



Lake Mackay Sulphate of Potash Project

Level 2 Vertebrate and Targeted Fauna Survey

Prepared for
Agrimin Limited
by Strategen

January 2018

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Client: Agrimin Limited

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Executive Summary

Agrimin Ltd (Agrimin) commissioned Strategen to undertake a level 2 vertebrate and targeted fauna survey for the Lake Mackay Sulphate of Potash (SOP) Project. Lake Mackay (locally known as Wilkinkara) is a seasonally inundated salt lake located in the Great Sandy Desert on the Western Australian (WA) and Northern Territory (NT) border, with most of the lake located in WA. The SOP project comprises 12 tenements covering the majority of Lake Mackay for a combined area of approximately 347,722 ha (Figure 1). The nearest township is Kiwirrkurra, approximately 65 km south-west of the lake.

Searches of the WA Department of Biodiversity, Conservation and Attractions (DBCA) threatened fauna database (150 km search), EPBC Protected Matters Search Tool (60 km search) and NatureMap (3 x 40 km search, [40 km is the maximum search that can be undertaken with this database]) radial searches (centred on approximately the middle of the Survey Area) were undertaken to identify fauna species of conservation significance potentially occurring in the Survey Area.

The field survey was undertaken for a total of 12 days from 10 to 21 November 2017 (there were an additional three days of travel). The survey involved a trapping programme, targeted searches for conservation significant species (particularly Great Desert Skink, Night Parrot and Bilby), habitat assessments, camera traps, Song Meter 2 (SM2) acoustic recording units (for the Night Parrot) and opportunistic observations. The primary focus of the survey was two proposed infrastructure areas – the western and southern areas - and then a greater Study Area (that includes the Western Australian side of Lake Mackay).

Three staff (Principal Zoologist, Zoologist and Principal Ecologist) set up the trap sites which included trap site selection, the digging of pitfall traps and fences, and the laying out of Elliott and cage traps before proceeding to carry out the survey. The field staff were greatly assisted by the Kiwirrkurra IPA Rangers and Ranger Co-ordinator, given their extensive local knowledge and experience with the fauna of the region. In addition, the Rangers have exceptional track identification skills and this was utilised wherever and whenever possible.

Database searches returned 94 vertebrate species from 40 families. Of these, 37 were reptile species from eight families, 36 were bird species from 21 families and 21 were mammal species from 11 families.

A total of 25 conservation significant species (including Priority species) were identified during the desktop review of database searches (Appendix 2). These comprised one reptile species, 19 bird species from 12 families and five mammal species from three families. A total of 21 conservation significant species were then considered for the likelihood of occurrence in the Survey Area (outlined in Table 9 and reported in the results).

During the field survey, 117 species from 51 families were recorded. This consisted of two amphibian species from one family, 38 reptile species from nine families, 65 bird species from 33 families and 12 mammal species from eight families. Four of the 12 mammal species were introduced - the Red Fox (*Vulpes Vulpes*), the Feral Cat (*Felis catus*), the European Rabbit (*Oryctolagus cininculus*) and the Camel (*Camelus dromedarius*).

Four broad fauna habitats were identified in the proposed western and southern infrastructure areas:

- Dune / Swale
- Claypan Swale
- Lake Margin
- Sandplain.

These habitats are widespread and common in the Study Area and more broadly across the region.

During the targeted fauna survey, none of the species targeted were recorded and no other species of conservation significance were documented. The six species of conservation significance - Great Desert Skink, Night Parrot, Princess Parrot, Brush-tailed Mulgara, Bilby and Northern Marsupial Mole (the Marsupial Mole was not specifically targeted during this survey because of survey constraints) - that were targeted during this survey are still considered Likely (except for the Night Parrot – see section 5.2.2) to occur in the proposed infrastructure areas and greater Study Area. They are all considered likely to occur because of the following reasons:

- there are records of these species in the region
- suitable habitat is present in the proposed infrastructure areas and greater Study Area
- to date, surveys for species such as the Night Parrot can only be considered preliminary
- survey conditions (detectability) for species such as the Night Parrot were considered suboptimal
- more survey effort, particularly in the proposed western infrastructure area (and immediate surrounds) would most likely result in more species being recorded, including those of conservation significance.

In conclusion, a lack of observation of these conservation significant species during the field survey does not necessarily mean a lack of presence. Relatively limited survey effort, limited access, limited database results (due to few previous ecological studies), remoteness of the location and suitable habitat availability make it difficult to dismiss these species, particularly as detectability is low for many of them. Further survey effort may be required, particularly in the proposed western infrastructure area, or any further potential areas of disturbance that may be considered and are so far un-surveyed. In addition, for certain species such as the Night Parrot, additional survey effort may need to be guided by favourable environmental conditions such as large rainfall events which appear to trigger less cryptic behaviour in Night Parrots found elsewhere.

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1. Introduction

1.1 The Project

Agrimin Ltd (Agrimin) is looking to develop a Sulphate of Potash (SOP) Project at Lake Mackay (locally known as Wilkinkara) which is a seasonally inundated salt lake located in the Great Sandy Desert on the Western Australian (WA) and Northern Territory (NT) border, with most of the lake located in WA. Lake Mackay is the 4th largest salt lake in Australia dominated by an episodically inundated shallow lake bed as well as surrounding freshwater claypans.

The SOP project comprises 12 tenements covering most of Lake Mackay for a combined area of approximately 347,722 ha (Study Area). The nearest major town is Alice Springs which is approximately 540 km south-east and the nearest community is Kiwirrkurra, approximately 65 km south-west of the lake (Figure 1).

Agrimin has executed Land Access and Native Title Agreements with the Kiwirrkurra People and the Company is encouraged by the high level of support that local Aboriginal people are providing to the Project. The SOP project also lies within the Kiwirrkurra Indigenous Protected Area (IPA) where the Kiwirrkurra Rangers undertake work on country to help conserve the biodiversity and cultural values of the land.

In September 2016, Ecologia (2017) undertook a level 1 fauna assessment in conjunction with a single-phase level 2 flora survey with the potential Project disturbance footprint focussed on a proposed infrastructure envelope (the southern area) located on the southern boundary of the lake (Figure 2). In April and May 2017, 360 Environmental (2017a, b and c) undertook a series of ecological studies that included:

- a second phase flora and vegetation survey of several Islands on Lake Mackay, two proposed infrastructure areas (eastern and western), a proposed bore field and an access track
- a Waterbird survey at various sites on the lake and at a number of claypans off the lake
- a single-phase fauna survey (vertebrates and Short Range Endemic Invertebrate fauna [SREs]) that included an assessment of several islands on the lake and in two proposed infrastructure areas (eastern and western)
- a subterranean fauna pilot study.

The May 2017 fauna survey was primarily focused on two proposed infrastructure areas (the southern area and a new eastern area [Figure 1]) adjacent to the southern boundary of the lake and two islands located on the lake together with habitat assessments and opportunistic observations on several other small islands on the lake.

Following these surveys and due to the addition of a third proposed infrastructure area (the western area, Figure 1) which had not been surveyed previously as part of the SOP project, Agrimin commissioned Strategen to undertake a second-phase level 2 fauna survey and targeted fauna survey for the proposed western and southern infrastructure areas. The subsequent November 2017 fauna survey primarily focussed on these two proposed infrastructure areas. These two locations, along with other opportunistic observations made while travelling by helicopter, vehicle and by foot between survey sites, are collectively referred to as the Survey Area (Figure 1).

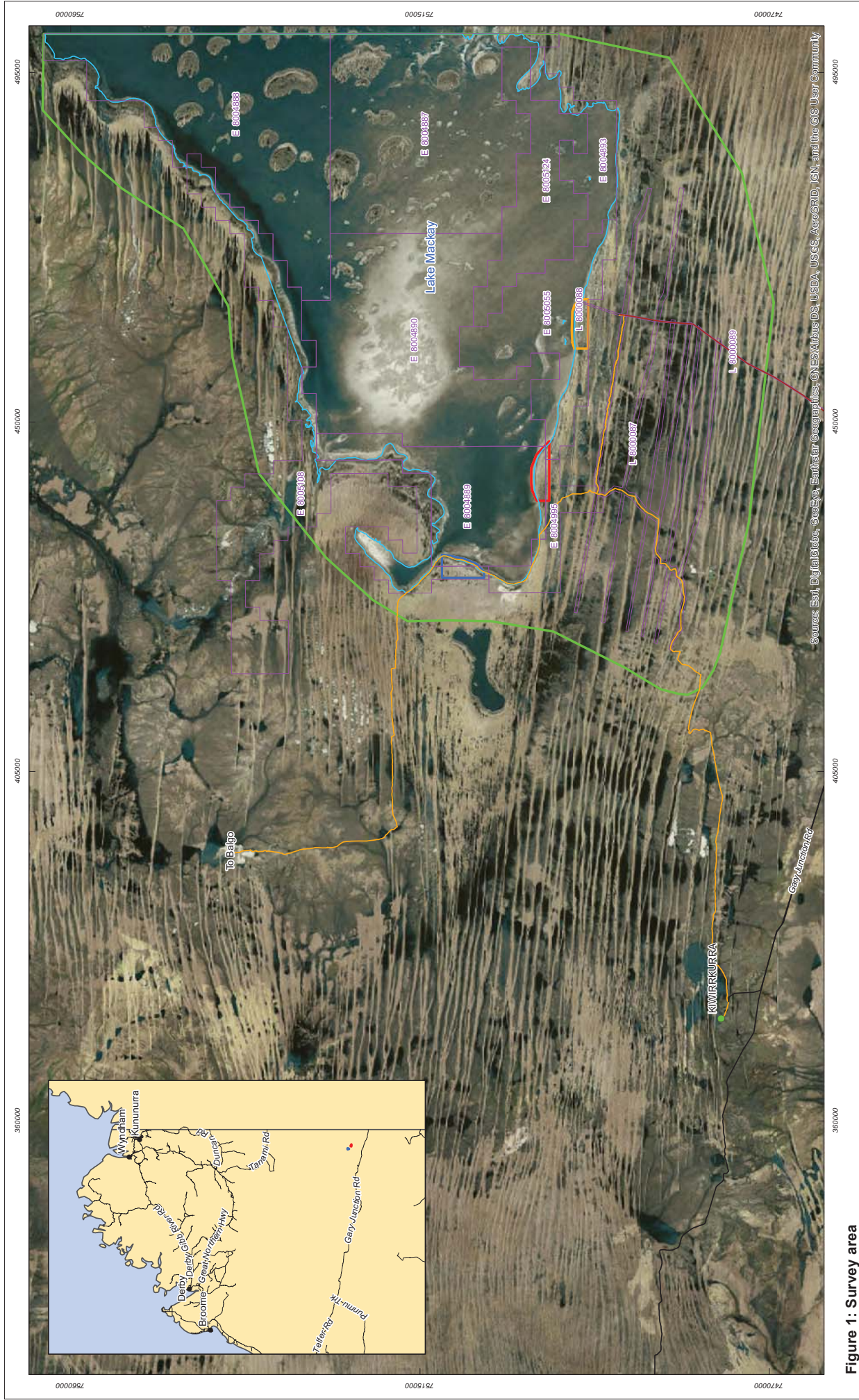
It should be noted that the proposed southern, eastern and western infrastructure areas provide options for the location of off-lake infrastructure, with only one of these areas to be selected for future Project development related activities.

