall Mulga over scattered shrubs and sparse spinifex on loam flat. (VSA4)	60 pitfall nights. 30 funnel nights. 6 X bird census
	Pit 10	51 J 248600, 7032859		
Site 2	Pit 1	51 J 247657, 7031836	Very open Mallee and scattered tall shrubs on gypsum/calcrete rise near lake edge. (VSA3)	60 pitfall nights 30 funnel nights. 6 X bird census
	Pit 10	51 J 247818, 7031706		
Site 3	Pit 1	51 J 248157, 7033674	Tall Mulga over scattered shrubs and sparse spinifex on loam flat. (VSA4)	60 pitfall nights 30 funnel nights. 6 X bird census
	Pit 10	51 J 248186, 7033846		
Site 4	Pit 1	51 J 247787, 7032286	Tall Mulga over scattered shrubs and moderately dense spinifex on sandy loam rise on edge of lake. (VSA4)	60 pitfall nights 30 funnel nights. 6 X bird census
	Pit 10	51 J 247768, 7032071		
Site 5	Pit 1	51 J 251008, 7032514	Scattered low Mallee with moderately dense acacia shrubland over spinifex on sandy loam plain. (VSA5)	60 pitfall nights 25 funnel nights. 6 X bird census
	Pit 10	51 J 251072, 7032335		
Site 6	Pit 1	51 J 256172, 7021104	Scattered tall shrubs including a large melaleuca on gypsum /calcrete rise on lake edge in south. (VSA3)	60 pitfall nights 30 funnel nights. 6 X bird census
	Pit 10	51 J 256238, 7020837		
Site 7	Pit 1	51 J 257294, 7022917	Tall Mulga over low and quite uniform spinifex on sandy loam flat. (VSA4)	60 pitfall nights 25 funnel nights. 6 X bird census
	Pit 10	51 J 257156, 7023091		
Site 8	Pit 1	51 J 254693, 7027777	Scattered low Mallee with moderately dense acacia shrubland over spinifex on sandy loam plain. (VSA5)	60 pitfall nights 0 funnel nights. 6 X bird census
	Pit 10	51 J 254791, 7027577		
Site 9	Pit 1	51 J 245960, 7039121	Open shrubland and spinifex on sandy dune ridge. (VSA6)	60 pitfall nights 10 funnel nights. 6 X bird census
	Pit 10	51 J 246065, 7039096		
Site 10	Pit 1	51 J 242328, 7044030	Open shrubland and spinifex on sandy dune ridge. (VSA6).	60 pitfall nights 0 funnel nights. 6 X bird census
	Pit 10	51 J 242340, 7043847		

2.3.5 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 Greater Bilby, Brush-tailed Mulgara, Marsupial Mole and Malleefowl. Searching for these species was undertaken in the October 2019 field survey.

The Bilby, Mulgara and Malleefowl were searched for using a walked transect approach, looking for burrows, tracks, scats, foraging holes and mounds. The walked transect approach involves personnel walking line abreast at a spacing appropriate for the vegetation density and area to be covered (usually 20-50m), and this method was deployed at three areas east of Lake Way in spinifex on sandplain that was suitable habitat for Mulgara and Bilby (and possibly Malleefowl), and in the proposed processing plant area (possibly suitable for Malleefowl). The searched areas are indicated on Figure 3; the total area searched was c. 150ha. Some of the search areas appear as hollow rectangles as the transect followed a rectangular pattern with the sides of the rectangle well-separated. Personnel who walked these areas were all experienced in recognising signs of the target species, or were close to someone with appropriate experience and had been shown photographs of signs. Locations of signs such as Mulgara burrows were recorded, and these burrows were categorised as active (clear evidence of recent movement, tracks, and/or scats at entrance) or inactive (no signs of activity, weathered but still distinct). Opportunistic observations on other fauna were made during these walked transects.

The sandy ridges east of Lake Way appeared suitable for the Marsupial Mole (*Notoryctes* sp.) although the species was not returned from the database search. Therefore, two 'mole trenches' were dug near site 9; these were located at (51J) 245603mE, 7039148mN and 245620mE, 7039181mN. They were on the upper to middle slope of a large dune, where marsupial moles are commonly active. Mole trenches are 1.5 to 2m long, a metre deep and can be dug to expose old and recent burrows of marsupial moles due to the difference in soil density created by the passage of the animal. The two trenches were dug on 7th October and checked on 10th October.

Note that no surveys of significant waterbird species could be undertaken as Lake Way was dry in October 2019.

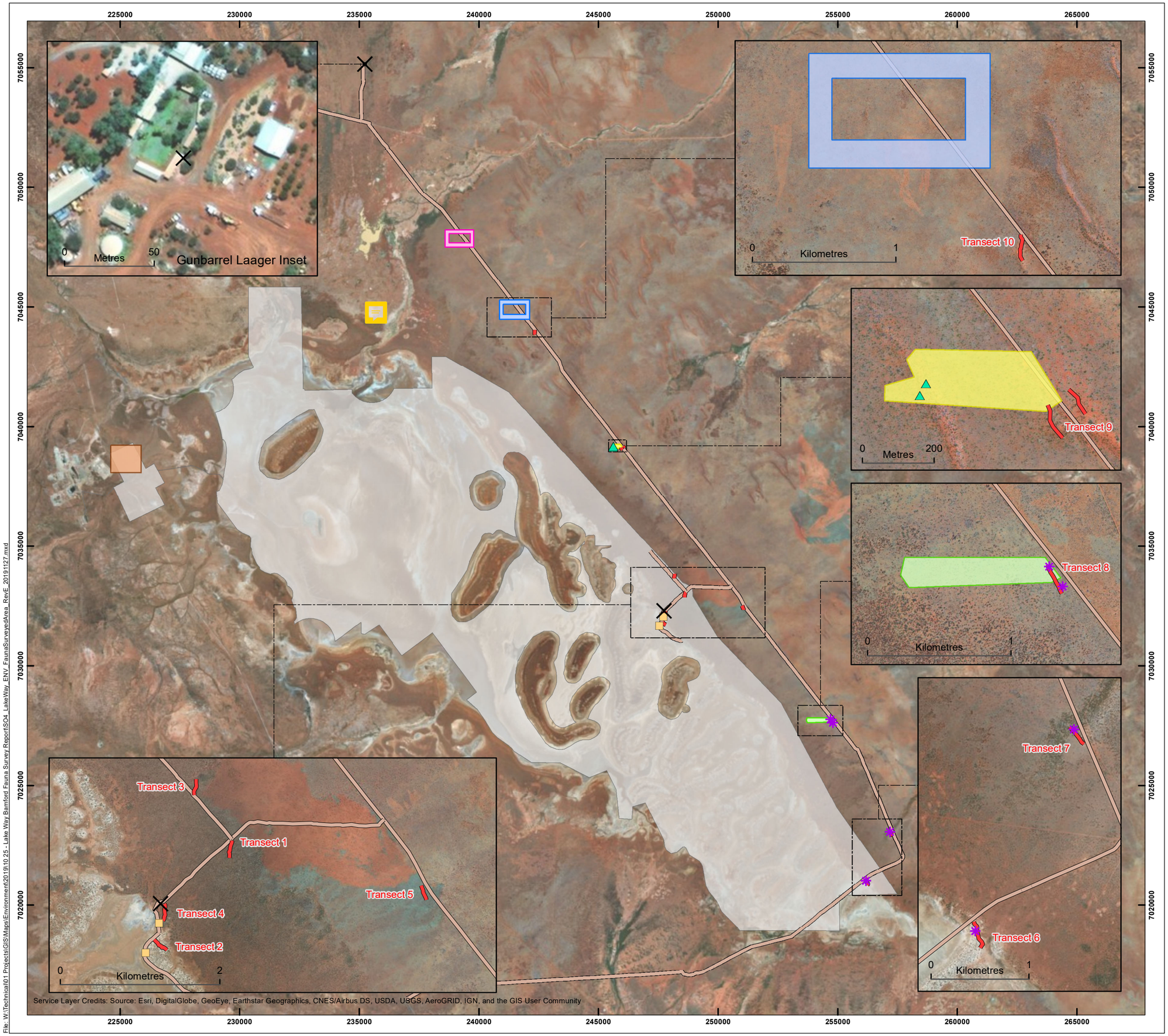
2.3.6 Motion-sensitive cameras and recording devices

Locations of motion-sensitive cameras, bat echolocation recorders and audio-recorders are given in Table 3 and indicated on Figure 3. Cameras BCE10 and BCE04 were set at sites 6 and 7 respectively, and were baited (universal bait encased in a perforated plastic tube) in order to lure fauna into view. Cameras BCE02 and BCE17 were set on active Mulgara burrows at site 8 and were not baited. The two audiomoths were set on the edge of Lake Way near a large expanse of salt marsh shrubland and were intended to target the Night Parrot. The bat detector was set in a grove of tall Mulga also close to the edge of Lake Way and the target species was the Inland Greater Long-eared Bat. The audiomoths and bat detector were

set for four nights, while the cameras were set for five nights. A bat detector was also set for one night (6th October) at the Gunbarrel Laager north of the project area.

Table 3. Locations of cameras and recording devices.

Device and unit code	Easting	Northing	Sampling period
Audio recorder (Audiomoth 05)	247551	7031666	7th to 11th October
Audio recorder (Audiomoth 06)	247718.4	7032039	7th to 11th October
Bat Detector 01	247738.6	7032286	7th to 11th October
Reconyx camera (BCE10)	256188.1	7021006	6th to 11th October
Reconyx camera (BCE04)	257193.7	7023062	6th to 11th October
Reconyx camera (BCE02)	254703	7027765	6th to 11th October
Reconyx camera (BCE17)	254797.7	7027625	6th to 11th October



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GDA 1994 MGA Zone 51

Lake Way

Figure 3
Location of fauna sampling sites
for the expansion project

Legend

- Audiomoth (recording unit)
- Bat Detector
- Mole Trench
- Motion-sensitive Camera
- Track
- Pitfall Transect
- Mulagra Transects Area 1
- Mulagra Transects Area 2
- Mulagra Transects Area 3
- Mulagra Transects Area 4
- Fauna Transect

Development Envelope

- Development Envelope

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Author: J. Payne

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	years. Previous experience includes studies on relevant conservation significant species: Mulgara, Bilby, Malleefowl, marsupial mole 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 providing an overview of fauna values of the project area. Waterbirds could not be sampled due to dry conditions
Proportion of fauna identified, recorded and/or collected.	All vertebrate fauna species encountered were identified with the exception of one skink species; a specimen has been lodged with the WA Museum. Several species of scorpions, slaters and mygalomorph spiders were collected and taken to specialists for identification. Rainfall over the preceding two years had been very poor, and as a result many fauna species were at low levels of abundance (and thus may have been undetectable) or may have been absent. This did not significantly affect results and species expected but not detected are all common in the greater region, or landscape interpretation provided an effective approach to the assessment.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	Abundant information from databases and previous studies (see Section 2.2.1).
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 Way may be required after a period of heavy rain.
Timing/weather/season/ cycle.	Survey was conducted in October 2019. This is a suitable time for Level 2 surveys in the Murchison.
Disturbances (e.g. fire, flood, accidental human intervention etc.) that affected results of survey.	No disturbance as such, but some areas badly degraded by livestock (Cattle) which is likely to have affected the fauna assemblage
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. Across the January/February and October field trips, Lake Way and surrounding areas were visited throughout where access was possible and permitted.

Completeness (e.g. was relevant area fully surveyed).	Site was 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 some limitations to access around the lake for cultural reasons which limited the extent of survey effort, but this is considered unlikely to have materially affected survey results.
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 DotEE (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:

Fauna values

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

- 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 information the site inspection, including actual records and landscape interpretation;
- 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, with an emphasis on landscape interpretation;
- 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.

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.

The Lake Way project can be considered a large proposed development as it spans much of Lake Way; over 40km north-south. 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 5. Assessment criteria for impacts upon fauna. The 'immediate area' is within approximately a 15km radius of the centrepoint of the project area.

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% but <50% within the immediate area. No change in viability or conservation status of taxon.
Critical	Taxon decline >50% (including local 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)

These vary with distance from lake, and there are distinct differences in substrate type. The most distinctive and limited in distribution is associated with gypsum/calcrete soils close to the lake and across some islands within the lake. Main VSAs are illustrated on Plates 1 to 9, and mapped on Figure 4. Note that mapping of VSA3 is incomplete due to restricted access to these areas by the botanists.

1. Open playa of Lake Way (plate 1). Bare ground that floods intermittently after major rainfall events. This lies mainly in the north of Lake Way and thus in the demonstration project area rather than in the 200 ktpa expansion area. Vegetation type Playa.
2. Salt marsh of Lake Way (plate 2). Chenopod shrublands on margins of Lake Way that flood after major rainfall events. These are extensive between the islands in the 200 ktpa expansion area. Vegetation types Tect, F, I, N, R, X and BA.
3. Very open Mallee and scattered tall shrubs on gypsum/calcrete rises forming a narrow and incomplete band around the lake, and also on islands in the lake (plate 3). Well-developed in the 200 ktpa expansion area. Sometimes large melaleuca on margin nearest lake. Vegetation types E and J.
4. Mulga over scattered shrubs and generally scattered spinifex on loam to loamy-sand flats (plates 4, 5 and 6). Quite variable in density of Mulga, shrubs and spinifex. Soils sandier close to lake. Generally forms a broad and variable band of vegetation east of the lake. Also present in West Creek borefield area and generally north of Lake Way. This VSA encompasses drainage lines. Vegetation types AC, Z and D.
5. Scattered low Mallee with moderately dense Acacia shrubland over spinifex on sandy loam plain (plate 7). Very extensive away from lake to east. Vegetation types O and L.
6. Open shrubland and spinifex on sandy dune ridge (plate 8). There are a few such dunes east of Lake Way. Vegetation type Q.
7. Very open Acacia shrubland with occasional thickets over sparse grasses and herbs on gravelly rises (plate 9). Generally west of Lake Way such as in the proposed accommodation area, and along part of the pipeline route from the West Creek borefield. Vegetation types AB, H and Y.

Plate 1. VSA 1. Lake Way playa (north-east of the lake).

Plate 2. VSA2. Sparse salt marsh shrubland in south of Lake Way.

Plate 3. VSA3. Scattered tall shrubs on gypsum/calcrete on margin of Lake Way (Site 3).

Plate 4. VSA4. Mulga over scattered spinifex on loam flat (Site 7).

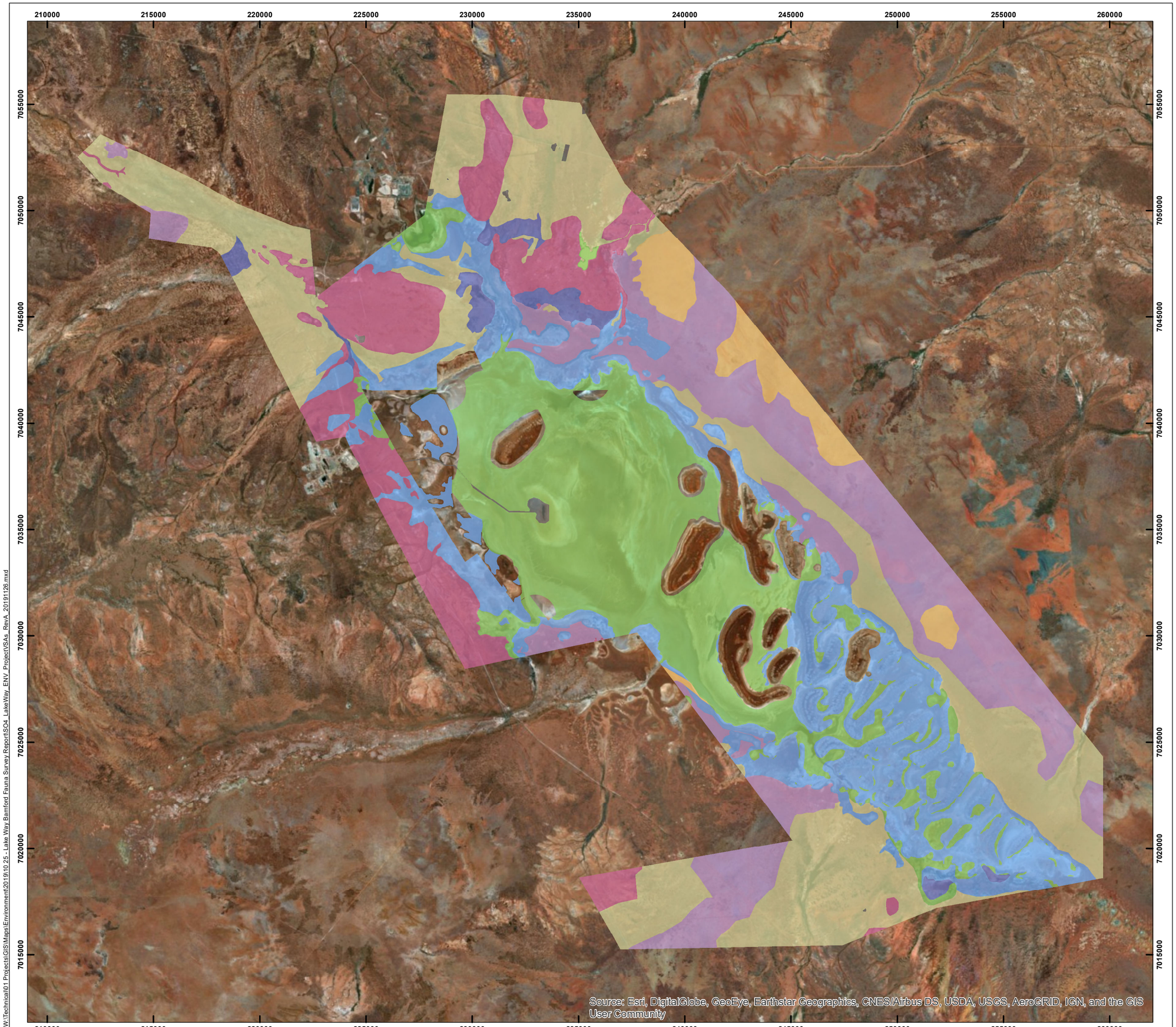
Plate 5. VSA4. Mulga on slightly gravelly loam flat north of Lake Way (pipeline corridor area).