The purpose of this assessment was to provide Agrimin with further and more detailed data to support environmental approvals for the SOP project.

1.1.1 Objectives

The broad objectives of the level 2 fauna survey were to:

- conduct a desktop review of fauna databases and relevant literature
- undertake a baseline fauna survey to characterise fauna in the southern and western infrastructure areas
- undertake a targeted survey for fauna species of conservation significance
- undertake habitat assessments to define and delineate the main broad habitats present
- document all of the above in a comprehensive report.



1.2 Background to Protected Fauna

Fauna is protected formally and informally by various legislative and non-legislative measures.

Legislative measures:

- Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)
- Biodiversity Conservation Act 2016 (BC Act)
- Wildlife Conservation Act 1950 (WC Act)
- Environmental Protection Act 1986 (EP Act).

Non-legislative measures:

- WA Department of Biodiversity, Conservation and Attractions (DBCA) Priority lists for flora, ecological communities and fauna
- recognition of locally significant populations by DBCA.

A short description of each is given below. Other definitions, including species conservation categories, are provided in Appendix 1.

1.2.1 EPBC Act

The EPBC Act aims to protect matters of national environmental significance, which are detailed in Appendix 1. Under the EPBC Act, the Commonwealth Department of the Environment and Energy (DEE) lists protected species and Threatened Ecological Communities (TECs) by criteria set out in the Act. Species are considered to be conservation significant if they are listed as Threatened (i.e. Critically Endangered, Endangered and Vulnerable) or Migratory.

Bird species protected as Migratory under the EPBC Act include those listed under international migratory bird agreements relating to the protection of birds which migrate between Australia and other countries, for which Australia has agreed. This includes the Japan-Australia Migratory Bird Agreement (JAMBA), the China-Australia Migratory Bird Agreement (CAMBA), the Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA) and the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

Some marine fauna or terrestrial fauna that use marine habitats are listed as Marine under the EPBC Act. These species are only considered conservation significant when a proposed development occurs in a Commonwealth marine area (i.e. any Commonwealth Waters or Commonwealth Marine Protected Area). Outside of such areas, the EPBC Act does not consider these species to be matters of national environmental significance so are not protected under the Act. As such, species listed as Marine only under the EPBC Act are not considered to be conservation significant in this assessment.

1.2.2 WC Act

DBCA lists taxa under the provisions of the WC Act as protected and are classified as Schedule 1 to Schedule 7 according to their need for protection (see Appendix 1). The WC Act makes it an offence to 'take' threatened species without an appropriate licence. There are financial penalties for contravening the WC Act.

1.2.3 EP Act

Significant habitat necessary for the maintenance of fauna indigenous to Western Australia as well as TECs is given special consideration in environmental impact assessments, and areas covered by TECs have special status as Environmentally Sensitive Areas (ESAs) under the EP Act and the Environmental Protection (Clearing of Native Vegetation) Regulations 2004.

1.2.4 DBCA Priority Lists

DBCA lists 'Priority' fauna that have not been assigned statutory protection as 'Scheduled' under the WC Act, but which are under consideration for declaration as 'Scheduled' fauna. In summary, Priority 1 fauna are those with few, poorly known populations on threatened lands, Priority 2 fauna are species with few poorly known populations on conservation lands and Priority 3 fauna are those with several poorly known populations, some on conservation lands. Priority 4 fauna are species in need of monitoring: not currently threatened or in need of special protection, but could become so and usually represented on conservation lands. Priority 5 fauna are species in need of monitoring: not considered threatened, but the subject of a specific conservation programme, the cessation of which would result in the species becoming threatened within five years (Appendix 1).

In addition, DBCA maintains a list of Priority Ecological Communities which identifies those communities that need further investigation before possible nomination for TEC status.

Although DBCA Priority species and communities have no formal legal protection, they are under consideration as 'Scheduled' taxa under the WC Act or as ESAs under the EP Act Informal Recognition of Fauna.

1.2.5 Informal Recognition of Threatened Fauna

Certain populations or communities of fauna may be of local significance or interest because of their patterns of distribution and abundance. For example, fauna may be locally significant because they are range extensions to the previously known distribution or are newly discovered species (and have the potential to be of more than local significance). In addition, many species are in decline as a result of threatening processes (land clearing, grazing, and changed fire regimes) and relict populations of such species assume local importance for DBCA. It is not uncommon for DBCA to make comment on these species of interest.

2. Biophysical Environment

2.1 Climate

The Great Sandy Desert Bioregion experiences an arid tropical climate in the north, grading into a temperate-subtropical climate in the south, where dry conditions with hot summers and mild winters occur (Tille 2006).

The nearest and most relevant Bureau of Meteorology (BoM) weather station for the greater Study Area is Walungurru Airport (Station No. 0015664), approximately 120 km south-east of the southern section of the greater Study Area. The Walungurru Airport station receives a mean minimum temperature that ranges from 10.4°C to 26°C and mean maximum that ranges from 23.2°C to 39.4°C. The annual average rainfall is 306.1 mm (BoM 2017).

Walungurru Airport station recorded 696 mm of rain in the 12 months prior to the survey (November 2016 – October 2017) which is 390.1 mm above the long-term average rainfall for the same period (Figure 2). In the three months prior to the survey (August – October 2017) 40.6 mm of rainfall was recorded which is below the 94.6 mm average rainfall for the same period (BoM 2017).

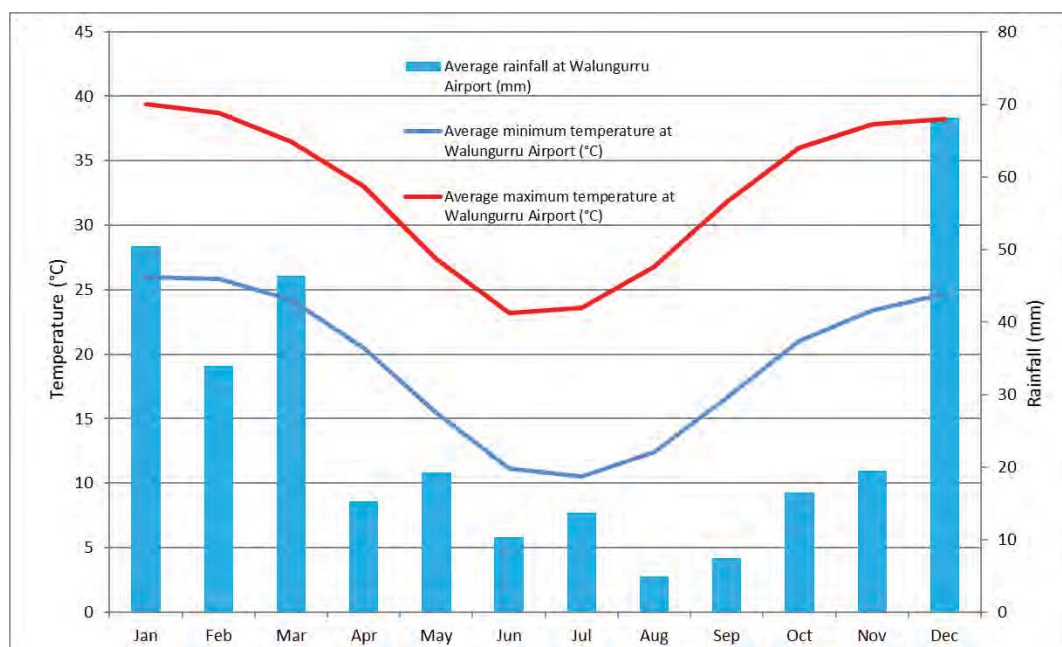


Figure 2: Mean monthly climatic data for temperature (2001 to 2017) and rainfall (1998 to 2017) from the Walungurru Airport weather station.

Local temperature and rainfall statistics are also now recorded at the Agrimin camp site located approximately 8 km to the south of the lake. The data for November 2017 is shown in Table 1.

Table 1: Rainfall and maximum and minimum temperatures for the Agrimin camp site in November 2017.

Date (November 2017)	Max temp (°C)	Min Temp (°C)	Rainfall (mm)
1	35	15	0
2	35	15	0
3	35	15	0
4	42	15	0
5	41	15	0
6	44	15	0
7	40	15	0
8	35	18	0.5
9	37	18	0
10	25	18	0
11	35	15	2
12	37	18	0
13	41	20	3
14	42	22	0
15	38	24	0
16	38	22	2.5
17	40	23	0
18	43	23	0
19	41	23	2
20	41	24	8
21	44	22	0
22	43	22	0

Date (November 2017)	Max temp (°C)	Min Temp (°C)	Rainfall (mm)
23	43	23	0
24	41	26	0
25	40	25	0
26	35	24	0
27	39	21	0
28	41	21	0
29	40	21	25
30	43	21	0

2.2 Soils

The dominant soils of the Great Sandy Desert dune fields and sandplains are red deep sands and red sandy earths, with some red loamy earths and shallow gravels in depressions between dunes (Tille 2006). Hilly areas typically comprise red loamy earths, with red shallow loams, red shallow sands, stony soils and shallow gravels (Tille 2006). Five soil units have been mapped within the greater Study Area using the Digital Atlas of Australian soils (Bureau of Rural Sciences 2009) (Table 2). However, only two soil units have been mapped for the two proposed infrastructure areas during this survey (Figure 3).

Table 2: Soil units and their occurrence in the greater Study Area.

Soil Unit	Description
AB39	Gently undulating plain dominated by longitudinal dunes of varying frequency; some exposures of ironstone gravels on low rises occur in the dune swales.
AB55	Broad, very gently undulating upland (tableland) elevated above adjacent dune fields; some low laterite-capped residuals showing exposures of sedimentary rocks; some dunes, some salt lakes and pans.
AB56	Plains extensively covered with longitudinal dunes; some hilly residuals with rock outcrops.
SV12	Plains studded with salt pans, seasonal lakes; calcrete (kunkar) platforms; and fringing dunes.
MY110	Plains with some longitudinal dunes; some stony residuals of sedimentary rocks which are sometimes capped with a lateritic dust.

2.3 Geology

The Survey Area lies in the Canning Province of the Great Sandy Desert bioregion as described by Tille (2006). The inland landforms of the Great Sandy Desert are predominantly east to west running linear dunes with swales opening locally onto sandplains. Some undulating plains and uplands occur. Among the dunes are areas of small claypans and isolated residual sandstone hills as well as areas of ironstone gravels and some breakaways capped by laterite duricrust (Tille 2006). Seven geological units have been mapped in the greater Study Area as part of the Geological Series of WA (Table 3).

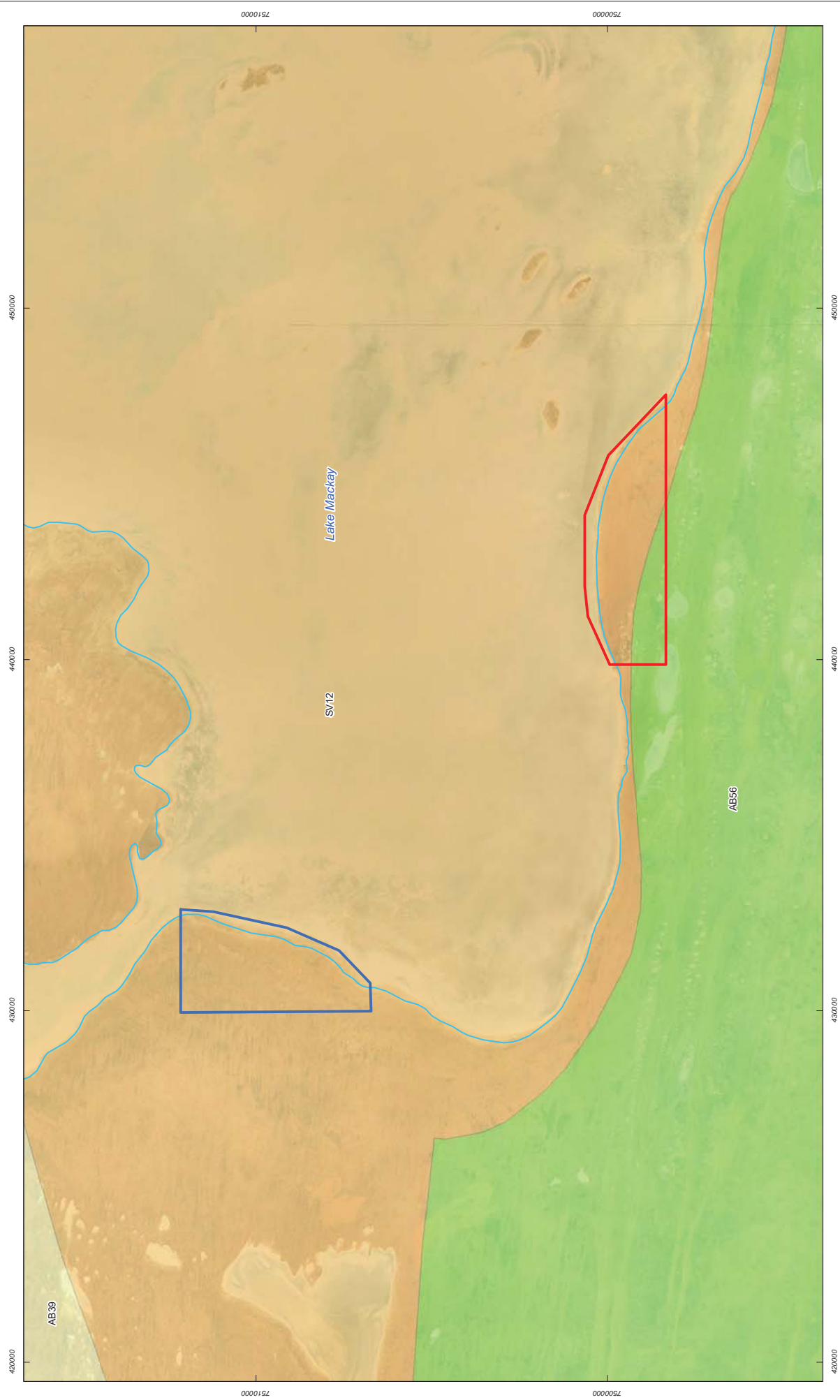
Table 3: Geology in the greater Study Area.

Geological Code	Description
Colluvium 38491	Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite.
Lake Deposits 38492	Lacustrine or residual mud, clay, silt and sand, commonly gypsiferous and/or saline; playa, claypan, and swamp deposits; peat; peaty sand and clay; halitic and gypsiferous evaporites.
Dunes 38496	Dunes, sandplain with dunes and swales; may include numerous interdune claypans; residual and aeolian sand with minor silt and clay; aeolian red quartz sand, clay and silt, in places gypsiferous; yellow hummocky sand.
Calcrete 38497	Pisolitic, nodular or massive calcrete; ferruginous inclusions; calcerous cementing of bedrock and transported materials; locally with intercalated chalcony; as low mounds, in playa lakes, or as valley calcrete; locally dissected and karstified
Sandplain 38499	Sandplain may include some residual alluvium; sand dominant; gravel, clay.
Lunette Dunes 72955	Quartz and gypsum dunes and mounds (kopi); may include minor silt, sand, gravel, and clay flats adjacent to playas; locally includes some playa sediments.
Alluvium 74331	Reworked or incised sandy alluvium in older stream channels; lateritised alluvial terraces above younger alluvium; alluvial and colluvial outwash deposits not in defined channel systems; sand, silt, gravel, clay, evaporates.

2.4 Biogeographical Regionalisation of Australia

The Biogeographic Regionalisation of Australia (IBRA7) divides Australia into 89 bioregions based on major biological, geographical and geological attributes. These bioregions are subdivided into 419 subregions as part of a refinement of the IBRA framework (DEE 2016a). The Survey Area extends across the Mackay subregion which forms part of the Great Sandy Desert Bioregion (Figure 4).

The Great Sandy Desert Bioregion includes the tropical inland 'red-centre' desert as well as the 'Percival' and 'Auld' palaeoriver systems. It mainly comprises tree steppe grading to shrub steppe in the south, with open hummock grasslands of *Triodia pungens* and *Triodia schinzii* together with scattered trees of *Owenia reticulata* and Bloodwood (*Corymbia* spp.), and shrubs of *Acacia* spp., *Grevillea wickenhamii* and *G. refracta* on Quaternary red longitudinal sand dune fields overlying Jurassic and Cretaceous sandstones of the Canning and Amadeus Basins. *Casuarina decaisneana* (Desert Oak) occurs in the south and east of the region. Gently undulating lateritised uplands support shrub steppe such as *Acacia pachycarpa* shrublands over *Triodia pungens* hummock grass. Calcrete and evaporate surfaces are associated with occluded palaeo-drainage systems that traverse the desert. These include extensive salt lake chains with samphire low shrublands and *Melaleuca glomerata* to *M. lasiandra* shrublands. The climate is arid tropical with summer rainfall (Kendrick 2001).