Plate 6. VSA4. Mulga on loam flat in West Creek borefield area.

Plate 7. VSA5. Scattered Mallee and acacia over spinifex hummock grassland on sand to sandy loam flat (Site 8).

Plate 8. VSA6. Shrubs over spinifex on sand ridge (site 10).

Plate 9. VSA7. Sparse shrubland of acacia with scattered grasses on gravelly rise (accommodation area).



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GDA 1994 MGA Zone 51

Lake Way

Figure 4
Distribution of Vegetation and Substrate Association (VSAs) in the project area

Legend

Vegetation Substrate Associations

- Cleared Vegetation
- 1
- 2
- 3
- 4
- 5
- 6
- 7

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3.2 Fauna

3.2.1 Overview of fauna assemblage

The desktop study identified 286 vertebrate fauna species as potentially occurring in the project area (Table 6 and Appendix 5): 8 frogs, 79 reptiles, 161 birds and 28 native (plus 10 introduced) mammals. The assemblage includes 23 species of conservation significance (Section 3.3.2). Far fewer species were confirmed to be present: 1 frog, 28 reptiles, 55 birds, and 13 native and 5 introduced mammals. Results of field investigations are presented below. The 'expected' assemblage is generous as it comes from database records collected over a large area and includes species that may occur occasionally in the project area, but for which it is not important (such as birds that rarely fly overhead), or which are associated with environments not present in the project area (such as rocky landscapes). In addition, dry conditions in the region mean that many species (e.g. waterbirds and irruptive species) were absent at the time of the surveys. Species considered to be extinct in the survey area are included in Appendix 5 but are not expected to be present.

Frogs. Up to 8 species may be present in the area and only one species (the Inland Tree-Frog) was confirmed, but that was found only at the Gunbarrel Laager accommodation near Wiluna. All species except this tree-frog are expected to be resident, with the tree-frog possibly restricted to anthropogenic environments where water is regularly available. The other seven species are adapted to very arid environments and may be active only after rain, at other times sheltering by burrowing deeply into soil. They all have aquatic larvae that rely on freshwater, so temporary bodies of freshwater that form along West Creek and around the margins of Lake Way are likely to be important for breeding. All the frog species are widespread in the semi-arid to arid landscapes of the Eastern Murchison and adjacent subregions, and none is of conservation significance.

Reptiles. Up to 78 species (27 confirmed present) are known from the general area and all are assumed to be resident (Table 6), although reptile distributions can be patchy with differences in vegetation and substrate types and therefore not all 78 species may be present in the project area, but the combination of sandy soils, gypsum soils and slightly rocky landscapes is unusual in the region and would contribute to high reptile richness. It would take massive sampling effort over several years to confirm the entire assemblage, and this could not be justified since most species are widespread. There are likely to be different reptile assemblages in different VSAs and the sampling conducted in October 2019 provides a very preliminary investigations of these patterns (see below). For example, there are likely to be quite distinctive and different assemblages in the gypsum soils compared with the sand ridges. One species is semi-aquatic (the Flat-shelled Tortoise) and may occur along West Creek, while the Salt Lake Dragon (confirmed present) occurs in chenopod shrublands around salt lakes throughout the region. Almost all the reptile species are widespread in the semi-arid to arid landscapes of the Eastern Murchison and adjacent subregions, but two species, the Barking Gecko (with a largely southern distribution) and *Lerista* 'Lake Way' (with a possibly very restricted distribution) are considered of CS3. No reptile species are listed under legislation (CS1) or are considered of conservation

priority (CS2). The Barking Gecko and *Lerista* 'Lake Way' are discussed further below (Section 3.2.2).

Birds. Up to 161 species may be present, of which 55 were confirmed during field investigations. The number of species recorded was low due to annual conditions, with some birds expected to be resident simply not observed, possibly because population densities have declined, and species expected as visitors being absent. Numbers of species expected to be resident, regular visitor or irregular visitors are similar (56, 45 and 41 respectively), with predictably a high proportion of resident species recorded (Table 6). The bird assemblage is clearly divided into landbirds (118 species) and waterbirds (43 species), which are listed separately in Appendix 5. Waterbirds are mostly irregular visitors reliant upon water being present in Lake Way, with only five species observed around pools in the north of the lake in January/February 2019. Despite this, waterbird breeding has been recorded on Lake Way and the lake may occasionally be important for such breeding events (Bamford and Bancroft 2004). Waterbirds are further discussed under the significant species section below. Almost all the bird species are widespread in the semi-arid to arid landscapes of the Eastern Murchison and adjacent subregions, with 17 considered to be of conservation significance which are further discussed below (Section 3.2.2).

Mammals. The mammal assemblage is depauperate with several locally extinct species including the Chuditch, Boodie (Burrowing Bettong) and several bandicoot species (Appendix 5). Twenty-eight native mammals and 10 introduced mammal species may occur in the survey area, but only 13 native species (and five introduced species) were confirmed during the field investigation. The native species were mostly bats and it appeared that the terrestrial mammal fauna, and in particular small species, was poor. This is likely to be the result of seasonal conditions being extremely dry, as the populations of many terrestrial mammals decline in poor periods. As with other fauna groups, the mammal assemblage is widespread in the semi-arid to arid landscapes of the Eastern Murchison and adjacent subregions, but of interest was the presence of two species of ningaui, one close to the southern extent of its range (*Ningaui ridei*) and the other at the extreme north of its range (*Ningaui yvonnae*). This may be a reflection of the sandy soils east of Lake Way, which are also responsible for the abundance of the Brush-tailed Mulgara (a priority (CS2) species). Only three (possibly four) mammals of conservation significance are expected to be present and are discussed below (Section 3.2.2).

Invertebrates. Invertebrates were investigated separately, but two mygalomorph (trapdoor) spiders, two isopods (slaters) and several scorpions were opportunistically collected during vertebrate sampling. The trapdoor spiders were *Aname* HB1 – 5385 and a second species of *Aname* that could not be identified as the specimens were immature (V. Framenau pers. comm.). The slaters were *Buddelundia* 55 and *Buddelundia labiata* (S. Judd pers. comm.). The scorpions have not yet been identified.

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

- Uniqueness: The assemblage is likely to be typical of a very broad region of the Eastern Murchison and adjacent subregions, although the juxtaposition of VSAs and particularly the presence of sandy soils, gypsum soils and Lake Way itself may give an unusual combination of species for a small area. Among the reptiles there are sandy soil and possibly gypsum soil specialists, among the mammals the presence and abundance of the Brush-tailed Mulgara relates to the presence of sandy soils, and the assemblage includes waterbirds that would be present on Lake Way during flood events.
- 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 Way, and many of the land birds that are irruptive in arid landscapes), 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 and the presence of Lake Way.

Table 6. Composition of vertebrate fauna assemblage in the project area; number of species confirmed in parenthesis. Locally extinct species are not included as expected.

Taxon	Number of species expected	Number of species in each status category				
		Resident	Regular visitor or migrant	Irregular visitor	Vagrant	Locally extinct
Frogs	8 (1)	7	-	1 (1)	-	-
Reptiles	79 (28)	79 (28)	-	-	-	-
Birds	161 (55)	56 (36)	45 (17)	41 (2)	19	-
Native mammals	28 (13)	27 (13)	1	-	-	8
Introduced mammals	10 (5)	6 (4)	1 (1)	1	2	-
Total	**286 (102)**	**175 (81)**	**47 (18)**	**42 (3)**	**19**	**8**

3.2.2 Fauna of conservation significance

Twenty-three vertebrate species of conservation significance may occur in the survey area, with the majority of these being wetland birds classed as CS1 (Tables 7 and 8, and Appendix 5). An additional species, the Greater Bilby, was not confirmed but is known

from nearby (see discussion on species below) and suitable habitat is present, so it is included in discussion below.

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 9. Species or groups of species are discussed below.

Table 7. Composition of extant conservation significant fauna within the survey area with confirmed presence in brackets.

Taxon	**Conservation Significant fauna**			**Total**
	CS1	**CS2**	**CS3**	
Frogs	-	-	-	-
Reptiles	-	-	2 (2)	2 (2)
Birds	12		6 (1)	18 (1)
Native Mammals	1?	2 (2)	1 (1)	3 (3)
Total	**12**	**2 (2)**	**9 (4)**	**23 (6)**

Table 8. Conservation significant species expected to occur in the survey area. Species recorded are indicated.

Species	Common Name	Conservation significance	Recorded	Predicted status
Reptiles				
Underwoodisaurus milii	Barking Gecko	CS3	X	Resident
Lerista 'Lake Way'		CS3	X	Resident
Birds				
Leipoa ocellata	Malleefowl	CS1 (V,S3[v])		Irregular, non-breeding Visitor
Falco hypoleucos	Grey Falcon	CS1 (S3[v])		Vagrant
Falco peregrinus	Peregrine Falcon	CS1 (S7)		Regular Visitor
Ardeotis australis	Australian Bustard	CS3	X	Regular visitor

Up to 11 migratory waterbird species	See Appendix 5.	CS1 (M)		Regular/Irregular Visitors, Vagrants
Burhinus grallarius	Bush Stone-curlew	CS3		Irregular Visitor
Cladorhynchus leucocephalus	Banded Stilt	CS3		Irregular visitor
Polytelis anthopeplus	Regent Parrot	CS3		Vagrant
Polytelis alexandrae	Princess Parrot	CS1 (V,P4)		Vagrant
Pezoporus occidentalis	Night Parrot	CS1 E,S1 [ce]		Vagrant
Apus pacificus	Fork-tailed Swift	CS1 (M)		Irregular Visitor
Acanthiza iredalei iredalei	Slender-billed Thornbill (Western)	CS3		Regular Visitor
Stipiturus ruficeps	Rufous-crowned Emu wren	CS3		Irregular visitor
Mammals				
Dasycercus blythi	Brush-tailed Mulgara	CS2 (P4)	X	Resident
Ningaui yvonnae	Mallee Ningaui	CS3	X	Resident
Macrotis lagotis	Greater Bilby	CS1 (S3, v)		Locally extinct but population nearby
Nyctophilus major tor	Central Long-eared Bat	CS2 (P3)	X	Resident

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

Twelve birds and possibly one mammal of conservation significance level 1 may be present.

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. At Yeelirrie Station to the west, 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, notably the gravelly soils to the west of Lake Way, although they will also construct mounds in sandy soils if vegetation is sufficiently dense. No active or even recently-active mound were found, however, one very long unused (centuries since last use?) mound was found in the accommodation area. 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

Blakers *et al*. (1984) consider that Australia is one of the strongholds of the Peregrine Falcon, 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 on Yeelirrie Station to the south-west (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 11 species

This group includes several shorebird (plovers and sandpipers), the Glossy Ibis and the Gull-billed Tern. These are known to occur locally and regionally over a wide variety of wetland environments and all those listed in Appendix 5 potentially occur on Lake Way as regular visitors, irregular visitors or vagrants. 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. Note that all these migratory waterbird species are non-breeding visitors with the exception of the Gull-billed Tern, which is reported to have bred on Lake Way in the summer of 1988/1989 when the lake was in flood (Bancroft and Bamford 2004). The birds were utilising raised earthern bunds on the lake that had been created during mining in the area.

Princess Parrot

The Princess Parrot species 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. 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). A specimen was collected in 1964 from Wanjarri Nature Reserve (DBCA 2018), however few other records exists for the region. The species is likely to be a vagrant to the project area and there is virtually no potential breeding habitat (the Princess Parrot nests in tree hollows, often in large trees along watercourses).

Night Parrot

There is a known population of the Night Parrot in the Wiluna area, approximately 85km north-east of Lake Way (near Matuwa (formerly Lorna Glen Station); see Hamilton *et al.* 2017). What little is known about the Night Parrot, particularly the Western Australian population/s, suggests that it has a preference for long-unburnt spinifex grassland, chenopod shrublands and the ecotone between these two vegetation types. It may forage in areas rich in grasses and herbs. The species may utilise the chenopod shrublands on the lake edge, though no areas of mature spinifex grassland were recorded during the site visits. The species was surveyed for by Botanica Consulting using autonomous recording units placed close to chenopod shrublands and where spinifex was present on adjacent uplands. The species was not recorded. Two recording units set during the October field investigations also failed to detect the species. Despite this, the Night Parrot may potentially occur as a vagrant in the survey area given the nearby records and some suitable habitat.

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.

Greater Bilby

A translocated population of the Bilby is thriving on Matuwa (formerly Lorna Glen Station) where feral predators are controlled, and a burrow similar in structure to a Bilby burrow was found along the track east of Lake Way in October 2019 (Plate 10). However, intensive searching in the region of this burrow failed to locate any further evidence, so if the burrow was dug by a Bilby the animal had moved on. With the presence of Bilbies nearby (<100km to the north), suitable habitat in the form of spinifex on sandplain, and assuming ongoing feral predator control, it is possible that Bilbies will occur in the project area in the future.

Plate 10. A possible disused Bilby burrow east of Lake Way. A Bilby burrow is usually higher than it is wide, but this burrow appears to be partly filled-in.

Conservation Significance Level 2

Two mammals are listed as conservation significance level 2.

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 appeared to be moderately common in the spinifex sandplain areas east of Lake Way. During walked transects, evidence of Mulgara was found regularly (Appendix 8), with dozens of active burrows, more inactive burrows and occasional scats, tracks and foraging holes. Motion sensitive cameras set on active burrows (Plate 11) failed to record animals, perhaps due to the presence of people and equipment, although this has not been found to be a problem previously.

Plate 11. A motion-sensitive camera set on an active Mulgara burrow at site 8.

Central Long-eared Bat

The distribution of 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 to the south-west (Bamford *et al.* 2011). The echo-locations calls of this species are very hard to distinguish from those of a related (common) species, but Shepherd (Appendix 6, this report) concluded that the Central Long-eared Bat was detected at the recording unit near the edge of Lake Way (Figure 3). This was an area of tall Mulga and the bats probably favour such areas where suitable tree hollows provide shelter. It was also close to an area of scattered Mallee on gypsum soil, and these Mallee may also provide roosting hollows.

Conservation Significance Level 3

Two reptile, nine birds and one mammal are listed as conservation significance level 3.

Barking Gecko

The Barking Gecko is a largely southerly species but with scattered populations around salt lakes through the East Murchison subregion. In this area, they appear to be associated with shrublands on gypsum soils (M. Bamford pers obs.). Two animals were caught during sampling in October 2019 (Sites 1 and 6) and the population around Lake Way is probably a northern outlier for the species. This makes it locally significant.

***Lerista* 'Lake Way'**

This small lizard (Plate 11) could not be identified using available information and identification guides, and a specimen has therefore been lodged with the WA Museum. DNA has been sent to a specialist to determine if it is an aberrant individual of a known species, or currently an unrecognised species. Distinctive features are a large head in proportion to the body, two fingers/three toes, lines on the flank but two lines of dots on the back, and a red tail. The specimen came from Site 3 on gypsum soil, and was from leaflitter around a Mallee. It is possibly a gypsum soil specialist around Lake Way (and other lakes in the region?).