Scale 1:100,000 at A3

0 1,100 2,200 3,300 m

N

Legend

□ Lake Mackay

□ Proposed southern infrastructure area

□ Proposed western infrastructure area

Soil Landscape Mapping Unit

AB39

AB56

SV12

Coordinate System: GDA 1984 MGA Zone 52

Note that positional errors may occur in some areas

Date: 20/12/2017

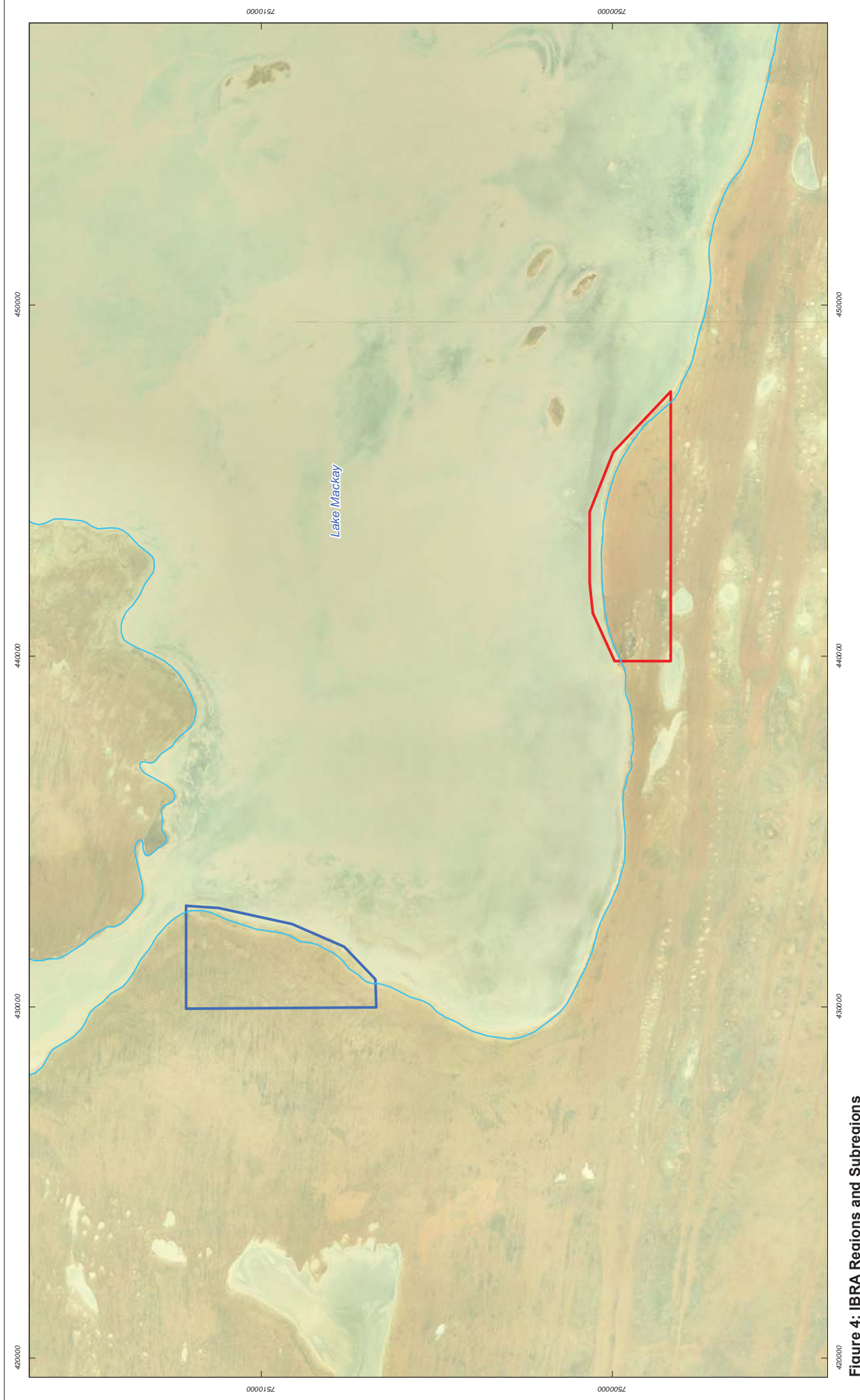


Figure 4: IBRA Regions and Subregions

Scale 1:100,000 at A3

0 1,100 2,200 3,300 m

North Arrow

Legend

- Blue outline: Lake Mackay
- Red outline: Proposed southern infrastructure area
- Blue outline: Proposed western infrastructure area

IBRA Region and Subregion

- Yellow box: Great Sandy Desert, Subregion Mackay

Coordinate System: GDA 1984 MGA Zone 52
 Note that positional errors may occur in some areas
 Date: 20/12/2017
 Author: J. Crute
 Project: IBRA Regions and Subregions
 File: G:\Data\2017\IBRA\IBRA_Region\Subregions\IBRA_Region_Mackay\IBRA_Region_Mackay_2017.mxd

2.5 Broad Vegetation Types

Mapping of the vegetation of the Great Sandy Desert region of WA was completed on a broad scale (1:1,000,000) by Beard (1976). These vegetation types were later re-assessed by Shepherd et al. (2001) to account for clearing in the intensive land use zones, dividing some larger vegetation units into smaller units. The current pre-European vegetation mapping dataset of WA is an output of a joint project between DAFWA and DBCA (Beard *et al.* 2013).

This mapping forms the basis of the vegetation extent statistics released annually by DBCA. There are four Shepherd et al. (2001) vegetation associations occurring within the greater Study Area. These vegetation types are described in Table 4.

Table 4: Broad vegetation types in the greater Study Area.

Shepherd Vegetation Unit	Description
125-Great Sandy Desert	Bare areas; salt lakes.
134-Great Sandy Desert	Mosaic: Hummock grasslands, open low tree steppe, desert bloodwood and feathertop spinifex on sandhills/hummock grasslands, shrub steppe; mixed shrubs over spinifex between sandhills.
174-Great Sandy Desert	Hummock grasslands, shrub steppe; mixed shrubs over soft spinifex.
2041-Great Sandy Desert	Succulent steppe with scrub; tea tree over salt flats.

2.5.1 Previous Ecological Studies

The Survey Area is very remote, with the nearest community being Kiwirrkurra with around 200 people lying approximately 65 km to the south-west of Lake Mackay. The nearest population of note is Alice Springs which is approximately 580 km south-east of the lake. Access to the lake from Kiwirrkurra is primarily limited to one main, unsealed track.

Given Lake Mackay's remoteness, there has been comparatively little fauna survey work undertaken in or surrounding the Survey Area. Nevertheless, there have been some recent surveys completed associated with this Project (360 environmental 2017a, b and c, Ecologia 2017) and nearby in the Kiwirrkurra Indigenous Protected Area (IPA) as part of the Bush Blitz (2015) programme (this is a partnership between the Australian Government through Parks Australia and the Australian Biological Resources Study, BHP Billiton Sustainable Communities and Earthwatch Australia).

Previous ecological studies are summarised in Table 5 below.

Table 5: Previous ecological studies undertaken in the proposed infrastructure areas and in or near the greater Study Area.

*Conservation significance is based on listing as of submission date on report and includes species listed as Priority species by DBCA Service (Department of Biodiversity, Conservation and Attractions [DBCA]), Scheduled under the WC Act and threatened under the EPBC Act.

Reference	Survey Type	Survey Date	Proximity to Survey Area	Methods	Broad Habitats Described	*Conservation Significant Species Recorded
Level 2 Vertebrate Fauna Survey at Lake Mackay for Agrimin (360 Environmental July 2017a)	Level 2 vertebrate fauna baseline survey	10 – 19 May 2017	Same Survey Area	<ul style="list-style-type: none"> Systematic trapping (pitfall, Elliott, cage and funnel traps) Bird surveys Bat surveys using SM2 detectors Camera traps Spotlighting Habitat assessments Opportunistic observations Searches for evidence of conservation significant species. 	<ul style="list-style-type: none"> Dune Swale Claypan swale Lake margin. 	
Detailed Flora and Vegetation Assessment at Lake Mackay for Agrimin (360 Environmental July 2017b)	Second-phase Detailed flora and vegetation assessment	14 – 23 April 2017	Same Survey Area	The survey included an assessment of 34 (50 x 50 m) quadrats, 24 (3 x 3m) quadrats from 4 transects and 11 relevés. Additionally, a series of targeted searches and opportunistic collections were undertaken in the survey area.	<ul style="list-style-type: none"> Sandplain Dunes Island dunes Claypan plains Island swales Lake margin Saltpan. 	<ul style="list-style-type: none"> <i>Tecticornia globulifera</i> (P1) <i>Goodenia virgata</i> (P2) <i>Goodenia modesta</i> (P3).
Waterbird Survey at Lake Mackay for Agrimin (360 Environmental July 2017c)	Primarily a waterbird survey (also comprised other birds) that included ground and aerial assessments	14 -17 April 2017	Same Survey Area	<ul style="list-style-type: none"> Ground survey with binoculars and spotting scope (visual and aural identification of birds) Aerial survey with helicopter – identification with the unaided eye and binoculars. 	<ul style="list-style-type: none"> Saline open water of Lake Mackay Claypans to the south of Lake Mackay. 	<ul style="list-style-type: none"> Australian Painted Snipe (<i>Rostratula australis</i>) Common Greenshank (<i>Tringa nebularia</i>) Red-necked Stint (<i>Calidris ruficollis</i>) Sharp-tailed Sandpiper (<i>Calidris acuminata</i>).