Plate 11. *Lerista* 'Lake Way'.

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 formerly 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). Tracks were found during the walked transects and the remains of a bird were found under powerlines in the West Creek borefield area, possibly a bird killed by striking the wires.

Bush Stone-curlew

The ground-dwelling Bush Stone-curlew inhabits lightly timbered open woodlands and dense Acacia shrublands, often along drainage lines (J. Turpin, 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 at least an irregular visitor to the project area, but was not detected in the 2019 surveys.

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 southern 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 project 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 thus likely to be only a vagrant to the project area.

Banded Stilt

This species breeds intermittently but in large numbers on inland salt lakes, generally in response to major flood events. Breeding has not been documented on Lake Way, but it has been recorded on lakes to the north-east and south-east (Marchant and Higgins 1993). Lake Way has the sort of characteristics that make it a potential breeding site. Because the Banded Stilt breeds infrequently and often in few, large colonies, single breeding events can be very important for the species.

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 species. 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 salt marsh vegetation is broadly suitable for the species, although much of it is very low and the thornbill usually favours patches of tall samphire. Although not observed, access to the vegetation across Lake Way was limited on cultural grounds and it has to be assumed to be a resident.

Rufous-crowned Emu wren

The Rufous-crowned Emu-wren has a fragmented population in northern and central Australia and is generally uncommon. It is associated with tall, dense spinifex and long-unburnt mature hummock grasslands, whereas all the spinifex in the project area was recently burnt (probably within the last 10-15 years). It is possible that the species is locally extinct due to inappropriate fire regimes, but it may still be present in the region so is

assumed to be an irregular visitor to the project area. With an altered fire regime, it could increase in abundance.

Mallee Ningaui

This is generally a species of spinifex on sandplain through the Goldfields and it was not returned from databases for the Lake Way area, but one of three ningaui specimens caught in the October survey was identified as the Mallee Ningaui on the basis of a very short inner hind toe and lack of guard hairs (a long inner toe and presence of guard hairs are features of the Wongai Ningaui that was also recorded and is already known from the area). The Mallee Ningaui on the sandy soils at Lake Way can therefore be considered to be an isolated and locally significant population.

Invertebrates

Of the invertebrates collected, the species of trapdoor spider that could not be identified (*Aname* sp.) was considered to be a possible short range endemic (V. Framenau pers. comm.), which would make it locally significant. The record of the slater *Buddelundia* 55 represented the second known location for the species, with all previous records from one area about 60km north of Lake Way (S. Judd unpubl. data). This could be considered a possible short range endemic if it is confined to the Lake Way area and one other location.

3.2.3 Patterns of biodiversity

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 patterns of soils and vegetation (VSAs) across the landscape, and from sampling results. Some patterns of biodiversity between sites and VSAs can be interpreted from capture data for reptile and mammal trapping, bird censussing and opportunistic observations. Table 9 provides a summary of capture data for each systematic sampling transect, while Table 10 presents the results of bird censussing along the transects. The fauna assemblage and associated VSAs are discussed below.

Trapping resulted in the capture of 118 individuals of 29 species: 26 reptiles and three mammals. These are low numbers of captures for the sampling effort, and it was further noted that many of the lizards were in poor condition, with little fat on their tails and often pelvic bones protruding prominently under the skin. Very few clear trends are apparent, but VSA 3 (gypsum soils near Lake Way) had few species and captures, except for many individuals of the widespread gecko *Gehyra variegata* at just site 2, at least some of the sites in VSA 4 (Mulga on loamy-sand) were rich in species and individuals, notably site 4 that was sandier than other VSA 2 sites, and VSA 6 (sand ridges) was low in species but high in numbers of captures due to the abundance of *Lerista bipes,* which was noticeable abundant in this VSA. The two ningaui species were both caught in VSA 4, but *N. yvonnae* was caught at site 1 which was sandy and close to Lake Way, while *N. ridei* was caught only at site 7 (3 individuals) where the soil was a heavy loamy-sand with fairly uniform but low spinifex. Numbers of mammal individuals and species caught was low.

Table 9. Trapping results with sampling sites grouped by VSA type.

Species	VSA 3		VSA 4				VSA5		VSA 6	
	2	6	1	3	4	7	5	8	9	10
Ctenophorus isolepis			2	2				2	1	
Ctenophorus nuchalis						1				
Moloch horridus										1
Pogona minor			1		1					
Diplodactylus granariensis					1					
Rhynchoedura ornata		1	4	1			1		1	
Underwoodisaurus milii		1		1						
Gehyra variegata	6	1	1		1		2	1		
Heteronotia binoei						2	1	1		
Ctenotus dux										1
Ctenotus helenae					2					
Ctenotus leonhardii			1		1	1				
Ctenotus piankai							1			
Ctenotus quattuordecimlineatus										1
Ctenotus schomburgkii				2	1					
Eremiascincus richardsonii		1								
Lerista bipes	4	1			1		2		10	15
Lerista kingi					2		3			
Lerista timida	1				1					
*Lerista sp. '*Lake Way'	1									
Liopholis inornata			2	1						2
Menetia greyii							1		1	
Varanus brevicauda								1	1	
Varanus eremius							1			
Anilios hamatus			1							
Simoselaps bertholdi					1					
Tachyglossus aculeatus								1		
Ningaui ridei						3				
Ningaui yvonnae			1							
N species	4	5	8	5	10	4	8	5	5	5
N captures	12	5	13	7	12	7	12	6	14	20

Bird censussing results were poor (Table 10), again reflecting poor conditions. Despite this, it was apparent that birds were more numerous in the Mulga areas (VSA 4), and that the spinifex on sandplain was particularly poor in birds. This also, however, may be a seasonal and annual effect, as shrubs in the sandplain areas were not flowering, but would be rich sources of nectar when flowering does occur.

Table 10. Bird census results from systematic sampling transects

Species	VSA 3		VSA 4				VSA5		VSA 6	
	2	6	1	3	4	7	5	8	9	10
Australian Ringneck	1									
Rainbow Bee-eater			4	2						
Chestnut-rumped Thornbill				6		1				
Redthroat				3						
Yellow-throated Miner	2	1			3					
Singing Honeyeater		4	2		1	2				1
Rufous Whistler		1				1	1			
Varied Sittella			1							
White-backed Swallow		1								
Australasian Pipit									1	
N species	2	4	3	3	2	3	1	-	1	1
N observations	3	7	7	11	4	4		-	1	1

Opportunistic observations and results of night surveys served to confirm species not detected in systematic methods, which was especially important for birds, but contribute little to an understanding of patterns of biodiversity. The Salt Lake Dragon was recorded twice on the margins of the chenopod shrublands, as would be expected. A large proportion of bird species were recorded only at the accommodation (Gunbarrel Laager; see Figure 3), where water was available, and it was also noted that one species of bat was very abundant at that location. The annotated species list (Appendix 7) summarises opportunistic observations.

Although patterns of biodiversity were poorly documented by sampling and no strong patterns are apparent, a few general trends can be identified:

- The gypsum soils (VSA 3) may have some restricted range reptile species;
- Sand ridges (VSA 6) support high levels of reptile abundance;
- Areas within VSA 4 where the soil is sandy may be richer in reptiles than elsewhere;
- VSA 4 in general was more important for birds than other VSAs, but this may be an artefact of the season and extreme annual conditions.
- Sand plains (VSA 5), while generally poor in species supported the Brush-tailed Mulgara.
- Lake Way is likely to be intermittently important for waterbirds.

Note that the above patterns of biodiversity do not address aquatic macroinvertebrates and subterranean invertebrate assemblages that are being investigated and reported on separately.

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 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 these have not been burnt too often. However, the apparent absence of the Rufous-crowned Emu-wren and possibly also the Night Parrot may be an artefact of too-frequent spinifex fires. This could also have contributed to low numbers of reptile and small mammal captures.

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 and Boodie (Burbidge and McKenzie 1989). The Fox is of greatest concern; Bilbies coexist with feral Cats in the Great Sandy Desert (M. Bamford pers. obs), but feral Cats have been implicated in the failure of attempts to reintroduce the Bilby (Miller *et al*. 2010). The Fox and Cat are both likely to be present in the survey area, although only the Cat was confirmed. 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 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 are resident in the project area and can cause widespread damage to vegetation and habitat. Extensive damage to vegetation from Cattle grazing was also evident.

Local hydrology. Surface and sub-surface hydrology may be complex at the site, particularly close to Lake Way; complex hydrology around salt lake systems is a feature of the Eastern Murchison (Cowan 2001). While clearly important for aquatic macroinvertebrates and subterranean fauna, hydrology may also be important for terrestrial fauna where vegetation such as Mulga, is sensitive to local hydrological patterns. (Kofoed 1998). The reliance of vegetation on the gypsum soils (VSA 3) around the margins of the lake is unknown.

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 soils (VSA 3) and even the Mulga (VSA 4) around Lake Way.

3.2.5 Summary of fauna values

The desktop study identified 286 vertebrate fauna species as potentially occurring in the project area: 8 frogs, 79 reptiles, 161 birds and 38 mammals (28 native and 10 introduced species). The assemblage includes up to 22 species of conservation significance. Field investigations confirmed the presence of 104 vertebrate fauna species including: one frog, 28 reptiles, 55 birds and 18 mammals (13 native and five introduced). Confirmed species included a number of conservation significance, while poor seasonal and annual conditions affected the field results. 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 possibly some birds. The assemblage is likely to be typical of a very broad region of the Eastern Murchison and adjacent subregions, although the juxtaposition of VSAs and particularly the presence of sandy soils, gypsum soils and Lake Way itself may give an unusual combination of species for a small area.

Species of conservation significance.
This list includes up to 22 species. Most notable is the presence of a possibly undescribed lizard (*Lerista* 'Lake Way') in the gypsum soils close to Lake Way (VSA 3), the presence of a moderately dense population of the Brush-tailed Mulgara on sandy soils (VSA 5) east of Lake Way, and the occasional presence of migratory and other waterbirds on Lake Way when conditions are suitable.

Patterns of biodiversity.
These are poorly defined on available information, and no one VSA stands out, but the Mulga areas (VSA 4) were notable at least during the October 2019 investigations.

Significant species are most closely linked to Lake Way itself (waterbirds), the gypsum soils on the margins of the lake (VSA 3, some reptiles) and spinifex sandplain (VSA5; Brush-tailed Mulgara.

Key ecological processes.
Fire, feral species and hydrology are the key ecological processes affecting the fauna assemblage. 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/Wild Dog, 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). The vegetation in the area is affected by feral herbivores, most notable Rabbits and domestic livestock.

Vegetation and Substrate Associations (VSAs)
These provide habitat for fauna and the project area is characterised by a wide range of VSAs across a relatively small area. Key VSAs are:

- Open playa of Lake Way (north). Bare ground that floods intermittently after major rainfall events.
- Salt marsh (chenopod shrublands) of Lake Way. Chenopod shrublands on margins and across much of the south of Lake Way that flood after major rainfall events.
- Very open Mallee and scattered tall shrubs on gypsum/calcrete rises around the south of the lake; also present on islands in the south of the lake.
- Mulga over scattered shrubs and generally scattered spinifex on loam to loamy-sand flats. Forms a broad and variable band of vegetation east and north of the lake. Also present in West Creek borefield area.
- Scattered low Mallee with moderately dense acacia shrubland over spinifex on sandy loam plain. Very extensive away from lake to east.
- Open shrubland and spinifex on sandy dune ridge. East of Lake Way.
- Very open Acacia shrubland with occasional thickets over sparse grasses and herbs on gravelly rises. Generally west of Lake Way including part of the pipeline route from the West Creek borefield.

3.3 Impact Assessment

Impacting processes have to be considered in the context of fauna values and the nature of the proposed development. Much of the proposed development is based on the bed of Lake Way, but there will be roads, some clearing, groundwater abstraction, pipeline installation and some degree of disturbance such as light and noise. Predicted impacts are examined below; impacting processes are outlined in Appendix 2 and definitions of levels of impact significance are given in Table 5. Based on the impact assessment below, mitigation measures are presented in Section 4.

3.4 Impacting processes

Habitat loss leading to population decline.
The proposed development will result in some localised loss of native vegetation but much of the development is on the lake bed. The percentage of the lake bed that will be excavated or otherwise altered as part of the combined demonstration and 200 ktpa expansion projects is 13.4% (2,750 ha of the 20,490.2 ha of Lake Way).

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 significant long-term adverse impacts upon fauna populations in the region. Impact Minor.

Habitat loss leading to population fragmentation.
There may be some risk of habitat fragmentation affecting small, ground-dwelling fauna. This could result from linear infrastructure such as trenches, pipes and roads where they pass through linear VSAs such as VSA 3 (gypsum soils), VSA 4 (Mulga) and VSA 6 (dunes). Some mitigation measures are possible (see below). Impact 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. 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 evaporation ponds (such as 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 predation pressure from Cats and Foxes, and grazing impacts from Rabbits and domestic livestock, but sensitive species have largely been exterminated (although the Mulgara is sometimes considered to be sensitive to feral predators and remain abundant). 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. 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 VSAs may be impacted, resulting in impacts to fauna species. Some vegetation associations are likely to be reliant on surface (sheet-flow) and sub-surface flows that may be altered by clearing, earthworks and drainage management. As a result, habitat degradation may occur beyond the development footprint. Some increased runoff from development can be expected and pipeline trenches can alter surface flow (sheet-flow)upon which sheet-flow vegetation such as 'groved' and banded Mulga relies (Kofoed 1998; Anderson and Hodgkinson 1997). The sensitivity of subterranean assemblages is unknown. Maintaining local hydrological patterns is considered the key to managing impacts upon fauna in the survey area. Impact Minor if risks can be managed.

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. Mulga in particular is sensitive to fire, while biodiversity in grassland environments can be altered by changes in the fire regime. Salt Lake Potash operations can lead to a change in the fire regime due to an increase in the potential for fires as a result of the project. Impact Negligible assuming some management; also some potential for beneficial fire 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 breed on small islands in Lake Miranda. Impact could therefore be considered potentially Minor to Moderate.

Overall, impacts of greatest concern are related to:

- Disruption of patterns of movement of small, terrestrial fauna due to linear infrastructure (trenches, pipelines and roads);
- 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 on-lake and off-lake earthworks, 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
- Ongoing mortality, notably light causing local mortality of invertebrates and increases in abundance of predatory species.

4 Recommendations

Much of the development footprint is confined to Lake Way where a key concern is hydrological change. Much of the fauna assemblage is generally widespread and has lost most significant species, but key features include being occasional use of Lake Way by waterbirds, some unusual reptiles on gypsum soils close to the lake, and a population of the Brush-tailed Mulgara. Subterranean fauna assemblages are also significant but are not considered in this report. Much of the fauna assemblage is generally widely represented. but there remain concerns 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.
- 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 Way flood.
- Check infrastructure where there may be a risk of fauna entrapment or where there is a strike risk (such as overhead powerlines and even mesh fences).
- 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 could 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. Managing hydrological change will require detailed monitoring.
- 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 Way should be monitored if flooding occurs to ensure that if birds are present and breeding, actions required to ensure that disturbance does not occur can be implemented.
- Monitor local groundwater levels.
- The Mulgara population appears to be substantial and may be worth monitoring as an indicator of ecosystem health.

5 References

Anderson, V.J and Hodgkinson, K.C. (1997). Grass-mediated Capture of Resource Flows and the Maintenance of Banded Mulga in a Semi-arid Woodland. *Australian Journal of Botany* **45**, 331-342.

Anstis, M. (2013). Tadpoles and Frogs of Australia. New Holland Publishers, Sydney.

Atlas of Living Australia (2018). Online database resource. http://ala.org.au/species-by-location. (accessed January 2019).

Bamford and Bancroft (2004). Review of the Wetland Avifauna of Lake Way. Unpublished report for Agincourt Resources by Bamford Consulting Ecologists, Kingsley.

Bamford, M., Bancroft, W. and Sibbell, N. (2010). Twenty years and two transects; spatial and temporal variation in local patterns of biodiversity – frogs, reptiles and small mammals. Presentation at 2010 conference of the Ecological Society of Australia, Canberra.

Bamford, M.J. and Roberts, J.D. (2003). The impact of fire upon frogs and reptiles in south-west Western Australia. pp. 349-362 in: Fire in ecosystems of south-west Western Australia. Eds. I. Abbott and N. Burrows. Backhuys Publishers, Leiden.

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 Metcalf, B. (2019). Lake Way Project Demonstration Plant – Salt Lake Potash Ltd. Fauna assessment of proposed project area. Unpubl. report by Bamford Consulting Ecologists, Kingsley.