Reference	Survey Type	Survey Date	Proximity to Survey Area	Methods	Broad Habitats Described	*Conservation Significant Species Recorded
Level 1 fauna and single phase level 2 flora assessment at Lake Mackay for Agrimin (Ecologia 2017)	Level 1 fauna and Level 2 flora and vegetation assessment (please note that only the fauna component is summarised here)	6-13 September 2016	Similar Survey Area	<ul style="list-style-type: none"> Habitat assessments Transects on foot to search for signs i.e. burrows, scats and footprints Camera traps Bat survey using Song Meter 2 (SM2) acoustic recording device Opportunistic observations. 	<ul style="list-style-type: none"> Sandplain Saline Flats Dunefields Samphire Mulga Woodlands Stony Rise. 	<ul style="list-style-type: none"> Rainbow Bee-eater (<i>Merops ornatus</i>) Northern Marsupial Mole (<i>Notoryctes caurinus</i>) (sign - old tunnels evident in cross section of a dune).
Kiwirrkurra Indigenous Protected Area Bushblitz Survey (Cowan, M., Bray, R., & Patridge, R. 2015)	Survey of mammals and reptiles	5-19 September 2015	Some sites in the current Survey Area, the remaining around Kiwirrkurra and Nyinmi (about 100 km west of Kiwirrkurra)	<ul style="list-style-type: none"> Pitfall traps (20 Litre buckets) with 50-60 m drift fence Funnel traps Elliott traps Camera traps Bat survey using Song Meter 2 (SM2) acoustic recording device Timed active foraging Spotlighting Opportunistic observations. 	<ul style="list-style-type: none"> Sandplain Dunes Mulga Woodland Low rocky hills Boulder piles. 	<ul style="list-style-type: none"> Great Desert Skink (<i>Liopholis kintorei</i>) Northern Marsupial Mole (<i>Notoryctes caurinus</i>) tracks Bilby (<i>Macrotis lagotis</i>).

3. Methods

3.1 Background

The Level 2 vertebrate fauna survey and the targeted fauna survey were compliant with the EPA requirements for the environmental survey and reporting of fauna in WA and relevant EPBC Act survey guidelines, where practicable and relevant, and as set out in the following documents:

- Terrestrial Biological Surveys as an Element of Biodiversity Protection. Position Statement No. 3 (EPA 2002)
- EPA Guidance Statement No. 51, Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA 2004)
- Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia. Guidance Statement No. 56 (EPA 2004)
- Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA-DEC 2010)
- Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016)
- Interim guideline for the preliminary surveys of Night Parrot (*Pezoporus occidentalis*) in Western Australia. Version 1 – May 2017 (DBCA 2017)
- Guidelines for surveys to detect the presence of Bilbies, and assess the importance of habitat in Western Australia. Version 1 – August 2017 (DBCA 2017)
- Survey Guidelines for Australia's Threatened Birds. EPBC Act survey guidelines 6.2 (2010) (DSEWPaC)
- Survey Guidelines for Australia's Threatened Frogs. EPBC Act survey guidelines 6.3 (2010) (DSEWPaC)
- Survey Guidelines for Australia's Threatened Mammals. EPBC Act survey guidelines 6.5 (2011) (DSEWPaC)
- Survey Guidelines for Australia's Threatened Reptiles. EPBC Act survey guidelines 6.6 (2011) (DSEWPaC).

3.2 Second-phase Fauna Survey Methods

3.2.1 Fauna Database Review

Searches of DBCA's threatened fauna database (150 km search), EPBC Protected Matters Search Tool (60 km search) and NatureMap (3 x 40 km search [40 km is the maximum search that can be undertaken with this database]) radial searches (centred on approximately the middle of the Survey Area) were undertaken to identify fauna species of conservation significance potentially occurring in the Survey Area (DBCA 2017a, DEE 2017; DBCA 2017b) (Appendix 2). Please note that, originally, an 80 km radial search request of the threatened fauna database was submitted to DBCA, however, a 150 km buffer was applied in order to select a greater number of records that adequately demonstrate the potential species composition in the Survey Area. Due to the limitations of the NatureMap search capability, three 40 km searches were undertaken and compiled to adequately demonstrate the potential species composition in the Survey Area.

Collectively, these sources were used to compile a list of species that have been previously recorded in the vicinity of the Survey Area (Appendix 3). This list invariably includes some species that do not occur in the Survey Area as some fauna have a limited or patchy distribution or a high level of habitat specificity for habitats which are not located in the Survey Area. These fauna were examined and then excluded from the list, where relevant.

3.2.2 Field Survey

The field survey was undertaken for a total of 12 days from 10 – 21 November 2017 (there were an additional three days of travel). Three staff (Principal Zoologist, Zoologist and Principal Ecologist) set up the trap sites which included trap site selection, the digging of pitfall traps and fences, and the laying out of Elliott and cage traps before proceeding to carry out the survey.

The field staff were greatly assisted by the Kiwirrkurra IPA Rangers and Ranger Co-ordinator (Photos 1, 2 and 3), given their extensive local knowledge and experience with the fauna of the region. The Rangers also have exceptional track identification skills and this was utilised wherever and whenever possible.



Photo 1: IPA Rangers and Ranger Co-ordinator assisting Strategen staff with fauna trapping



Photo 2: IPA Ranger and Ranger Co-ordinator checking fauna traps



Photo 3: IPA Ranger (Nolia) with captured Bynoe's Gecko (*Heteronotia binoei*)

The purpose of the field survey was to build on the information gained during the first phase in May 2017, providing a more comprehensive description of the fauna values in the previously surveyed southern area and in the proposed western infrastructure area.

The field survey consisted primarily of a baseline trapping programme, fauna habitat assessment, opportunistic observations, camera traps and spotlighting (although this was limited due to restricted access to sites). A targeted survey for species of conservation significance was undertaken concurrently (see section 3.3 for methods).

It is important to note that, due to the vast size and remoteness of the study area, it was not possible for it to be surveyed and accessed in its entirety. There are a very limited number of existing tracks and no off-track driving is permitted as part of an agreement with the local Traditional Owners (Kiwirrkurra People).

Consequently, access for the most part was limited to the use of a helicopter (particularly as trapping equipment and digging tools cannot be carried far off tracks), with the survey effort primarily focussing on the proposed infrastructure areas and surrounds.

3.2.3 Baseline Trapping Programme

A total of four trap sites (systematic sample units) were sampled in a range of habitats in the southern and western proposed infrastructure areas. Trap site locations chosen were representative of the habitat types present in the Survey Area. Two trap sites were established in each of the proposed infrastructure areas - SA1 and SA2 in the southern area, WA1 and WA2 in the western area (Figure 5a and 5b).

Data collected systematically (i.e. where methods and effort are the same per sample unit) can be analysed to determine patterns in the species richness, abundance and composition of the fauna. Trap sites were selected to obtain a broad coverage of the habitats available in the Survey Area and to be readily accessible to check traps in a timely manner from an animal ethics perspective (Table 6 and Appendix 4).

Table 6: Trap site locations.

Trap Site	Location	Habitat	Easting	Northing
SA1	Southern Proposed Infrastructure Area	Dune and swale	444832	7499224
SA2	Southern Proposed Infrastructure Area	Dune and swale	443095	7499481
WA1	Western Proposed Infrastructure Area	Dune and swale	431317	7509099
WA2	Western Proposed Infrastructure Area	Sandplain	431987	7510480



Figure 5a: Habitat mapping (Proposed western infrastructure area)

Scale 1:32,000 at A3

0 220 440 660 880 m

Coordinate System: GDA 1984 MGA Zone 52

Note that positional errors may occur in some areas

Date: 21/12/2017

Author: JCrute

Path: G:\C:\2017\AGI\AGI1748_V1_GIS_documents\190224\AGI1748_001_RevC.mxd

Legend

November 2017 survey

- Habitat assessment
- Night Parrot SM2 locations
- Trap site location
- 2-Ha Plot

Mine design

- Proposed western infrastructure area
- Causeway link to on-lake infrastructure
- Road
- Solar heating system
- Stockpile
- Truck facilities
- Vehicle facilities