Barrett, G., Silcocks, A., Barry, S., Cunningham, R. and Poulter, R. (2003). The new atlas of Australian birds. Melbourne: Birds Australia.

Bennelongia Environmental Consultants (2017). Lake Wells Potash Project: Wetland Ecology Baseline Survey. Unpublished report for Australian Potash Ltd.

Benshemesh, J. (2007). National Recovery Plan for Malleefowl. Department for Environment and Heritage, South Australia.

Benshemesh, J., S. Dennings, C. Danzi, and A. Sanders. (2008). Malleefowl searches at Yeelirrie station in arid Western Australia: a valuable collaboration between industry and volunteers. In: Davies S.J.J.F. (ed) Katanning National Malleefowl Forum 2007. School of Environmental Biology Bulletin No.28, Curtin University of Technology, Perth WA.

Birdlife Australia (2018). Birdata Database and Map Tool. http://birdata.birdlife.org.au/ (accessed January 2019).

BirdLife International (2018). Data Zone. http://datazone.birdlife.org (accessed August 2018).

Blakers, M., Davies, S.J.J.F. and Reilly, P.N. (1984). The Atlas of Australian Birds. Royal Australasian Ornithologists Union. Melbourne University Press.

Botanica (2019). Vegetation mapping of the Salt Lake Potash project, Laker Way.

Bradstock, R.A., Williams, R.J., Gill, A.M. (2012). Flammable Australia: fire regimes, biodiversity and ecosystems in a changing world. CSIRO Publishing.

Burbidge, A. A. and McKenzie, N. L. (1989). Patterns in the modern decline of Western Australia's vertebrate fauna: causes and conservation implications. Biological Conservation 50: 143-198.

Calver, M. C., Lymbery, A. J., McComb, J. and Bamford, M. J. (2009). Environmental Biology. Cambridge University Press, Melbourne, Australia.

Churchill, S. (2008). Australian Bats. Reed New Holland Press, Sydney.

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.

Clevenger, A. P. and Waltho, N. (2000). Factors influencing the effectiveness of wildlife underpasses in Banff National Park, Alberta, Canada. *Conservation Biology***14**: 1-11.

Curnutt, J.L., Pimm, S.L. and Maurer, B.A. (1996). Population Variability of Sparrows in Space and Time. *Oikos*. 76(1): 131-144.

DBCA (2019). Priority Ecological Communities for Western Australia Version 28. Species and Communities Programme, Department of Biodiversity, Conservation and Attractions, 17 January 2019.

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.

DotE. (2013). Matters of National Environmental Significance. Significant Impact Guidelines 1.1. Commonwealth of Australia. Department of the Environment. Canberra, Australia.

Dufty, A. C. (1989). Some population characteristics of *Perameles gunnii* in Victoria. *Wildlife Research* **18**: 355-365.

Ecologia (2015). Extension to the Wiluna Uranium Project – Cumulative Impact Assessment. Unpublished report to Toro Energy Ltd.

EPA (2012). Report and Recommendations of the EPA: Wiluna Uranium Project, Toro Energy Ltd. Report 1437.

Environmental Protection Authority (2002). Terrestrial Biological surveys as an Element of Biodiversity Protection. Position Statement No. 3. Environmental Protection Authority, Perth, Western Australia.

Environmental Protection Authority (2004). Guidance for the assessment of environmental factors: Terrestrial fauna surveys for environmental impact assessment in Western Australia. No. 56. Environmental Protection Authority, Perth, Western Australia.

Environmental Protection Authority and Department of Environment and Conservation (2010). Technical Guide - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment. Technical report for the Environmental Protection Authority and the Department of Environment and Conservation.

Environment Australia (2000). Revision of the Interim Biogeographic Regionalisation for Australia (IBRA) and Development of Version 5.1 - Summary Report. Environment Australia, Department of Environment and Heritage, Canberra, Australian Capital Territory.

Focused Vision Consulting (2017). Ecological Monitoring Program, Lake Way L5206/1987/10; Blackhams Resources Ltd. – Matilda Operations Pty Ltd. Unpublished report by Focused Vision Consulting, in conjunction with Bennelongia Environmental Consultants, for Blackhams Resources

Fox, B. J. (1982). Fire and mammalian secondary succession in an Australian coastal heath. *Ecology* **63**: 1332-1341.

Garnett, S. and Crowley, G. (2000). The Action Plan for Australian Birds. Environment Australia and the Royal Australasian Ornithologists Union.

Gill, A. M., Groves, R. H. and Noble, I. R. (Eds). (1981). *Fire and the Australian Biota*. Australian Academy of Science, Canberra, Australian Capital Territory.

Gleeson, J. and Gleeson, D. (2012). Reducing thre Impacts of Development on Wildlife. CSIRO Publishing, Collingwood.

Hamilton, N. A., Onus, M., Withnell, B., and Withnell, K. (2017). Recent sightings of the Night Parrot (*Pezoporus occidentalis*) from Matuwa (Lorna Glen) and Millrose Station in Western Australia. *Australian Field Ornithology* **34**, 71–75.

Harrington, R. (2002). The effects of artificial watering points on the distribution and abundance of avifauna in an arid and semi-arid mallee environment. PhD thesis. Department of Zoology, Univesity of Melbourne, Melbourne, Victoria.

Harvey, M. S. (2002). Short-range endemism among the Australian fauna: some examples from non-marine environments. *Invertebrate Systematics* **16**: 555-570.

How, R.A. and Dell, J. (1990). Vertebrate fauna of Bold Park, Perth. West. Aust. Nat. 18: 122-131.

Jackson, S. D. and Griffin, C. R. (2000). A Strategy for Mitigating Highway Impacts on Wildlife. In: Messmer, T. A. and West, B. (Eds), *Wildlife and Highways: Seeking Solutions to an Ecological and Socio – economic Dilemma,* pp. 143-159. The Wildlife Society.

Johnstone, R.E. and Storr, G.M. (1998). Handbook of Western Australian Birds Vol 1 – Non-passerines (Emu to Dollarbird). Western Australian Museum, Perth.

Johnstone, R.E. and Storr, G.M. (2004). Handbook of Western Australian Birds. Vol 2: Passerines (Blue-winged Pitta to Goldfinch). Western Australian Museum, Perth.

Jones, M. E. (2000). Road upgrade, road mortality and remedial measures: impacts on a population of Eastern Quolls and Tasmanian Devils. *Wildlife Research* **27**: 289-296.

Kofoed, P. (1998). A wizard with wavelengths. *Ecos* **96**: 32-35.

Latz, P.K. (1995). Bushfires and Bushtucker: Aboriginal plant use in Central Australia . Alice Springs, IAD Press.

Letnic, M., Dickman, C.R., Tischler, M.K., Tamayo, B. and Beh, C.L. (2004). The responses of small mammals and lizards to post-fire succession and rainfall in arid Australia. *Journal of arid environments* **59** (1): 85-114

Mace, G. and Stuart, S. (1994). Draft IUCN Red List Categories, Version 2.2. *Species; Newsletter of the Species Survival Commission. IUCN - The World Conservation Union.***21-22**: 13-24.

Menkhorst, P. and Knight, F. (2004). A Field Guide to the Mammals of Australia. Oxford University Press, Melbourne.

Menkhorst, P., Rogers, D., Clarke, R., Davies, J., Marsack, P. and Franklin, K. (2017). The Australian Bird Guide. CSIRO Publishing, Clayton South.

McKenzie, N.L. and Hall, N.J. (eds.) (1992). The biological survey of the eastern Goldfields of Western Australia. Part 8. Kurnalpi-Kalgoorlie Study Area. Records of the Western Australian Museum Supplement No. 41:1-125. Perth, WA.

Miller, E., Dunlop, J. and Morris, K. (2010). Rangelands restoration: fauna recovery at Lorna Glen, Western Australia. Progress report August 2006 to June 2010. Unpubl. Report, WA Department of Environment and Conservation, Woodvale.

Outback Ecology Services (2006). Wiluna Gold. Monitoring of Lake Way during mining operations. Unpublished report to Agincourt Resources.

Outback Ecology Services (2008). Lake Way Baseline Environmental Survey: Salt Lake Ecology. Unpubl. report to Toro Energy Ltd (Nova Energy Ltd).

Outback Ecology Services (2012a). Appendix E: Revision of "Toro Energy Ltd Wiluna Uranium Project Subterranean Fauna Assessment, March 2011". Unpublished report to Toro Energy Ltd.

Outback Ecology Services (2012b). Wiluna Uranium Project Stygofauna May 2012. Memo to Toro Energy Ltd. 7th May 2012.

Read, J.L., Parkhurst, B. and Delean, S. (2015). Can Australian bushbirds be used as Canaries? Detection of pervasive environmental impacts at an arid Australian mine-site. Emu 115 (2): 117-125.

Rich, C. and Longcore, T. (Eds). (2006). *Ecological Consequences of Artificial Night Lighting*. Island Press, Washington D.C., USA.

Scheick, B. K. and Jones, M. D. (1999). Locating wildlife underpasses prior to expansion on Highway 64 in North Carolina. In: Evink, G. L., Garrett, P. and Ziegler, D. (Eds), *Proceedings of the Third International Conference on Wildlife Ecology and Transportation,* pp. 247-252. Florida Department of Transportation, Tallahassee, Florida, USA.

Southgate, R., Paltridge, R., Masters, P. and Carthew, S. (2007). Bilby distribution and fire a test of alternative models of habitat suitability in the Tanami Desert Australia. Ecography 30: 758-776.

Storr, G.M., Smith, L.A. and Johnstone, R.E. (1983). Lizards of Western Australia. II. Dragons and Monitors. W.A. Museum, Perth.

Storr, G.M., Smith, L.A. and Johnstone, R.E. (1990). Lizards of Western Australia. III. Geckoes and Pygopodids. W.A. Museum, Perth.

Storr, G.M., Smith, L.A. and Johnstone, R.E. (1999). Lizards of Western Australia. I. Skinks. Revised Edition. W.A. Museum, Perth.

Storr, G.M., Smith, L.A. and Johnstone, R.E. (2002). Snakes of Western Australia. W.A. Museum, Perth.

Thackway, R. and Cresswell, I.D. (1995). An Interim Biogeographic Regionalisation for Australia: A framework for establishing the national system of reserves, Version 4.0. Australian Nature Conservation Agency, Canberra.

Toro Energy Ltd (2015). Extension to the Wiluna Uranium Project; Assessment No: 2002 (CMS14025): Public Environmental Review.

Toro Energy Ltd. (2015). Wiluna Uranium Project. Extension to the Wiluna Uranium Project. Assessment No. 2002. Public Environmental Review.

Tyler, M.J., Smith, L.A. and Johnstone, R.E. (2000). Frogs of Western Australia. W.A. Museum, Perth.

Van Dyck, S. and Strahan, R. (Eds.) (2008). Mammals of Australia. 3rd Edition. Australian Museum, Sydney.

Wilson, S. and Swan, G. (2013). A Complete Guide to Reptiles of Australia. Fourth edition. New Holland Publishers (Australia), Sydney.

6 Appendices

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

6.2 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.

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.

6.3 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 Department of Biodiversity, Conservation and Attractions; Priority species (species not listed under the *Biodiversity Conservation Act 2016*, but for which there is some concern).

Priority 1 (P1)	Taxa with few, poorly known populations on threatened lands.
Priority 2 (P2)	Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.
Priority 3 (P3)	Taxa with several, poorly known populations, some on conservation lands.
Priority 4. (P4)	Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change.

6.4 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 interaction of ecological processes with 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 and Energy (DoEE 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, 2008):

- 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, DSEWPaC (2013) (now DoEE) 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:

- 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?

6.5 Appendix 5. Vertebrate fauna assemblage of the region

The list is based on upon database and literature searches and the January/February and October 2019 field investigations. Sources of information are:

- ALA: Atlas of Living Australia, searched January 2019;
- N: Naturemap Database, searched January 2019;
- EPBC: EPBC Protected Matters, searched January 2019;
- BA: Birdlife Australia's Birdata database, searched January 2019;
- B&B: Bancroft & Bamford (2004) review of the avifauna of Lake Way; marked (*) are those species recorded from Lake Way itself; some of those were recorded breeding (BR)
- BCE 2019: species observed in the project area (in parenthesis if observed but outside the project area only) in 2019 surveys (January/February and October);

Conservation significance (CS) codes:

- CS1, CS2, CS3 = (summary) levels of conservation significance. See Appendix 4 for full explanation.
- EPBC Act listings: Cr = Critically Endangered, E = Endangered, V = Vulnerable, M = Migratory (see Appendix 3).
- Biodiversity Conservation Act listings: for all CS1 species S1 to 7 = Schedules 1 to 7 respectively, (see Appendix 3).
- DBCA Priority species: P1 to P4 = Priority 1 to 4 (see Appendix 4).

FROGS		**CS**	**ALA**	**N**	**BCE 2019**	**Expected status in area**
HYLIDAE						
Water-holding Frog	*Cyclorana platycephala*		X	X		Resident
Sheep Frog	*Cyclorana maini*			X		Resident
Desert Tree Frog	*Litoria rubella*				(X)	Irregular visitor
LIMNODYNASTIDAE						
Kunapalari Frog	*Neobatrachus kunapalari*		X	X		Resident
Desert Trilling Frog	*Neobatrachus sudellae*		X	X		Resident
Shoemaker Frog	*Neobatrachus sutor*			X		Resident
Plonking Frog	*Neobatrachus wilsmorei*		X	X		Resident
MYOBATRACHIDAE						
Western Toadlet	*Pseudophryne occidentalis*			X		Resident

REPTILES		**CS**	**ALA**	**N**	**BCE 2019**	**Expected status in area**
CHELUIDAE						
Flat-shelled Tortoise	*Chelodina steindachneri*					Resident
AGAMIDAE						
Long-nosed Water Dragon	*Gowidon longistrostris*		X	X		Resident
Military Dragon	*Ctenophorus isolepis*		X	X	X	Resident
Central Netted Dragon	*Ctenophorus nuchalis*			X	X	Resident
Western Netted Dragon	*Ctenophorus reticulatus*			X		Resident

REPTILES		CS	ALA	N	BCE 2019	Expected status in area
Salt Lake Dragon	*Ctenophorus salinarum*		X	X	X	Resident
Lozenge-marked Dragon	*Ctenophorus scutulatus*		X	X		Resident
Mulga Dragon	*Caimanops (Diporiphora) amphiboluroides*					Resident
Thorny Devil	*Moloch horridus*		X	X	X	Resident
Western Bearded Dragon	*Pogona minor*		X	X	X	Resident
Pebble Dragon	*Tympanocryptis cephalus*			X		Resident
DIPLODACTYLIDAE						
Fat-tailed Gecko	*Diplodactylus conspicillatus*		X	X		Resident
Goldfields Stone Gecko	*Diplodactylus granariensis*			X	X	Resident
Western Saddled Ground Gecko	*Diplodactylus pulcher*			X		Resident
	Diplodactylus vittatus		X	X		Resident
	Lucasium damaeum			X		Resident
Mottled Ground Gecko	*Lucasium squarrosum*		X	X		Resident
	Lucasium stenodactylum			X		Resident
Beaked Gecko	*Rhynchoedura ornata*		X	X	X	Resident
Jewelled Gecko	*Strophurus elderi*		X	X		Resident
Western Ring-tailed Gecko	*Strophurus strophurus*			X		Resident
Western Shield Spiny-tailed Gecko	*Strophurus wellingtonae*			X		Resident
CARPHODACTYLIDAE						
Smooth Knob-tailed Gecko	*Nephrurus laevissimus*		X	X		Resident
Midline Knob-tailed Gecko	*Nephrurus vertebralis*		X	X		Resident
Banded Knob-tailed Gecko	*Nephrurus wheeleri*			X		Resident
Barking Gecko	*Underwoodisaurus milii*	CS3		X	X	Resident
GEKKONIDAE						
Purple Arid Dtella	*Gehyra purpurascens*					Resident
Variegated Dtella	*Gehyra variegata*		X	X	X	Resident
Bynoe's Gecko	*Heteronotia binoei*			X	X	Resident
PYGOPODIDAE						
Unbanded Delma	*Delma butleri*		X	X		Resident
Burton's Legless Lizard	*Lialis burtonis*		X	X		Resident
Western Hooded Scaly-foot	*Pygopus nigriceps*					Resident
SCINCIDAE						
Buchanan’s Snake-eyed Skink	*Cryptoblepharus buchananii*					Resident
Peron’s Fence Skink	*Cryptoblepharus plagiocephalus*		X	X		Resident
	Ctenotus dux				X	Resident
	Ctenotus helenae				X	Resident
	Ctenotus leonhardii		X	X	X	Resident
Leopard Skink	*Ctenotus pantherinus*			X		Resident
	Ctenotus piankai				X	Resident