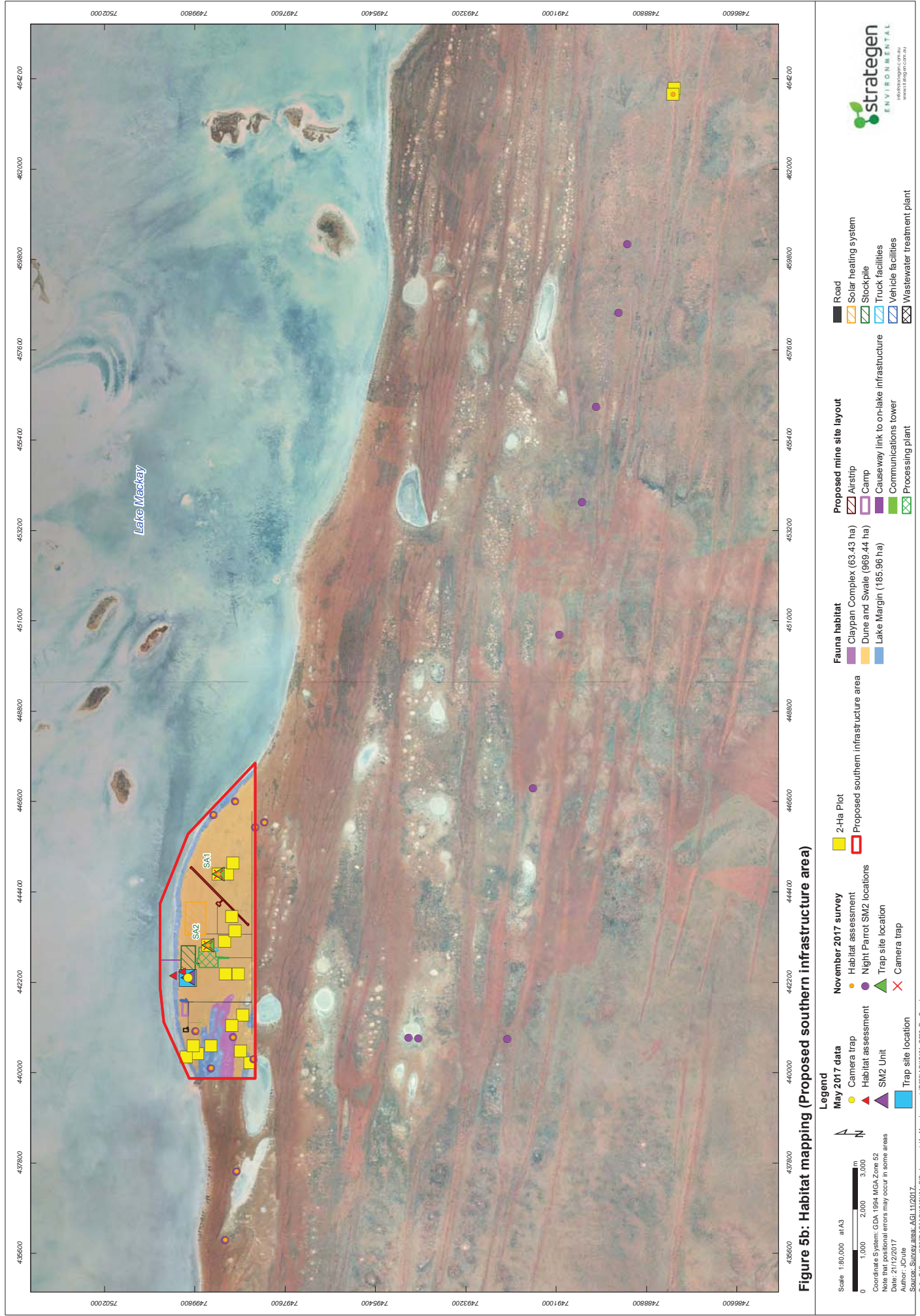
Fauna habitat

- Dune and Swale (689.08 ha)
- Sandplain (335.42 ha)
- Lake Margin (196.18 ha)

Wastewater treatment plant

- Processing plant

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The trapping programme was carried out over seven nights at each of the trap sites, with the same survey effort (time, number of traps and search effort [defined as trap nights and person minutes]). All of the trap sites consisted of a 100 m x 100 m (1 ha) quadrat.

The trap site set up in each quadrat consisted of the following (Figure 6):

- ten pitfall traps with drift fence, consisting of two lines of five pitfall traps (10 x 20 L buckets) at 5 m intervals, each with a 20 m section of drift fence
- set along the sides of the drift fence are 16 funnel traps (8 at each pitfall line)
- around the perimeter of the quadrat 10 Elliott and four cage traps were spaced equidistantly
- Elliott and cage traps were baited with sardines and universal bait (peanut butter, oats and water).

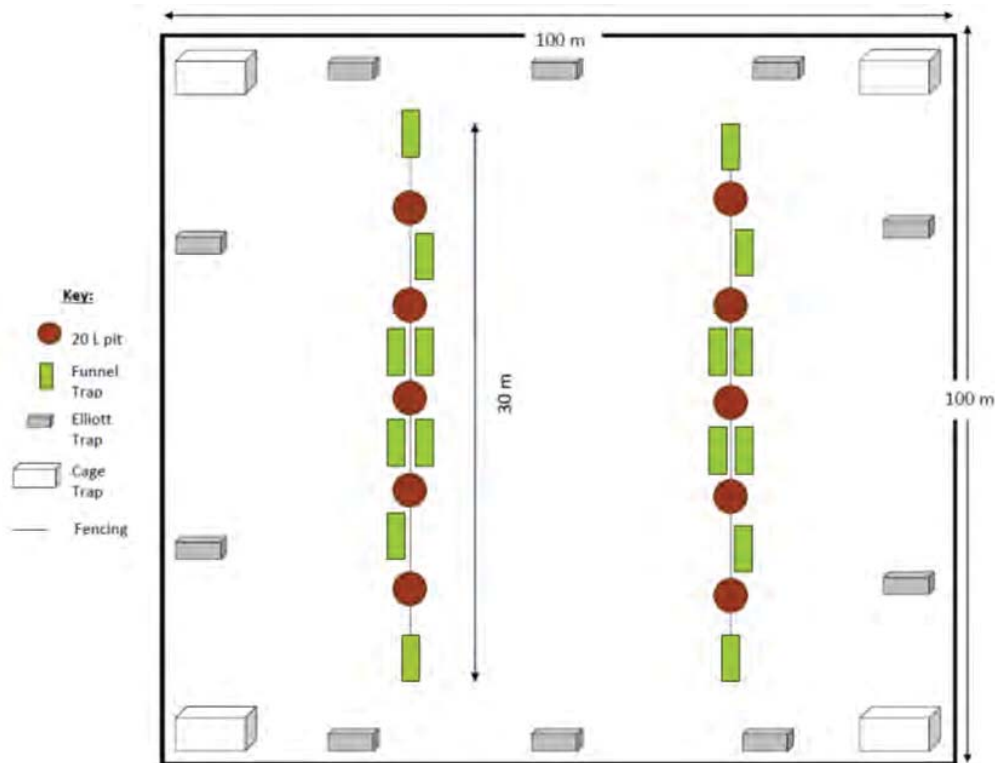


Figure 6: Quadrat Layout

Valuable assistance was provided by the Kiwirrkurra IPA Rangers with regard to trap site set-up.



Photo 4: IPA Ranger assisting Strategen staff with installing pitfall traps

Table 7 provides a summary of the survey effort across both the May 2017 fauna survey and the November 2017 fauna survey.

Please note that at each of the four trap sites during the November 2017 fauna survey, Elliott traps and cage traps were closed on a number of occasions for animal ethics reasons due to extremely high temperatures.

Table 7: Summary of effort undertaken in the Survey Area at the trap sites.

Trap Site	Pitfall Buckets - No. of Nights	Funnel Traps - No. of Nights	Elliott Traps – No. of Nights	Cage Traps – No. of Nights	Bird Survey Person Minutes
May 2017 Fauna Survey					
1	70	112	70	28	90
2	70	112	70	28	90
3	67	112	70	28	90
4	70	112	70	28	90
5	70	112	70	28	90
6	62	112	70	28	90
November 2017 Fauna Survey					
SA1	67	112	40	28	90
SA2	70	112	40	28	90
WA1	70	112	40	28	90
WA2	70	112	40	28	90
Total Effort	686	1120	650	280	900

3.2.4 Habitat Assessment

Vegetation communities and landforms were used to identify the broad fauna habitats in the Survey Area. Habitat assessments were undertaken in each of the four trap sites (Appendix 5) and additional assessments were undertaken at SM2 locations and 2 ha Plot locations throughout the Survey Area. These fauna habitats were then assessed for their potential to support species of conservation significance and the quality of habitat they provide to a wider suite of fauna. The habitat assessments were documented systematically for each habitat type on standardised field sheets.

Overall, a total of 35 habitat assessments were completed for the Survey Area. Each broad habitat type description includes information including:

- location of the broad habitat type within the Survey Area (GPS co-ordinate) and its relative percentage
- habitat condition was assessed at each trap site as 'completely degraded' through to 'pristine', based on the scale given in Keighery (1994)
- landscape position
- dominant vegetation and structure (e.g. number of vegetation strata)
- hollow-bearing trees and dead stags (e.g. average size and abundance of hollows)
- description of any rock and rocky outcrops
- logs (e.g. abundance and size)
- substrate (e.g. leaf litter)
- wetlands, creeks, rivers, dams and other water bodies
- description of any observed nests and roosts (if present)
- subterranean roosts (e.g. caves, disused mineshafts and/or adits)
- associated fauna species observed using the habitat
- disturbance (e.g. cattle grazing, fire)
- photo showing a typical example of the broad habitat type.

The location of the habitat assessments is illustrated in Figures 5a and 5b.

3.2.5 Opportunistic Observations

Fauna were opportunistically observed and recorded during the survey. The opportunistic data supplements the systematic data collected at trap sites (Appendix 6). Opportunistic observations were limited due to the logistics of accessing the Survey Area.

During the opportunistic searches, the following techniques were used: raking through leaf litter, overturning rocks, looking under decorticated bark, investigating burrows, tracks and scats.

In addition, opportunistic records of fauna species encountered while travelling between trap sites were also documented (although, again, limited due to logistics). Opportunistic data comprises records of fauna species by location and coordinates are taken with a GPS in the case of any conservation significant fauna.

3.2.6 Systematic Bird Searches

Systematic bird surveys were undertaken in each of the four trap sites for a total effort of 90 minutes per trap site (see Table 7).

3.2.7 Nocturnal Spotlighting

Spotlighting and head torching at night from vehicles and on foot is an important survey tool as much of the region's fauna is nocturnal and/or crepuscular, particularly conservation significant species such as the Bilby. Due to logistical constraints and the requirement of access via helicopter, distances required to travel and safety considerations given the prevailing weather conditions, spotlighting at each of the trap sites was not possible. Spotlighting was, therefore, undertaken on foot near camp and by vehicle along either side of the access track for approximately 20 km. Spotlighting occurred on two nights for a total of 120 person minutes per night (two fieldworkers searching for 60 minutes each), totalling 240 minutes across two nights.

3.2.8 Camera Traps

Two camera traps were set up during the field survey at the four trap sites for a minimum of two nights (Figures 5a and 5b). Camera traps were baited with sardines and universal bait (peanut butter, oats and water) and placed in their field of view. Cameras were used to target species of conservation significance such as Bilby and Brush-tailed Mulgara.

3.2.9 Taxonomy

Where there is doubt on species names identified in the desktop assessment (through subsequent name changes or taxonomic reviews), an effort was made to determine the current scientific name for each taxon. In some cases, old scientific names may be presented where correct nomenclature could not be determined due to name changes. Some taxon names may be followed by 'sp.', meaning that the species name was not given in the data source, or the identification is in doubt. Where there are previously recorded taxa such as this that have the potential to be a conservation significant species, they are discussed specifically in the results and discussion section.