REPTILES		CS	ALA	N	BCE 2019	Expected status in area
Fourteen striped Ctenotus	*Ctenotus quattuordecimlineatus*		X	X	X	Resident
Barred Wedge-snout Ctenotus	*Ctenotus schomburgkii*			X		Resident
	Ctenotus severus			X		Resident
Spotted Ctenotus	*Ctenotus uber*					Resident
Pygmy Spiny-tailed Skink	*Egernia depressa*			X		Resident
Broad-banded Sand-swimmer	*Eremiascincus richardsonii*		X	X	X	Resident
	Lerista bipes		X	X	X	Resident
	Lerista desertorum		X	X		Resident
	Lerista kingi				X	Resident
Unpatterned Robust Slider	*Lerista macropisthopus*					Resident
Timid Slider	*Lerista timida*		X	X	X	Resident
	Lerista sp. 'Lake Way'	CS3			X	Resident
Desert Skink	*Liopholis inornata*		X	X	X	Resident
Common Dwarf Skink	*Menetia greyii*			X	X	Resident
Saltbush Morethia Skink	*Morethia adelaidensis*					Resident
Woodland Dark-flecked Morethia	*Morethia butleri*		X	X		Resident
Central Blue-tongue	*Tiliqua multifasciata*			X		Resident
Western Blue-tongue	*Tiliqua occipitalis*			X		Resident
VARANIDAE						
Short-tailed Pygmy Monitor	*Varanus brevicauda*			X	X	Resident
Stripe-tailed Monitor	*Varanus caudolineatus*			X		Resident
Pygmy Desert Monitor	*Varanus eremius*			X	X	Resident
Perentie	*Varanus giganteus*			X		Resident
Sand Goanna	*Varanus gouldii*		X	X	X	Resident
Yellow-spotted Monitor	*Varanus panoptes*			X	X	Resident
Black-headed Monitor	*Varanus tristis*			X		Resident
TYPHLOPIDAE						
Northern Hook-snouted Blind Snake	*Anilios hamatus*		X		X	Resident
Beaked Blind Snake	*Anilios waitii*		X			Resident
BOIDAE						
Pygmy Python	*Antaresia perthensis*			X		Resident
Stimson's Python	*Antaresia stimsoni*					Resident
ELAPIDAE						
Desert Death Adder	*Acanthophis pyrrhus*					Resident
North-western Shovel-nosed Snake	*Brachyurophis approximans*			X		Resident
Southern Shovel-nosed Snake	*Brachyurophis semifasciata*		X	X		Resident
Yellow-faced Whipsnake	*Demansia psammophis*			X		Resident
Moon Snake	*Furina ornata*			X		Resident
Monk Snake	*Parasuta monachus*		X	X		Resident
Mulga Snake	*Pseudechis australis*			X		Resident
Ringed Brown Snake	*Pseudonaja modesta*			X	X	Resident

REPTILES		CS	ALA	N	BCE 2019	Expected status in area
Western Brown Snake	*Pseudonaja mengdeni*			X		Resident
Jan's Banded Snake	*Simoselaps bertholdi*			X	X	Resident
Rosen's Snake	*Suta fasciata*		X	X		Resident

LAND BIRDS		CS	ALA	N	EPBC	BA	BCE 2019	Expected status in area
CASUARIIDAE								
Emu	*Dromaius novaehollandiae*			X		X	X	Resident
MEGAPODIIDAE								
Malleefowl	*Leipoa ocellata*	V S3			X			Irregular visitor
OTIDIDAE								
Australian Bustard	*Ardeotis australis*			X		X	X	Regular visitor
BURHINIDAE								
Bush Stone-curlew	*Burhinus grallarius*	CS3	X	X				Irregular visitor
PHASIANIDAE								
Brown Quail	*Synoicus ypsilophora*							Irregular visitor
TURNICIDAE								
Little Button-quail	*Turnix velox*					X		Regular visitor
COLUMBIDAE								
Diamond Dove	*Geopelia cuneata*			X		X		Regular Visitor
Crested Pigeon	*Ocyphaps lophotes*		X	X		X	X	Resident
Common Bronzewing	*Phaps chalcoptera*			X				Resident
CUCULIDAE								
Horsfield's Bronze-Cuckoo	*Chalcites basalis*			X		X		Migrant
Black-eared Cuckoo	*Chalcites osculans*				X	X		Regular visitor
Pallid Cuckoo	*Cuculus pallidus*			X		X		Migrant
APODIDAE								
Fork-tailed Swift	*Apus pacificus*	M S5						Irregular visitor
ACCIPITRIDAE								
Collared Sparrowhawk	*Accipiter cirrhocephalus*		X	X		X	X	Resident
Brown Goshawk	*Accipiter fasciatus*			X		X		Regular visitor
Wedge-tailed Eagle	*Aquila audax*			X		X	X	Resident
Spotted Harrier	*Circus assimilis*					X		Regular visitor
Black-shouldered Kite	*Elanus axillaris*			X		X		Regular visitor
Whistling Kite	*Haliastur sphenurus*		X	X		X	X	Regular visitor
Black-breasted Buzzard	*Hamirostra melanosternon*			X		X	X	Regular visitor
Little Eagle	*Hieraaetus morphnoides*					X		Regular visitor
Square-tailed Kite	*Lophoictinia isura*							Irregular visitor
Black Kite	*Milvus migrans*			X		X		Vagrant
FALCONIDAE								

LAND BIRDS		CS	ALA	N	EPBC	BA	BCE 2019	Expected status in area
Brown Falcon	*Falco berigora*		X	X		X		Regular visitor
Nankeen Kestrel	*Falco cenchroides*			X		X	X	Regular visitor
Grey Falcon	*Falco hypoleucos*	S3						Vagrant
Australian Hobby	*Falco longipennis*		X	X				Regular visitor
Peregrine Falcon	*Falco peregrinus*	S7						Regular visitor
Black Falcon	*Falco subniger*							Irregular visitor
STRIGIDAE								
Southern Boobook	*Ninox novaeseelandiae*							Resident
TYTONIDAE								
Barn Owl	*Tyto alba*							Regular visitor
PODARGIDAE								
Tawny Frogmouth	*Podargus strigoides*			X		X	X	Resident
CAPRIMULGIDAE								
Spotted Nightjar	*Eurostopodus argus*					X		Regular visitor
AEGOTHELIDAE								
Australian Owlet-nightjar	*Aegotheles cristatus*			X		X		Resident
MEROPIDAE								
Rainbow Bee-eater	*Merops ornatus*			X	X		X	Regular migrant
ALCEDINIDAE								
Red-backed Kingfisher	*Todiramphus pyrrhopygia*		X	X		X		Resident
Sacred Kingfisher	*Todiramphus sanctus*					X		Regular visitor
CACATUIDAE								
Major Mitchell's Cockatoo	*Cacatua leadbeateri*							Vagrant
Little Corella	*Cacatua sanguinea*		X	X		X		Regular visitor
Galah	*Eolophus roseicapilla*		X	X		X	X	Regular visitor
Cockatiel	*Nymphicus hollandicus*			X		X		Regular visitor
PSITTACIDAE								
Australian Ringneck	*Barnardius zonarius*		X	X		X	X	Resident
Purple-crowned Lorikeet	*Glossopsitta porphyrocephala*							Vagrant
Budgerigar	*Melopsittacus undulatus*			X		X		Regular visitor
Scarlet-chested Parrot	*Neopsephotus splendida*							Irregular visitor
Bourke's Parrot	*Neopsephotus bourkii*			X				Regular visitor
Night Parrot	*Pezoporus occidentalis*	E S1			X			Vagrant
Princess Parrot	*Polytelis alexandrae*	V P4			X			Vagrant
Regent Parrot	*Polytelis anthopeplus*							Vagrant
Mulga Parrot	*Psephotellus varius*		X	X		X	X	Resident
CLIMACTERIDAE								
White-browed Treecreeper	*Climacteris affinis*			X				Regular visitor
PTILONORHYNCHIDAE								

LAND BIRDS		CS	ALA	N	EPBC	BA	BCE 2019	Expected status in area
Western Bowerbird	*Ptilonorhynchus guttatus*		X	X		X	X	Resident
MALURIDAE								
Variegated Fairy-wren	*Malurus lamberti*		X	X		X		Resident
White-winged Fairy-wren	*Malurus leucopterus*		X	X		X	X	Resident
Splendid Fairy-wren	*Malurus splendens*		X	X		X	x	Resident
Rufous-crowned Emu-Wren	*Stipiturus ruficeps*	CS3	X					Irregular visitor
MELIPHAGIDAE								
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*		X	X		X	X	Resident
Pied Honeyeater	*Certhionyx variegatus*			X		X		Regular visitor
Grey Honeyeater	*Conopophila whitei*		X					Irregular visitor
White-fronted Chat	*Epthianura albifrons*							Irregular visitor
Orange Chat	*Epthianura aurifrons*		X	X				Irregular visitor
Crimson Chat	*Epthianura tricolor*		X	X		X	X	Regular visitor
Grey-fronted Honeyeater	*Ptilotula plumula*		X	X		X		Irregular visitor
White-plumed Honeyeater	*Ptilotula pencillata*		X	X		X	X	Regular visitor
Singing Honeyeater	*Gavicalis virescens*		X	X		X	X	Resident
Brown Honeyeater	*Lichmera indistincta*			X		X		Resident
Yellow-throated Miner	*Manorina flavigula*		X	X		X	X	Resident
White-fronted Honeyeater	*Purnella albifrons*			X		X		Regular visitor
Black Honeyeater	*Sugomel niger*					X	X	Regular visitor
PARDALOTIDAE								
Red-browed Pardalote	*Pardalotus rubricatus*					X		Resident
Striated Pardalote	*Pardalotus striatus*		X	X		X		Resident
ACANTHIZIDAE								
Inland Thornbill	*Acanthiza apicalis*		X	X		X		Resident
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*		X	X		X		Resident
Slender-billed Thornbill	*Acanthiza iredalei*	CS3	X					Resident
Slaty-backed Thornbill	*Acanthiza robustirostris*		X	X		X		Resident
Chestnut-rumped Thornbill	*Acanthiza uropygialis*		X	X		X	X	Resident
Southern Whiteface	*Aphelocephala leucopsis*		X	X		X		Resident
Rufous Fieldwren	*Calamanthus campestris*		X	X				Regular visitor
Western Gerygone	*Gerygone fusca*		X	X		X		Resident
Redthroat	*Pyrrholaemus brunneus*		X	X		X	X	Resident
Weebill	*Smicrornis brevirostris*		X	X		X	X	Resident
NEOSITTIDAE								
Varied Sittella	*Daphoenositta chrysoptera*		X	X			X	Resident
POMATOSTOMIDAE								

LAND BIRDS		CS	ALA	N	EPBC	BA	BCE 2019	Expected status in area
White-browed Babbler	*Pomatostomus superciliosus*		X	X		X	X	Resident
Grey-crowned Babbler	*Pomatostomus temporalis*		X	X		X	X	Resident
CINCLOSOMATIDAE								
Copper-backed Quail-thrush	*Cinclosoma casteneothorax*		X	X		X		Irregular visitor
Chiming Wedgebill	*Psophodes occidentalis*		X	X				Regular visitor
CAMPEPHAGIDAE								
Ground Cuckoo-shrike	*Coracina maxima*					X	X	Resident
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*		X	X		X	X	Resident
White-winged Triller	*Lalage tricolor*			X		X	X	Resident
PACHYCEPHALIDAE								
Grey Shrike-thrush	*Colluricincla harmonica*			X		X	X	Resident
Crested Bellbird	*Oreoica gutturalis*		X	X		X	X	Resident
Rufous Whistler	*Pachycephala rufiventris*		X	X		X	X	Resident
ARTAMIDAE								
Black-faced Woodswallow	*Artamus cinereus*		X	X		X	X	Resident
Little Woodswallow	*Artamus minor*							Irregular visitor
Masked Woodswallow	*Artamus personatus*		X	X		X	X	Regular Visitor
Pied Butcherbird	*Cracticus nigrogularis*			X		X	X	Resident
Australian Magpie	*Cracticus tibicen*		X	X		X	X	Resident
Grey Butcherbird	*Cracticus torquatus*			X		X	X	Resident
Grey Currawong	*Strepera versicolor*							Regular Visitor
RHIPIDURIDAE								
Grey Fantail	*Rhipidura albiscapa*					X		Regular visitor
Willie Wagtail	*Rhipidura leucophrys*		X			X	X	Resident
CORVIDAE								
Little Crow	*Corvus bennetti*			X		X	X	Resident
Torresian Crow	*Corvus orru*			X		X	X	Resident
MONARCHIDAE								
Magpie-lark	*Grallina cyanoleuca*		X	X		X	X	Resident
PETROICIDAE								
Hooded Robin	*Melanodryas cucullata*		X	X		X		Resident
Jacky Winter	*Microeca leucophaea*			X				Resident
Red-capped Robin	*Petroica goodenovii*		X	X		X	X	Resident
NECTARINIIDAE								
Mistletoebird	*Dicaeum hirundinaceum*			X		X	X	Regular visitor
ESTRILDIDAE								
Zebra Finch	*Taeniopygia guttata*		X	X		X	X	Resident
MOTACILLIDAE								
Australasian Pipit	*Anthus australis*		X	X		X	X	Regular visitor

LAND BIRDS		CS	ALA	N	EPBC	BA	BCE 2019	Expected status in area
LOCUSTELLIDAE								
Brown Songlark	*Cinclorhamphus cruralis*		X	X		X		Resident
Rufous Songlark	*Cinclorhamphus mathewsi*					X		Resident
HIRUNDINIDAE								
White-backed Swallow	*Cheramoeca leucosternum*			X		X	X	Regular visitor
Welcome Swallow	*Hirundo neoxena*			X		X	X	Regular visitor
Fairy Martin	*Petrochelidon ariel*			X		X		Irregular visitor
Tree Martin	*Petrochelidon nigricans*			X		X	X	Resident

WATERBIRDS		CS	ALA	N	EPBC	BA	B&B	BCE 2019	Expected status in area
ANATIDAE									
Grey Teal	*Anas gracilis*		X	X		X	X	X	Irregular visitor
Australasian Shoveler	*Anas rhynchotis*					X	X		Irregular visitor
Pacific Black Duck	*Anas superciliosa*					X	X	X	Irregular visitor
Hardhead	*Aythya australis*						X		Irregular visitor
Musk Duck	*Biziura lobata*						X		Vagrant
Australian Wood Duck	*Chenonetta jubata*			X		X	X	X	Regular visitor
Black Swan	*Cygnus atratus*			X		X	X		Irregular visitor
Pink-eared Duck	*Malacorhynchus membranaceus*						X		Regular visitor
Australian Shelduck	*Tadorna tadornoides*			X		X	X		Irregular visitor
PODICIPEDIDAE									
Hoary-headed Grebe	*Poliocephalus poliocephalus*			X		X	X		Regular visitor
Australasian Grebe	*Tachybaptus novaehollandiae*					X	X		Irregular visitor
RALLIDAE									
Eurasian Coot	*Fulica atra*						X		Irregular visitor
Australian Spotted Crake	*Porzana fluminea*						X		Irregular visitor
Black-tailed Native-hen	*Gallinula ventralis*			X		X	X		Irregular visitor
RECURVIROSTRIDAE									
Banded Stilt	*Cladorhynchus leucocephalus*	CS3					X		Irregular visitor
Black-winged Stilt	*Himantopus himantopus*			X		X	X		Irregular visitor

WATERBIRDS		CS	ALA	N	EPBC	BA	B&B	BCE 2019	Expected status in area
Red-necked Avocet	*Recurvirostra novaehollandiae*		X	X		X	X		Irregular Visitor
CHARADRIIDAE									
Inland Dotterel	*Charadrius australis*						X		Regular visitor
Black-fronted Dotterel	*Charadrius melanops*			X		X	X	X	Regular visitor
Red-capped Plover	*Charadrius ruficapillus*						X (BR)	X	Regular visitor
Oriental Plover	*Charadrius veredus*	M S5			X		X		Vagrant
Red-kneed Dotterel	*Erythrogonys cinctus*		X	X			X		Regular visitor
Banded Lapwing	*Vanellus tricolor*					X	X		Regular visitor
GLAREOLIDAE									
Australian Pratincole	*Stiltia isabella*						X		Irregular visitor
LARIDAE									
Silver Gull	*Chroicocephalus novaehollandiae*						X (BR)		Irregular visitor
Gull-billed Tern	*Gelochelidon nilotica*	M S5					X (BR)		Irregular visitor
Whiskered Tern	*Chlidonias hybrida*						X		Irregular visitor
SCOLOPACIDAE									
Sharp-tailed Sandpiper	*Calidris acuminata*	M S5			X		X		Irregular visitor
Curlew Sandpiper	*Calidris ferruginea*	Cr M S1 S5					X		Vagrant
Pectoral Sandpiper	*Calidris melanotos*	M S5			X				Vagrant
Red-necked Stint	*Calidris ruficollis*	M S5					X		Irregular visitor
Wood Sandpiper	*Tringa glareola*	M S5					X		Vagrant
Common Sandpiper	*Tringa hypoleucos*	M S5	X	X	X		X		Irregular visitor
Common Greenshank	*Tringa nebularia*	M S5					X		Irregular visitor
Marsh Sandpiper	*Tringa stagnatalis*	M S5							Irregular visitor
ARDEIDAE									
White-faced Heron	*Egretta novaehollandiae*			X		X	X		Irregular visitor
White-necked Heron	*Ardea pacifica*			X		X	X		Irregular visitor
Eastern Great Egret	*Ardea modesta (alba)*					X	X		Vagrant
Nankeen Night Heron	*Nycticorax caledonicus*						X		Vagrant
THRESKIORNITHIDAE									
Yellow-billed Spoonbill	*Platalea flavipes*						X		Vagrant
Glossy Ibis	*Plegadis falcinellus*	M S5							Vagrant
Australian White Ibis	*Threskiornis molucca*								Vagrant

WATERBIRDS		CS	ALA	N	EPBC	BA	B&B	BCE 2019	Expected status in area
Straw-necked Ibis	*Threskiornis spinicollis*						X		Vagrant
PHALACROCORACIDAE									
Little Pied Cormorant	*Phalacrocorax melanoleucos*						X		Irregular visitor
Little Black Cormorant	*Phalacrocorax sulcirostris*						X		Vagrant

MAMMALS		CS	ALA	N	EPBC	BCE 2019	Expected status in area
TACHYGLOSSIDAE							
Echidna	*Tachyglossus aculeatus*			X		X	Resident
DASYURIDAE							
Kultarr	*Antechinomys laniger*			X			Resident
Brush-tailed Mulgara	*Dasycercus blythi*	P4		X		X	Resident
Chuditch	*Dasyurus geoffroii*	V S3					Locally extinct
Mallee Ningaui	*Ningai yvonnae*	CS3				X	Resident
Wongai Ningaui	*Ningaui ridei*		X	X		X	Resident
Fat-tailed Dunnart	*Sminthopsis crassicaudata*			X			Resident
Little Long-tailed Dunnart	*Sminthopsis dolichura*						Resident
Hairy-footed Dunnart	*Sminthopsis hirtipes*			X			Resident
Stripe-faced Dunnart	*Sminthopsis macroura*			X			Resident
Ooldea Dunnart	*Sminthopsis ooldea*			X			Resident
Lesser Hairy-footed Dunnart	*Sminthopsis youngsoni*			X			Resident
THYLACOMYIDAE							
Greater Bilby	*Macrotis lagotis*	V S3					Locally extinct
POTOROIDAE							
Boodie	*Bettongia lesueur*	Ex S4					Locally extinct
PERAMELIDAE							
Pig-footed Bandicoot	*Chaeropus ecaudatus*	Ex S4					Extinct
Golden Bandicoot	*Isoodon auratus*	V S3					Locally extinct
Western Barred Bandicoot	*Perameles bougainville*	E S3					Locally extinct
MACROPODIDAE							
Rufous Hare-Wallaby	*Lagorchestes hirsutus*	Ex S4					Locally extinct
Euro, Biggada	*Macropus robustus*			X			Resident
Red Kangaroo, Marlu	*Macropus rufus*					X	Resident
EMBALLONURIDAE							
Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*					X	Resident
Hill's Sheathtail Bat	*Taphozous hilli*					x	Resident
MOLOSSIDAE							
White-striped Freetail Bat	*Austronomus australis*			X			Migrant
Inland Freetail Bat	*Ozimops petersi*			X			Resident

MAMMALS		CS	ALA	N	EPBC	BCE 2019	Expected status in area
Lumsden's Freetail Bat	*Ozimops lumsdenae*					X	Resident
Beccari's Freetail Bat	*Ozimops beccarii*			X			Resident
VESPERTILIONIDAE							
Gould's Wattled Bat	*Chalinolobus gouldii*			X		X	Resident
Lesser Long-eared Bat	*Nyctophilus geoffroyi*			X		X	Resident
Inland Long-eared Bat	*Nyctophilus major tor*	P3				X	Resident
Inland Broad-nosed Bat	*Scotorepens balstoni*		X	X		X	Resident
Inland Forest Bat	*Vespadelus baverstocki*						Resident
Inland Forest Bat	*Vespadelus finlaysoni*			X			Resident
MURIDAE							
Stick-nest Rat	*Leporillus* sp	Ex S4					Extinct
Spinifex Hopping-Mouse	*Notomys alexis*			X		X	Resident
Bolam's Mouse	*Pseudomys bolami*						Resident
Sandy Inland Mouse	*Pseudomys hermannsburgensis*			X			Resident
INTRODUCED MAMMALS							
European Cattle	*Bos taurus*	Int.		X		X	Resident
Camel	*Camelus dromedarius*	Int.				X	Regular visitor
Dog, Dingo	*Canis lupus*	Int.		X		X	Resident
Goat	*Capra hircus*	Int.					Irregular visitor
Donkey	*Equus asinus*	Int.		X			Vagrant
Horse	*Equus caballus*	Int.		X			Vagrant
Cat	*Felis catus*	Int.		X		X	Resident
House Mouse	*Mus musculus*	Int.		X			Resident
Rabbit	*Oryctolagus cuniculus*	Int.		X		X	Resident
Red Fox	*Vulpes vulpes*	Int.		X			Resident

6.6 **Appendix 6.** Summary of Lake Way Bat Survey Results (B. Shepherd; Matters of the Environment Pty Ltd).

Methods

An Anabat Swift (Titley) was deployed at two locations during the Lake Way Fauna Survey in October 2019. Settings on the detector are shown in Table 14 and deployment details are shown in Table 15.

Table 11. Settings of the Anabat Swift Bat detector

Device ID:	461287		Trigger frequency	8 to 200 kHz
Firmware	1.3		Min event	2 ms
Recording at:	320 ksps		Trigger window	2 seconds
Max file length	8 seconds		Sensitivity	16

Table 12. Deployment details of the Anabat Swift ultrasonic bat detector.

Time & Date Deployed	Time & Date Retrieved	Location	Lat	Long	Nights
20:18 5-Oct-19	05:24 06-Oct-19	Gunbarrel Laager	-26.59927	120.34138	1
7-Oct-19	10-Oct-19	East edge of fauna survey area	-26.80820	120.46223	2.5

The detector was set to record automatically (on detection of a possible bat call) from 30 minutes before sunset to 30 minutes after sunrise. Sunset was around 18:00 hrs while sunrise was around 05:30 hrs through the survey period.

Species expected in the Lake Way area were taken from Armstrong (2011). Calls were assessed using Anabat Insight and Wildlife Acoustics Kaleidoscope software and referenced against call characteristics provided in the following:

- Bullen, R.D. and Dunlop, J.N. (2012). Assessment of habitat usage by bats in the rangelands of Western Australia: comparison of echolocation call count and stable isotope analysis methods. *The Rangeland Journal*, **34**, 277-284.
- Fullard, J.H., Koehler, C., Surlykke, A. and McKenzie, N.L. (1991). Echolocation Ecology and Flight Morphology of Insectivorous Bats (Chiroptera) in South-western Australia. *Australian Journal of Zoology*, **39**, 427-38.
- McKenzie, N.L. and Bullen, R.D. (2009). The echolocation calls, habitat relationships, foraging niches and communities of Pilbara microbats. *Records of the Western Australian Museum, Supplement 78*: 123-155.

Calls obtained were compared using the following characteristics:

Call shape: Whether frequency modulation (FM) or constant frequency (CF), presence of tails and direction etc.

Fmax (kHz): Average maximum frequency of call pulses within each call sequence

Fppeak (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

TBC: Time between call pulses

Dur (ms): Average duration of call pulses.

Results

A large number of audio files (3,055) were recorded on the detector at Gunbarrel Laager, which provide almost a complete acoustic record for the entire night. Gunbarrel Laager was the accommodation used by the fauna survey team and had lighting and several sources of readily available water. Because of the large numbers of records, they were subsampled by assessing 40 files from every half hour of sampling (approximately 24% of samples). All files analysed that contained bats calls were from Gould's Wattled Bat (*Chalinolobus gouldii*) and from multiple bats in the majority of call sequences. A sample excerpt is provided in Figure 1. No other bats species were represented in the acoustic records from Gunbarrel Laager and therefore the sampling was not extended beyond 40 files every half an hour. Records contained echolocation pules and social calls, some of which were extensive. The (almost) constant bat activity indicated that the location the detector was placed close to a large roost or provided extensive foraging and drinking water opportunities, or both. Gould's Wattled Bat is one of the few species to readily take advantage of urban and man-made areas presumably taking advantage of the attraction that lighting has on insects. Due to the clear calls contained in the audio files from Gunbarrel Laager, all files that contained bat echolocation sequences could be allocated to species.

Potentially seven species were recorded from the Lake Wat project area (see Table 3). It is considered by most bat specialists that *Nyctophilus* spp cannot be differentiated by call sequences and call characteristics alone (Churchill, 2008; Milne *et al*., 2002). Therefore, some uncertainty exists around the identification of the two *Nyctophilus* spp listed in Table 3. These two species are the only *Nyctophilus* spp that can be expected in the Murchison region (Armstrong, 2011). Because there are two sets of echolocation sequences with similar near-vertical, almost straight FM sweeps, some of which have peak power around 57 kHz and the others at 46 kHz (one call sequence lies around 51 kHz and another at 60 kHz), it is presumed they are from the two separate species. The Central Long-eared Bat (*Nyctophilus major tor*) is classified as P3 by the DBCA and therefore of conservation significance. None of the other species expected in the area (whether recorded or not) is conservation significant. Calls obtained that were attributed to *Ozimops spp* are presumed to be *O. lumsdenae* based on distributions of the genus in Reardon *et al*. (2014). This species is likely to be formerly known as *Mormopterus* sp 3. All species detected were expected in the area according to Armstrong (2011).

Table 3. Characteristics of calls obtained from the survey area on Lake Way (location 2)

Species	Family	Fmax (kHz)	Fppeak (kHz)	Fmin (kHz)	TBC (ms)	Dur (ms)	Description
Yellow-bellied Sheath-tailed Bat *Saccolaimus flaviventris*	Emballonuridae	25.9	20.6	19.7	268.6	4.485	Harmonics @
Hill's Sheath-tailed Bat *Taphozous hilli*		27.7	26.8	25.9	204.3	5.663	Shallow curvilinear pulse
Inland Free-tailed Bat *Ozimops lumsdenae*	Molossidae	34.3	27.5	26.7	222.9	5.291	Shallow sweep. Non-alternating & harmonics @55kHz
Gould's Wattled Bat *Chalinolobus gouldii*	Vespertilionidae	42.6	32.5	31.9	187.5	4.478	Alternating calls
Lesser Long-eared Bat *Nyctophillus geoffroyi?*		80.7	45.6	41.4	84.4	3.324	Near vertical
Central Long-eared Bat *Nyctophillus major tor?*		83.9	56.9	45.7-48.2	79.2	3.336	Near vertical
Inland Broad-nosed Bat *Scotorepens balstoni*		50.6	33.8	32.2	177.1	4.078	FM sweep and down-sweeping tail. Non-alternating & harmonics @70 kHz

Table 4. Species detected over each night

Night	Species						
	S. flav.	*T. hilli*	*O. lumsdenae*	*C. gouldii*	*N. major tor?*	*N. geoffroyi?*	*S. balstoni*
5-6 Oct	-	-	-	✓	-	-	-
7-8 Oct	-	✓ (poss)	-	✓	✓	-	✓
8-9 Oct	✓	✓	✓	✓	✓	✓	-
9-10 Oct	-	✓		✓	✓	-	✓
10 Oct (evening)	-	-	-	-	-	-	✓

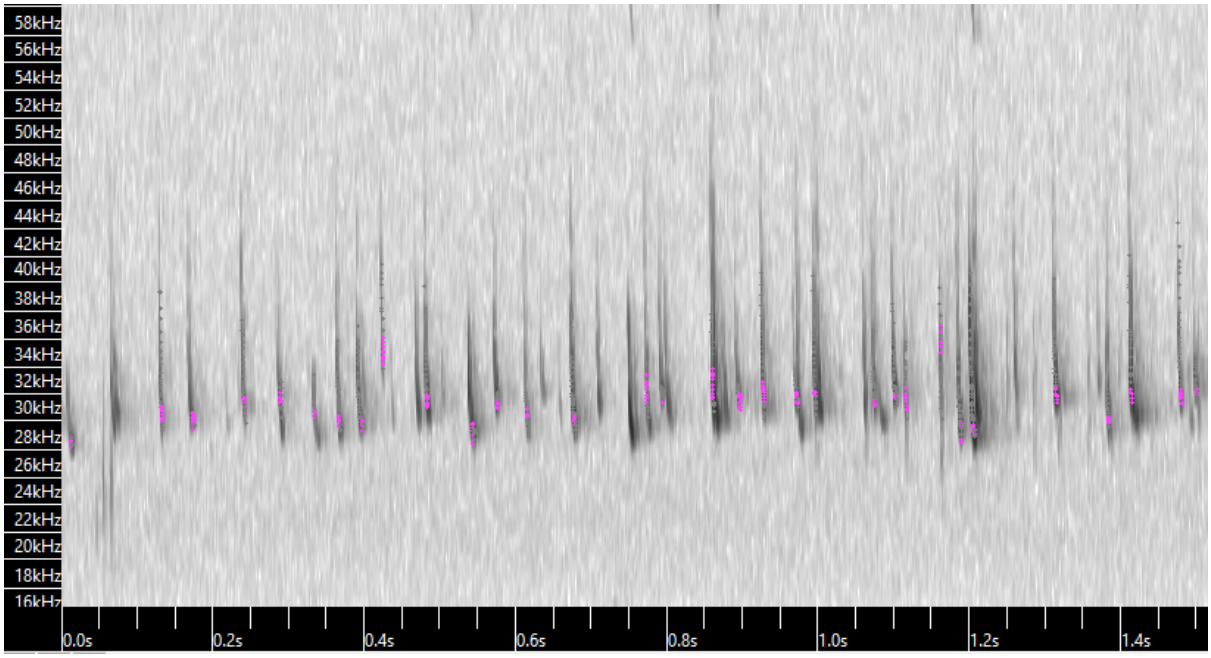

Figure 1. Typical sample of the *C. gouldii* records acquired at Gunbarrel Laager. Excerpt shows multiple bats calling.

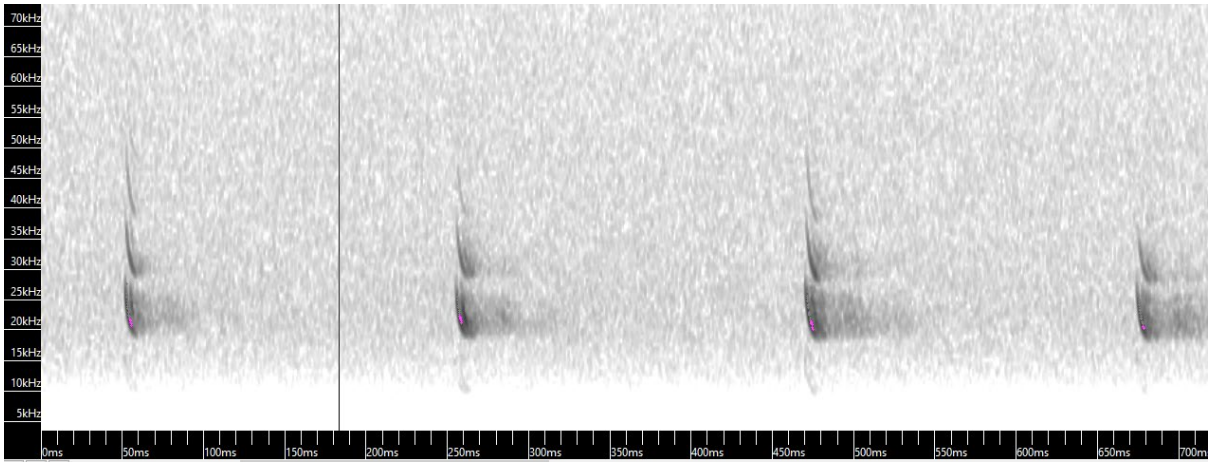

Figure 2. Excerpt from call sequence of *Saccolaimus flaviventris.* Note diagnostic secondary harmonic at 10 kHz.