Taxonomy and nomenclature in this report follows the accepted listing of published terrestrial vertebrate species. The listing for amphibians and reptiles follows Cogger (2014), the listing for birds follows Christidis & Boles (2008) and the listing for mammals follows Van Dyck & Strahan (2008).

3.3 Targeted Fauna Survey Methods

The following targeted vertebrate fauna species surveys were undertaken in the proposed western and southern infrastructure areas (and some areas outside of this [study area]) to determine their presence or absence (survey methods followed relevant guidance as outlined in section 3.1 above where relevant and practical). The species targeted were those deemed as either possible or likely to occur in the survey areas or greater study area based on database search results, known distribution (including known habitat preference) and previous survey results i.e. habitat present in the survey areas and wider study area.

The focus of these targeted surveys was those species listed under the EPBC Act, however, other species were also searched for at the same time, particularly when methods were similar i.e. looking for burrows, tracks and scats as is the case with the Great Desert Skink (Vu – EPBC Act), Bilby (Vu – EPBC Act) and Brush-tailed Mulgara (Priority 4). It is important to note that targeted surveys were done in conjunction with the trapping programme in order to help minimise logistical constraints, however, unavoidably, this also had an impact on the time available to target the species of conservation concern.

Four of the IPA Rangers and the IPA Ranger Co-ordinator (see Acknowledgements) also participated in the targeted surveys. The Rangers were able to utilise their extensive traditional ecological knowledge (TEK) of fauna distribution in the local area together with their ability to identify the signs of these targeted species to help improve the likelihood of detection during the survey. Targeted surveys for the following species were undertaken:

- Great Desert Skink (*Liopholis kintorei*) (Vulnerable under the EPBC Act)
- Night Parrot (*Pezoporus occidentalis*) (Endangered under the EPBC Act)
- Princess Parrot (*Polytelis alexandrae*) (Vulnerable under the EPBC Act)

- Rainbow Bee-eater (*Merops ornatus*) (Marine under the EPBC Act)
- Striated Grasswren (*Amytornis striatus striatus*) (P4 under the DBCA Priority list)
- Brush-tailed Mulgara (*Dasyercus blythi*) (P4 under the DBCA Priority list)
- Bilby (*Macrotis lagotis*) (Vulnerable under the EPBC Act).

Please note that these targeted fauna surveys excluded the migratory shorebirds recorded in April 2017 during the waterbird survey or those waterbirds considered likely to occur, as these species are most likely only present after large rainfall events when water is present on the lake and in the claypans. Further to this, time did not permit searches to be undertaken for the Northern Marsupial Mole (please see the fauna survey limitations and constraints table below in Section 4.1).

3.3.1 Great Desert Skink (Tjalapa), Bilby (Ninu) and Brush-tailed Mulgara (Murtija)

The most efficient and reliable technique to detect whether or not the Great Desert Skink, Bilby or Brush-tailed Mulgara are present, or have used an area, is the observation of signs, which could include scats e.g. active latrine sites for the Great Desert Skink, tracks, burrows and diggings (recently dug soil at the entrance of burrows for all three species). Bilbies are also known to produce multiple diggings at the base of plants while searching for larvae (Witchetty Grubs) that occur in the roots of plants such as *Acacia* sp. and these signs indicate use of an area.

To search in a systematic way for signs of all three species in a large area, the 2-ha sign plot method was employed (as per the DBCA survey guidelines to detect the presence of the Bilby – see section 3.1 above) in both the proposed western and southern infrastructure areas. The 2-ha sign plot method involved searching for Bilby signs (and the Great Desert Skink and Brush-tailed Mulgara) for a maximum 25 minutes in suitable habitat (see example data sheet and the data recorded in Appendix 7).

Transects were also walked and signs (for the Great Desert Skink, Bilby and Brush-tailed Mulgara) were looked for in both the proposed western and southern infrastructure areas, particularly while walking between the 2-ha sign plots.

The Kiwirrkurra IPA Rangers and Ranger Coordinator were present for four days (10-13 November) and during this time they searched for signs of the Great Desert Skink, Bilby and Brush-tailed Mulgara using the 2-ha sign plot method and transects as they regularly use this method in the Kiwirrkurra IPA. They primarily looked in the proposed southern infrastructure area during the survey.

3.3.2 Night Parrot

Night Parrots are very cryptic, nocturnal and there are very few recent records. In addition, there is very little known about their ecology and, therefore, they are currently difficult to detect. As a result, Dr Stephen (Steve) Murphy (Adaptive NRM), who is a recognised Night Parrot expert and has been undertaking surveys and research on the Night Parrot for many years, was engaged to provide specialist survey advice (see Appendix 8). Steve was also engaged to analyse the data recorded on the Song Meter 2+ acoustic recorders (SM2s). Prior to the Night Parrot survey, Dr Allan Burbidge of DBCA was consulted and he provided advice on habitat selection and SM2s and their use.

The methods used and the sites chosen during this survey were based on recommendations provided by Steve (Appendix 8). Note that the survey effort, particularly the number of sites where SM2s were located, is far less than recommended in Appendix 8 given the remoteness and accessibility of sites in the survey area, the survey time available and the number of SM2s that would be required to undertake such an extensive assessment. As a result, this Night Parrot survey is considered preliminary only.

The SM2 data collected was analysed using an automated computer recogniser system designed for Night Parrot calls (Appendix 9). The system is based on Queensland calls (call variants that include 1-4 syllables of the *dink* call).

The computer recogniser system has a known high commission error rate (i.e. provides a high number of false positives). This is potentially advantageous when searching for Night Parrot calls that may not be exactly like those on which the recogniser is based (e.g. WA Night Parrot calls that are known to be different from Night Parrot calls found elsewhere). It is expected that the two-syllable *didit* call would be detected by the recogniser as this is similar to the Queensland Night Parrot calls.

A more sophisticated recogniser system is currently being developed that will include a wider range of calls, including the WA calls. Until the Lake Mackay acoustic data can be analysed using this new method, the results of this survey should be treated as preliminary.



Photo 5: SM2 acoustic recorder



Photo 6: SM2 unit located at trap site WA1



Photo 7: SM2 unit located on the edge of Lake Mackay just north of the proposed western infrastructure area

3.3.3 Princess Parrot (Kilkintari), Rainbow Bee-eater and Striated Grasswren

These three species can be detected by sight, or by their distinctive calls and are for the most part relatively conspicuous due to their plumage and / or behaviour. These three species were searched for when undertaking general bird surveys and opportunistic observations during the survey.

4. Results

4.1 Fauna Survey Limitations and Constraints

Survey constraints are often difficult to predict, as is the extent to which they influence survey effort. The limitations and constraints of the fauna survey are outlined below in Table 8.

Table 8: Limitations and constraints associated with the survey

Variable	Impact on the Survey
Access	<p>The Survey Area is extremely remote. The nearest township is the Kiwirrkurra Community which is approximately 65 km to the south-west of the lake/ study area. It is virtually untouched, with very few existing access tracks. Access to these tracks is permissible by the Kiwirrkurra Community.</p> <p>This remoteness limited the extent to which opportunistic searches and more general fauna habitat assessments could be undertaken. Nevertheless, searches were undertaken as far as practicable <i>in lieu</i> of the access and transportation constraints.</p> <p>The focus of the survey effort was primarily the two proposed infrastructure areas (western area and southern area), surrounding areas and other, smaller locations. Four trap sites were established and located in habitats that are representative of those found in the Survey Area. However, given the size, there were sections that were not accessed (although the habitats that these areas supported were assessed in other locations throughout the proposed infrastructure areas during this survey and previous ones, where possible).</p> <p>Access to both the proposed western and southern infrastructure areas for the first eight days of the survey was provided exclusively by helicopter. However, due to the breakdown of the helicopter, access to the southern area was not possible and access to the western area was restricted by vehicle to limited existing tracks for the final four days of the survey.</p> <p>This limited access, resulted in less time on the ground than was scheduled. To prioritise and still cover essential elements of the baseline and targeted surveys, slight changes to the scope were required:</p> <ul style="list-style-type: none"> fewer transects were walked with regard to searches for: <ul style="list-style-type: none"> * Bilby * Mulgara * Great Desert Skink fewer SM2 unit locations chosen by Steve were surveyed for the Night Parrot Marsupial Mole burrows were not excavated spotlighting at trap sites was not possible.
Experience	<p>The personnel who undertook the survey were practitioners suitably qualified in their respective fields:</p> <ul style="list-style-type: none"> Project Manager, field staff and report review: Dr Ron Firth (Principal Zoologist) field staff, data interpretation and reporting: Laura Stevens (Zoologist) Kiwirrkurra IPA Rangers and Ranger Coordinator: extensive local knowledge of the region's fauna.