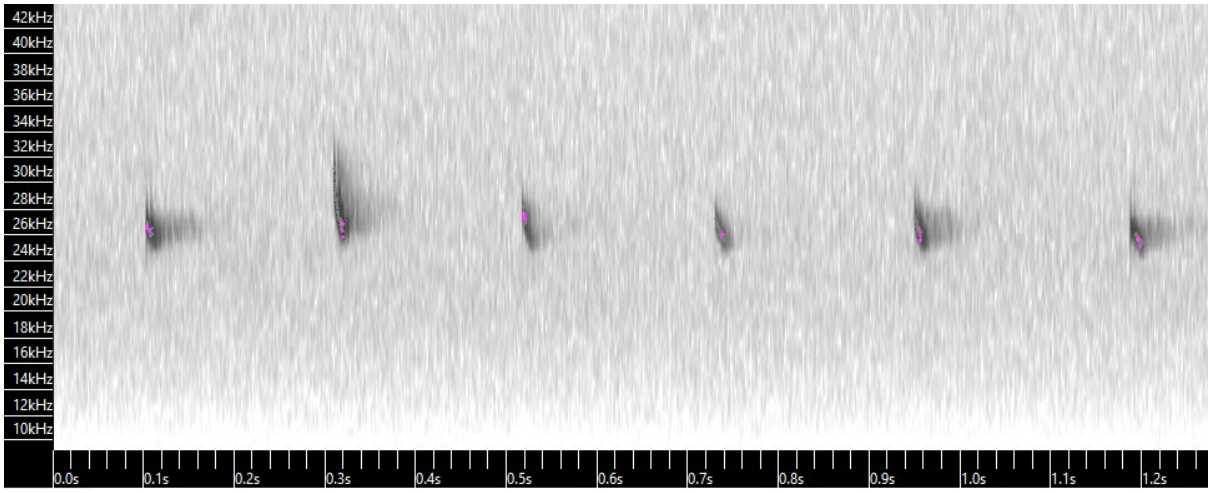

Figure 3. Excerpt from call sequence of *Taphozous hilli.*

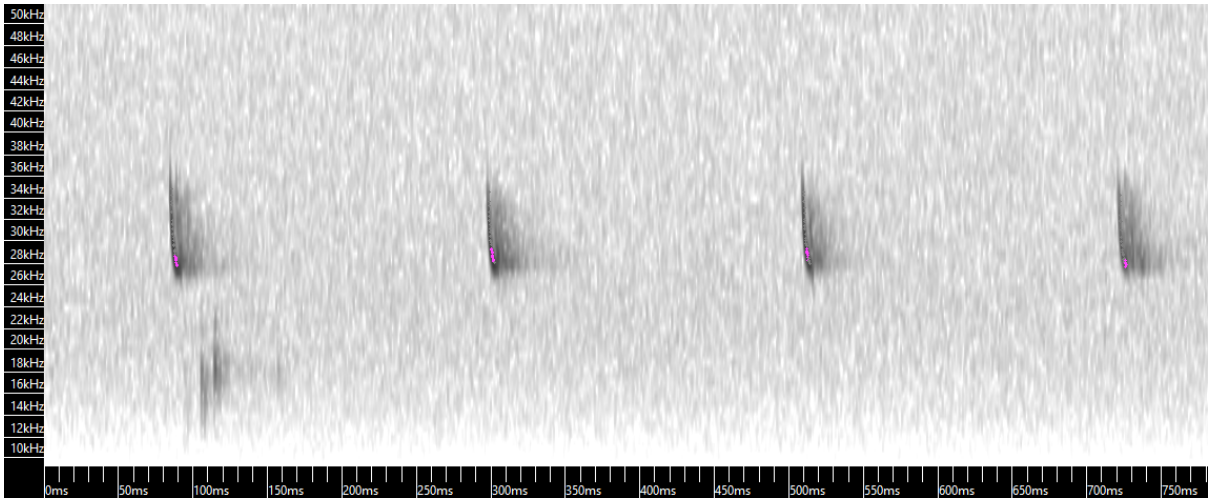

Figure 4. Excerpt from call sequence of possible *Ozimops lumsdenae* (previously known as *Mormopterus* sp 3).

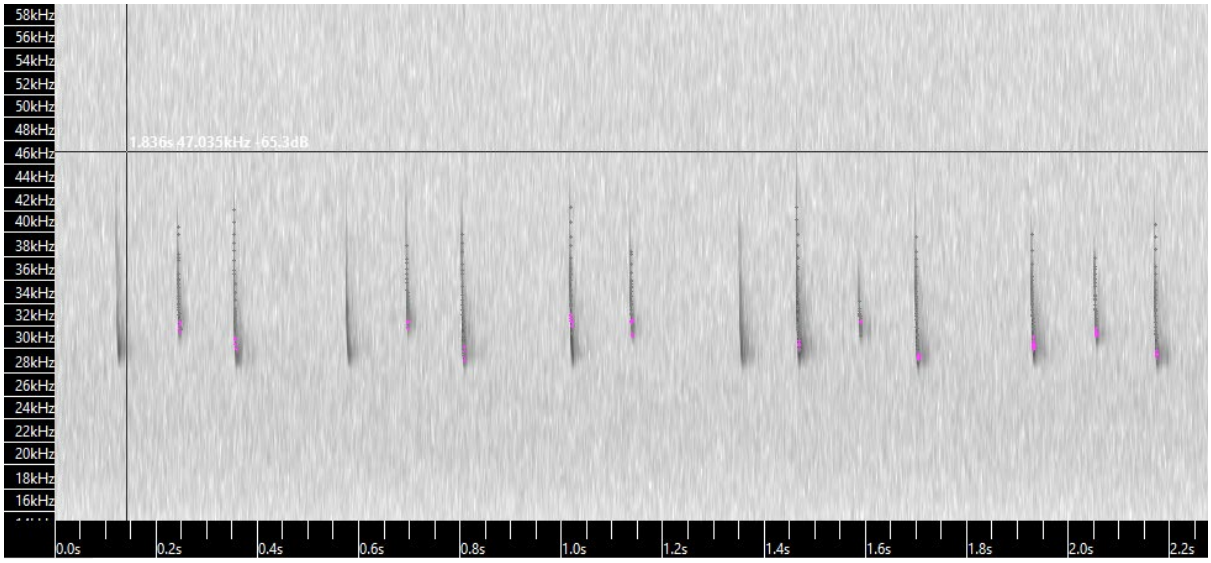

Figure 5. Excerpt from call sequence of *Chalinolobus gouldii.*

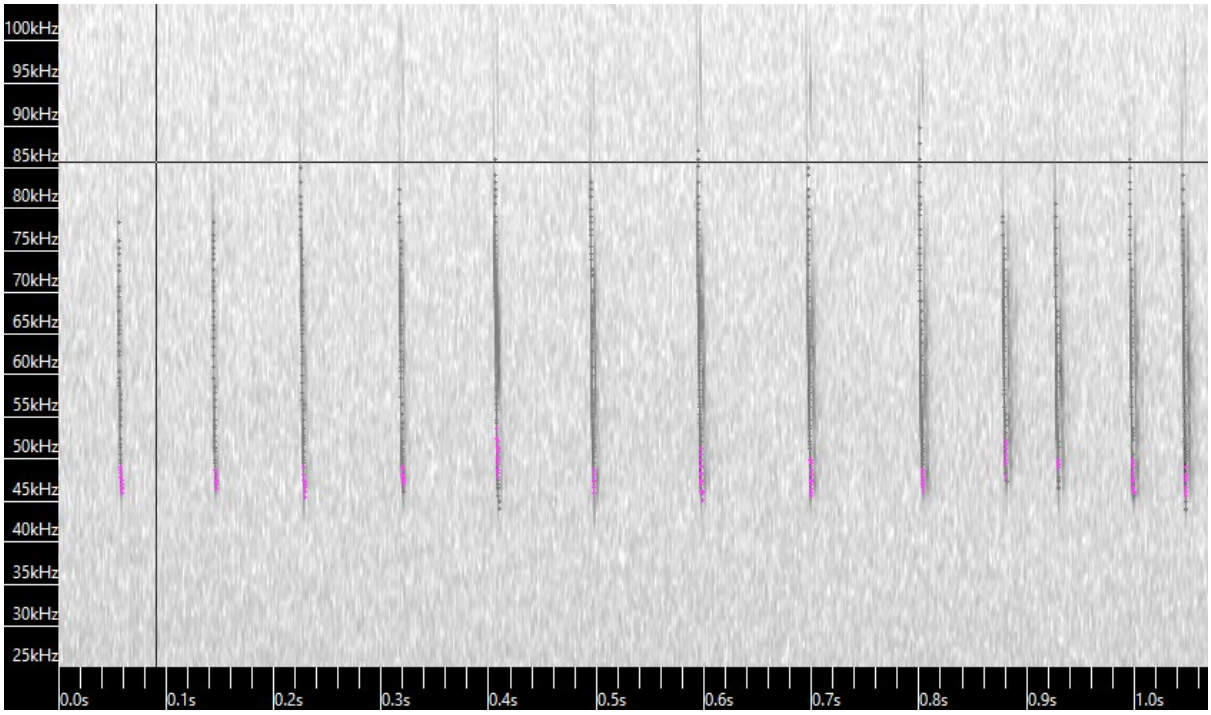

Figure 6. Excerpt from call sequence of *Nyctophilus major tor* (possible)

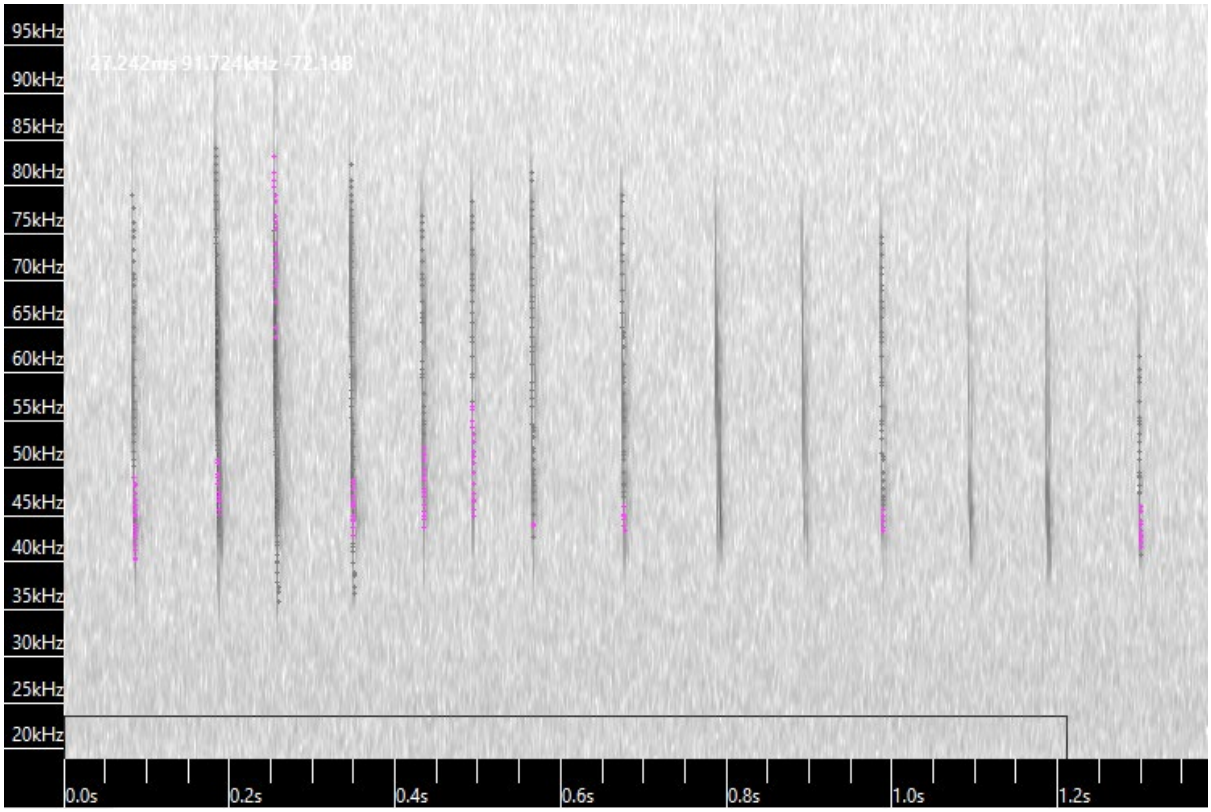

Figure 7. Excerpt from call sequence of *Nyctophilus geoffroyi*

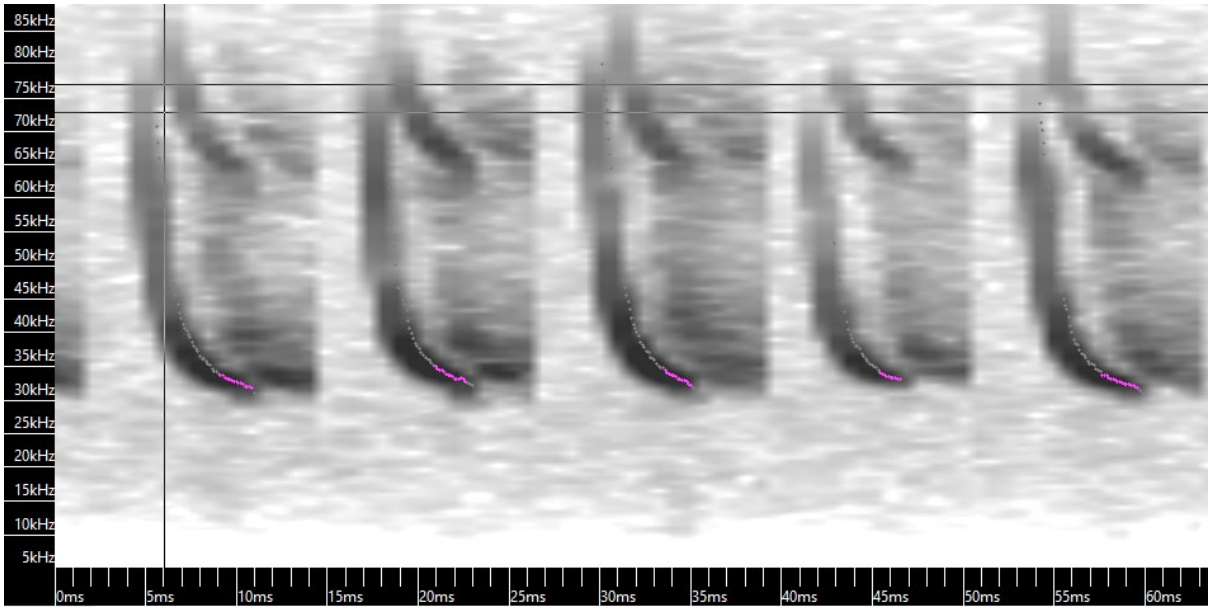

Figure 8. Excerpt from call sequence of *Scotorepens balstoni.* Time between call pulses has been compressed.

6.7 Appendix 7. Annotated species list 2019.

1. *Litoria rubella.* Common in showers at the Laager.
2. *Diplodactylus granariensis*. One caught at site 4.
3. *Gehyra variegata*. Several trapped. Some (always at the gypsum/calcrete sites) had white spots on the head and some on the body not attached to black bars.
4. *Heteronotia binoei*. Several trapped.
5. *Rhynchoedura ornata.* Several trapped.
6. *Underwoodisaurus milii*. One trapped at site 6.
7. *Ctenophorus isolepis*. Seen regularly and some caught. Males in breeding colour in October.
8. *Ctenophorus nuchalis*. One active and dug from burrow in proposed village/plant area (7/10).
9. *Ctenophorus salinarum*. One photographed by Josh Payne in south of lake (October) and one seen in north of lake in January.
10. *Moloch horridus*. Two hand-caught at site 10 and one crossing pipeline track near site 9 (8/10). A third at site 10 on 10/10 might have been one of the first two.
11. *Pogona minor*. One hand-caught at site 4 and one trapped at site 1.
12. *Varanus brevicauda*. Caught at sites 9 and 5.
13. *Varanus gouldii*. Seen along tracks occasionally.
14. *Varanus eremius*. One trapped transect 5.
15. *Varanus panoptes*. January February; one juvenile crossing Gunbarrel Hwy near Matilda Camp turnoff. Also one seen in shrubland on northern side of lake.
16. *Ctenotus dux*. One caught site 10 (11/10).
17. *Ctenotus helenae*. Pair caught in funnel trap at site 4.
18. *Ctenotus leonhardi*. One caught Site 4 (7/10); also caught sites 1 and 7.
19. *Ctenotus piankai*. One caught at site 5.
20. *Ctenotus quattordecimlineatus*. One caught at site 3 (7/10).
21. *Eremiascincus richardsonii*. One caught at Site 6.
22. *Lerista bipes*. Few caught in sandy sites.
23. *Lerista kingi*. One caught site 5 (5/10).
24. *Lerista timida*. One caught site 4 (6/10). Distinctly darker, glossier and more slender than *L. kingi*.
25. *Lerista sp*. 'Lake Way'. A small, slender lerista, two fingers and three toes, distinct red tail and rather large heard. Keys out to *L. desertorum* but not like that species.
26. *Liopholis inornata.* One caught site 1 and two caught at site 10.
27. *Menetia greyii*. Several caught. Strongly marked on flank with pale and dark zone.
28. *Anilios hamatus*. One caught site 1.
29. *Simoseelaps bertholdi*. One caught site 4.
30. *Pseudonaja modesta*. One seen near site 8 (11/10).

1. Emu. Tracks near site 5, around site 8, neat site 9 and in proposed processing plant area.
2. Malleefowl. Very, very long-disused mound in proposed processing plant area.
3. Grey Teal. Four on freshwater pool near Matilda Camp, January 2019.
4. Pacific Black Duck. Two on freshwater pool near Matilda Camp, January 2019.
5. Wood Duck. Three on small pool along Goldfields Hwy near Potash turnoff, January 2019.

6. Unidentified heron. One on freshwater pool near Matilda Camp. A small, stocky heron similar in size to Striated Heron. Plain blue-grey with white streaks prominent on side of neck and throat. Possibly a Black Bittern but identity unconfirmed. Likely to be a vagrant.
7. Black-breasted Buzzard. Seen near Millbillillie Homestead.
8. Collared Sparrowhawk. One near freshwater pool near Matilda Camp (January).
9. Wedge-tailed Eagle. One adult on roadkill one edge of Wiluna (4/10). Pair on Gunbarrel Highway near the Lager and a different pair seen in project area (morning of 5/10).
10. Whistling Kite. Two just south of Wiluna on Goldfields Highway (4/10). Nest with one bird sitting beside Gunbarrel Highway near old homestead between Laager and Wiluna.
11. Nankeen Kestrel. One near stone tank (5/10) and one over site 1 (7/10).
12. Crested Pigeon. Few around the Laager and at Matilda Camp in January.
13. Australian Bustard. Old tracks at site 8 and seen on Mulgara walk near possible Bilby burrow. Feathers at West Creek borefield.
14. Black-fronted Dotterel. Seven on freshwater pool near Matilda Camp (January).
15. Red-capped Plover. Two on small pool on northern edge of lake (January).
16. Australian Ringneck. Few around the Laager and occasionally in project area.
17. Mulga Parrot. Two at pipeline turnoff from Gunbarrel Highway (7/10).
18. Galah. Several on outskirts of Wiluna and about 30 occasionally around the Laager.
19. Rainbow Bee-eater. Four at site 1 (7/10) and seen occasionally throughout.
20. Tawny Frogmouth. One seen along pipeline track while spotlighting (7/10).
21. White-winged Fairy-wren. Party seen along pipeline track (4/10); also seen on edge of lake in January.
22. Splendid Fairy-wren. Party along West Creek borefield.
23. Chestnut-rumped Thornbill. Recorded Transect 4 and heard occasionally in Mulga elsewhere.
24. Weebill. Heard among eucalypts at the Laager and in Mallee at site 8 (7/10).
25. Yellow-throated Miner. Around Laager and heard in Mulga near south tank, and at sites 2 and 6.
26. Spiny-cheeked Honeyeater. Heard at Transect 4.
27. White-plumed Honeyeater. Around Laager.
28. Singing Honeyeater. In Mulga of project area in small numbers throughout.
29. Black Honeyeater. One heard near site 9 (10/10).
30. Crimson Chat. Along Pipeline track (5/10).
31. Redthroat. Recorded at Transect 4.
32. Grey Shrike-thrush. Heard at the Laager.
33. Rufous Whistler. Heard at site 1.
34. Crested Bellbird. Calling near Site 1 and seen occasionally along pipeline track.
35. Red-capped Robin. Seen near Gunbarrel Highway along pipeline road and near Site 6.
36. Varied Sittella. One seen briefly at site 1 (8/10).
37. Willie Wagtail. One along pipeline track near site 9 (6/10) and one along track near site 4 (7/10).
38. Black-faced Cuckoo-shrike. One seen in Mulga near site 6 and two near stone tank.
39. White-winged Triller. Female seen in shrubland north of lake (January).
40. Ground Cuckoo-shrike. Two perched in a eucalypt north of lake (January).
41. White-browed Babbler. Small group in processing plant area (7/10).
42. Grey-crowned Babbler. Heard around Laager and party near northern margin of lake (January).
43. Mistletoebird. Few around the Laager and in areas of tall Mulga.

44. Black-faced Woodswallow. Few on outskirts of Wiluna and seen in project area occasionally.
45. Masked Woodswallow. Flock of about 50 in project area near transect 5 (5/10).
46. White-browed Woodswallow. Few in flock of Masked Woodswallows; conspicuous because of dark belly and pale tail.
47. Magpie-lark. Few around the Laager.
48. Tree Martin. Few around Wiluna including one entering metal hollow at top of light pole; presumably breeding. One also nesting in ceiling over fuel bowsers; entering via a 50c sized hole in flat panel.
49. White-backed Swallow. One along pipeline track near site 5 (5/10) and one at site 6 (8/10).
50. Welcome Swallow. Few around Matilda Camp (January).
51. Zebra Finch. Few around stock watering points. Also seen in January.
52. Australian Pipit. One on flats just north of creek crossing.
53. Western Bowerbird. In Laager area and along Gunbarrel Highway.
54. Australian Magpie. Few around the Laager and along pipeline track. Also at Matilda Camp (January).
55. Pied Butcherbird. Calling and seen around the Laager and around Matilda Camp (January).
56. Grey Butcherbird. One in shrubland on northern edge of lake (January).
57. Little Crow. Few around the Laager and common in Wiluna. Occasionally in project area.
58. Torresian Crow. Few along northern edge of lake in January.
59. Australasian Pipit. Few along tracks and roads in January.

Echidna. Recent foraging and scats found. Animal found in burrow at site 8 (6/10) and possibly this animal in pitfall on 7/10. Lots of fresh tracks and scats around site 8 suggesting may be more than one animal.
Ningaui ridei. One male caught at site 9 and two at site 7. Slightly longer inner toe and larger crown than *N. yvonnae*, and dark guard hairs apparent.
Ningaui yvonnae. One male caught at site 3. Distinguished from *N. ridei* by very short inner hind toe.
Brush-tailed Mulgara. Several old and few active burrows found. Several active burrows with scats around site 8. Walked transect at site 8 and found more burrows and tracks. Also did walk around possible Bilby burrow and found more Mulgara burrows.
Great Bilby. Possibly old burrow along track north of Site 10, but unconfirmed and extensive searching in area failed to find any other evidence.
Boodie. Probable old warrens in gypsum rise at Site 6.
Red Kangaroo. Tracks and animals seen occasionally. Present around the Laager.
Spinifex Hopping-Mouse. Several groups of burrows in processing plant area.
Rabbit. Burrows and scats in gypsum rise areas. Fresh tracks at site 4 (8/10).
Dingo. Tracks along gas pipeline access road. Fresh tracks at site 4 (8/10).
Cat. Old tracks at a few locations.
Camel. Fairly recent tracks at a few locations.

6.8 **Appendix 8.** Locations and observations on walked transects in October 2019.

Codes for observations are:

MUBA Mulgara burrow active
MUBA Mulgara burrow inactive
MUBA Mulgara foraging digging
MUST Mulgara scat
MUTK Mulgara track
BUSTTK Bustard track
CATTK Cat track
ECHIDTK Echidna track

MULGARA TRANSECT 1			
CORNERS	Easting	Northing	Zone
Mul trans NEcnr	254689.1	7027782	51J
Mul trans NW cnr	253717.6	7027808	51J
Mul trans SE cnr	254695.6	7027679	51J
Mul Trans SW cnr	253748.8	7027673	51J
OBSERVATIONS			
MUBA	254657.3	7027760	51J
MUBA	254521.6	7027766	51J
MUBA	254484.4	7027770	51J
MUBA	254473.6	7027753	51J
MUBI	254382.1	7027781	51J
MUBI	254367.1	7027781	51J
MUBA	254292.9	7027781	51J
MUBA	254291.2	7027782	51J
MUBA	254280.4	7027781	51J
MUBI	254237.5	7027781	51J
MUBI	254118.7	7027772	51J
MUBI	254117.1	7027784	51J
MUBI	254054.9	7027779	51J
MUBI	254006.1	7027789	51J
MUBI	253973.9	7027782	51J
MUB I	253797.1	7027788	51J
MUBI	253752.1	7027774	51J
MUBI	254562.3	7027702	51J
MUBI	254713.6	7027710	51J
MUBI	254747.7	7027706	51J
MUBI	254683.7	7027763	51J
MULF1	253714.2	7027781	51J
MULST1	254698.4	7027769	51J
MUBA	254698.5	7027739	51J
MUBI	254652.1	7027729	51J

MUBA	254646.1	7027729	51J
MUBA	254674.1	7027746	51J
MUBA	254612.5	7027726	51J
MUBA	254512.9	7027741	51J
MUBA	254421.2	7027735	51J
MUBI	254399.8	7027739	51J
MUBI	254336.4	7027753	51J
MUBI	254317.7	7027731	51J
MUBI	253795.7	7027728	51J
MUBA	254643.9	7027731	51J
MUBA	254347.1	7027661	51J
MUBA	254338.8	7027660	51J
MUBA	254418.1	7027789	51J
MUBA	254420.1	7027783	51J
MUBA	254523.6	7027783	51J
MUBA	254574.8	7027778	51J
MUBI	254324.6	7027662	51J
MUBI	254236	7027673	51J
MUBI	253958.1	7027800	51J
MUBI	254130.8	7027803	51J
MUBI	254343.1	7027800	51J
MUBI	254482.4	7027793	51J
MUBI	254548.3	7027780	51J
MUTK	254546	7027676	51J

Mulgara Transect 2			
CORNERS			
NE2	245906.2	7039256	51J
NW2	245587.4	7039249	51J
SE2	245975.1	7039140	51J
SW2	245626.1	7039141	51J
OBSERVATIONS			
CATTK	245732.7	7039133	51J
MUBI	245563.6	7039182	51J
MUBI	245778.3	7039215	51J
MUBI	245850.5	7039212	51J
MUBI	245750.1	7039233	51J
MUBI	245649.7	7039220	51J
MUBI	245619.9	7039165	51J
MUBI	245713.5	7039174	51J
MUBTK	245907.7	7039127	51J

MULGARA TRANSECT 3			
Outside Corners			
NE3	239727.7	7048194	51J
NW3	238634.1	7048150	51J
SE3	239750.3	7047606	51J
SE3	239684.8	7047552	51J
SW3	238675	7047554	51J
Inside Corners			
BBTSW	238701.2	7047637	51J
BBTNE	239693.1	7048092	51J
BBTNW	238699.9	7048102	51J
BBTSE	239677	7047629	51J
OBSERVATIONS			
BUSTTRK	239682.2	7047833	51J
ECHITK	239756.1	7047645	51J
MUBA	239445.1	7048164	51J
MUBA	239720.1	7048200	51J
MUBA	239240.3	7047568	51J
MUBA	239171.1	7047561	51J
MUBA	239124.3	7047565	51J
MUBA	239092.1	7047558	51J
MUBA	239071.4	7047579	51J
MUBA	239696.7	7048076	51J
MUBA	239700.5	7047990	51J
MUBA	239441.8	7047616	51J
MUBA	238878	7047614	51J
MUBA	238826.4	7047593	51J
MUBA	238697.3	7047596	51J
MUBAST	239042	7047580	51J
MUBI	239215.3	7048192	51J
MUBI	239767.8	7047939	51J
MUBI	239758.7	7047875	51J
MUBI	239547.7	7047544	51J
MUBI	239377.1	7047525	51J
MUBI	238791.2	7047565	51J
MUBI	238643.7	7047750	51J
MUBI	239697.4	7047983	51J
MUBI	239243.4	7047609	51J
MUBI	239114.2	7047609	51J
MUBI	239046.9	7047609	51J
MUBI	238908	7047618	51J
MUBI	238880.8	7048121	51J

MUBI	238653.6	7048080	51J
MUBI	238658.4	7047777	51J
MUBI	238666.5	7047738	51J
MUBI	238989.6	7047591	51J
MUBI	239075.9	7047596	51J
MUBI	239115.5	7047594	51J
MUBI	239184.8	7047579	51J
MUBI	239667	7048166	51J
MUBI	239604.1	7048165	51J
MUBI	239198	7048171	51J
MUBI	239682.1	7047984	51J
MUBI	239677.9	7047661	51J
MUBI	239673.2	7047624	51J
MUBI	239144.9	7047621	51J
MUBI	238712.4	7047635	51J
MUBI	238700.8	7047932	51J
MUBI	238704.2	7048031	51J
MUST	239119.3	7047625	51J

Mulgara transect 4			
OUTSIDE CORNERS			
NE4	242078	7045229	51J
NW4	240883.7	7045235	51J
SE4	242088.7	7044606	51J
SW4	240881.9	7044550	51J
INSIDE CORNERS			
MT4SW	240981.2	7044663	51J
MT4NE	241960.2	7045155	51J
MT4SE	241969	7044659	51J
MT4NW	240994.3	7045150	51J
OBSERVATIONS			
BUSTTK	241273.9	7045253	51J
MUBA	241704.8	7045268	51J
MUBA	241748.1	7045244	51J
MUBA	241780.2	7045208	51J
MUBA	242096.7	7044842	51J
MUBA	242077.7	7044705	51J
MUBA	241625.2	7045236	51J
MUBA	241742.7	7045225	51J
MUBA	241838.9	7045234	51J
MUBA	242071.2	7044956	51J
MUBA	242074.7	7044606	51J

MUBA	240910.1	7044837	51J
MUBA	241765.6	7045147	51J
MUBA	241953.6	7045124	51J
MUBA	241716.3	7045169	51J
MUBA	241755	7045171	51J
MUBA	242009.3	7045067	51J
MUBA	240938.7	7045138	51J
MUBASCAT	241965.7	7045151	51J
MUBI	241567.5	7045224	51J
MUBI	241963.6	7045245	51J
MUBI	242069.4	7045229	51J
MUBI	242095	7044834	51J
MUBI	240866.5	7044604	51J
MUBI	240873	7044685	51J
MUBI	240874.7	7045005	51J
MUBI	241549.6	7045218	51J
MUBI	242047.4	7045213	51J
MUBI	242077	7045078	51J
MUBI	242074.4	7044991	51J
MUBI	242081.7	7044684	51J
MUBI	241839	7044554	51J
MUBI	241727.2	7044545	51J
MUBI	240880.1	7044612	51J
MUBI	240900.1	7044690	51J
MUBI	240905.6	7044730	51J
MUBI	240903.2	7045095	51J
MUBI	240967	7045231	51J
MUBI	241308.3	7045230	51J
MUBI	241804	7045147	51J
MUBI	241959.6	7045133	51J
MUBI	241959.9	7045096	51J
MUBI	241961.2	7045072	51J
MUBI	241954.8	7044978	51J
MUBI	241834.2	7044661	51J
MUBI	241271	7044664	51J
MUBI	240978.1	7044850	51J
MUBI	241920.3	7045171	51J
MUBI	241961.1	7045169	51J
MUBI	241972.2	7045152	51J
MUBI	242041.3	7045079	51J
MUBI	242035.2	7045070	51J
MUBI	241977.8	7045002	51J
MUBI	241978.1	7044823	51J
MUBI	241978.4	7044816	51J

MUBI	242023.9	7044695	51J
MUBI	241360.9	7044644	51J
MUBI	241273.8	7044643	51J
MUBI	241273.3	7044643	51J
MUBI	241194.1	7044644	51J
MUBI	241069.6	7045177	51J
MUBI	240941.6	7045139	51J
MUBISCAT	241919.3	7045143	51J
MUST	241664.7	7045208	51J
MUST	241885.4	7045251	51J
MUST	242105.2	7044778	51J