Variable	Impact on the Survey
Timing, weather, season	<p>The survey was undertaken from the 10 – 21 November 2017.</p> <p>The nearest and most relevant Bureau of Meteorology (BoM) weather station for the survey area is Walungurru Airport (Station No. 0015664), approximately 120 km south-east of southern section of the lake (study area). The Walungurru Airport station receives a mean minimum temperature that ranges from 10.4°C to 26°C and mean maximum that ranges from 23.2°C to 39.4°C. The annual average rainfall is 306.1 mm (BoM 2017).</p> <p>Walungurru Airport station recorded 696 mm of rain in the 12 months prior to the survey (November 2016 – October 2017) which is 390.1 mm above the long-term average rainfall for the same period (Figure 2). In the three months prior to the survey (August – October 2017), 40.6 mm of rainfall was recorded which is below the 94.6 mm average rainfall for the same period (BoM 2017).</p> <p>Temperature and rainfall are now recorded at the Agrimin camp site which is much closer and more relevant to the survey conditions than the Walungurru Airport station. During the survey period, 17.5 mm of rainfall was noted in the camp.</p> <p>The mean maximum temperature recorded at camp over the twelve-day survey was 38.8°C. The mean minimum temperature recorded at camp over the twelve-day survey was 21.2°C. These temperatures were within the long-term mean maximum and mean minimum ranges for Walungurru Airport (the closest reliable long-term averages).</p> <p>While these temperatures were within the long-term mean range for the area, such high temperatures influence both the field staff undertaking the survey and the activity of fauna, particularly diurnal reptiles and birds.</p> <p>Regarding the field staff, shade had to be sought especially in the mid-day heat and frequent breaks needed to be taken. Regarding the fauna, it was essential that traps were checked as early in the day as possible (careful helicopter scheduling was therefore important), extra (dampened) shade was placed inside traps and, when temperatures reached approximately 40°C, Elliott traps were closed and not used, for animal ethics reasons.</p> <p>In such high temperatures, it is considered likely that some species will have limited their activity (particularly diurnal reptiles and birds), consequently, detectability for some species is likely to have been decreased.</p>
Scope: Life forms sampled	<p>This was a Level 2 fauna survey, comprising a desktop review of secondary data and a field survey that included systematic baseline trapping, habitat assessments, systematic opportunistic observations, SM2 units and camera traps. Vertebrate groups targeted during the survey were reptiles, birds and mammals.</p> <p>Targeted vertebrate surveys for the following species were also undertaken:</p> <ul style="list-style-type: none"> • Great Desert Skink (<i>Liopholis kintorei</i>) (Vulnerable under the EPBC Act) • Night Parrot (<i>Pezoporus occidentalis</i>) (Endangered under the EPBC Act) • Princess Parrot (<i>Polytelis alexandrae</i>) (Vulnerable under the EPBC Act) • Rainbow Bee-eater (<i>Merops ornatus</i>) (Marine under the EPBC Act) • Striated Grasswren (<i>Amytornis striatus striatus</i>) (P4 under the DBCA Priority list) • Brush-tailed Mulgara (<i>Dasycercus blythi</i>) (P4 under the DBCA Priority list) • Bilby (<i>Macrotis lagotis</i>) (Vulnerable under the EPBC Act). <p>Due to time constraints as a result of helicopter breakdown, targeted searches for the Northern Marsupial Mole (<i>Notoryctes caurinus</i>) (P4 under the DBCA Priority list), were not undertaken.</p>
Sources of information	<p>The desktop analysis used several sources to produce a list of fauna species previously recorded near the study area. This includes records from the DBCA Threatened Fauna Database Search, (DBCA 2017a), the EPBC Protected Matters Search Tool (DEE 2017) and NatureMap (DBCA 2017b) as well as past consultant reports, field guides and other scientific literature (although this was relatively limited for the general area).</p> <p>The previous Level 2 Vertebrate Fauna Survey undertaken in May 2017 (360 Environmental) was utilised and built upon for this second season survey.</p>

Variable	Impact on the Survey
Completeness	<p>A total of 94 vertebrate species from 40 families were returned from database searches. Of these, 37 were reptile species from eight families, 36 were bird species from 21 families and 21 were mammal species from 11 families. In total across the April 2017 Waterbird survey, May 2017 fauna survey and the November 2017 fauna survey, a total of 117 species from 51 families were recorded. This consisted of two amphibian species from one family, 38 reptile species from nine families, 65 bird species from 33 families and 12 mammal species from eight families.</p> <p>Across both the May 2017 and November 2017 fauna surveys, a total of ten traps sites were surveyed. In the May fauna survey, six trap sites were surveyed over seven nights. Pitfall trap survey effort at trap sites totalled 409 nights, funnel traps 672 nights, Elliott traps 420 nights, cage traps 168 nights and bird survey effort was 480-person minutes. SM2 units and camera traps were placed at each of the six trap sites and 24 hours of opportunistic searches were undertaken. Spotlighting (based near camp due to trap site access constraints) totalled 120 minutes. Habitat assessments were undertaken at 22 locations across the Survey Area, including at trap sites.</p> <p>In the November 2017 fauna survey, four traps sites were surveyed over seven nights. Pitfall trap survey effort at trap sites totalled 277 nights, funnel traps 448 nights, Elliott traps 160 nights, cage traps 112 nights and bird survey effort was 360-person minutes. SM2 units and camera traps were placed at each of the four trap sites and 24 hours of opportunistic searches were undertaken. Spotlighting (based near camp due to trap site access constraints and along access tracks) totalled 240 minutes. Habitat assessments were undertaken at each trap site and at each 2-ha plot location.</p>
Disturbances	<p>Due to its remote location, pre-existing disturbances in the proposed infrastructure areas is considered extremely low. Very minor existing disturbance includes animal tracks (camels) and vehicle tracks.</p>

4.2 Fauna Results

4.2.1 Database results

Database searches returned 94 vertebrate species from 40 families. Of these, 37 were reptile species from eight families, 36 were bird species from 21 families and 21 were mammal species from 11 families.

A total of 25 conservation significant species (including Priority species) were identified during the desktop review of database searches (Appendix 2). These comprised one reptile species, 19 bird species from 12 families and five mammal species from three families. The likelihood of them occurring in the Survey Area is outlined in Table 9 and reported in the results.

The DBCA threatened fauna database, NatureMap and the EPBC Protected Matters Search Tool (PMST) returned a small number of species known to be historical records of species now extinct in the local area e.g. Red-tailed Phascogale (*Phascogale calura*) (locally called Kenngoor) and the Central Hare-wallaby (*Macropodidae lagorchestes asomatus*) (locally called Kuluwarri). Also, there were a number of database errors including the Grey Wagtail (*Motacilla cinerea*) which is a rare visitor and has just two confirmed records (Johnstone & Storr 1998). These species have been omitted from any further discussion.

It is important to note that the EPBC PMST is not entirely based on point records but also on broader information (e.g. bioclimatic distribution models), whereas the DBCA threatened fauna database and NatureMap are solely based on point records. Consequently, the results of the EPBC PMST are in some cases less accurate, particularly at a local scale (e.g. the Yellow Wagtail [*Motacilla flava*]). As a result, the EPBC PMST can include species that do not occur in the Survey Area because, for example, there is no habitat available or they are now known to be locally extinct.

In addition, many fauna species are not distributed evenly across the landscape, being more abundant in some places than others where they can be more readily detectable (Currie 2007). Furthermore, some small, common, ground-dwelling reptile and mammal species tend to be habitat specific, and many bird species can occur as regular migrants, occasional visitors or vagrants. Therefore, all of these species have been omitted from any further discussion regarding fauna results.

With the aforementioned species removed, a total of 21 conservation significant species (including Priority species) were identified during the review of the database searches as potentially occurring in the Survey Area. Of these, no species were recorded during the November 2017 fauna survey, twelve species are considered Likely, one is considered Possible and eight are considered Unlikely to occur in the Survey Area (Table 9).

The likelihood of conservation significant species occurring in the Survey Area can be seen (in Table 9) from the May 2017 fauna survey (including the April 2017 Waterbird survey) as well as the likelihood of conservation significant species occurring in the Survey Area from the November 2017 survey. As understanding and knowledge of the Survey Area has increased, together with input from the IPA Rangers, likelihood categories have evolved.

All 21 conservation significant species are discussed in section 5.1. The Striated Grasswren (*Amytornis striatus striatus*) was not returned from database results, however, the species is also included for consideration in this report since its distribution is considered Likely to include Lake Mackay (section 5.1.3).

The Likelihood of each species occurring is based on the following criteria:

- Recorded: Recorded during the field survey or site reconnaissance
- Likely: Suitable habitat is present in the Survey Area and the Survey Area is in the species' known distribution
- Possible: Limited or no suitable habitat is present in Survey Area, but is nearby. The species has good dispersal abilities and is known from the general area
- Unlikely: No suitable habitat is present in Survey Area but is nearby, the species has poor dispersal abilities but is known from the general area or suitable habitat is present, however, the Survey Area is outside of the species' known distribution.

Table 9: Conservation significant fauna recorded and potentially occurring in the Survey Area

IUCN listing – En = Endangered, Vu = Vulnerable and LC = Least Concern. En = Listed as Endangered under the EPBC Act, Vu = Listed as Vulnerable under the EPBC Act, Mi = Listed as Migratory under the EPBC Act, Ma = Listed as Marine under the EPBC Act, S = Scheduled (1 - 7) under the WC Act, P = Listed as Priority (1 – 5) by DBCA.

Species	Conservation Status (EPBC ACT, WC ACT & Priority)	May 2107 Survey Likelihood	November 2017 Survey Likelihood
Reptiles			
Great Desert Skink (<i>Liopholis kintorei</i>) (locally called Tjakura)	Vu, S3	Likely	Likely
Birds			
Fork-tailed Swift (<i>Apus pacificus</i>)	MiMa, S5	Recorded	Likely
Cattle Egret (<i>Ardea ibis</i>)	MiMa, S5	Unlikely	Unlikely
Eastern Great Egret (<i>Ardea modesta</i>)	MiMa, S5	Unlikely	Unlikely
Grey Falcon (<i>Falco hypoleucos</i>)	Vu, S3	Unlikely	Unlikely
Oriental Plover (<i>Charadrius veredus</i>)	MiMa, S5	Likely	Likely
Australian Painted Snipe (<i>Rostratula australis</i>)	En, S2	Recorded	Unlikely
Common Sandpiper (<i>Actitis hypoleucos</i>)	MiMa, S5	Likely	Likely
Sharp-tailed Sandpiper (<i>Calidris acuminata</i>)	MiMa, S5	Recorded	Unlikely
Pectoral Sandpiper (<i>Calidris melanotos</i>)	MiMa, S5	Likely	Likely
Common Greenshank (<i>Tringa nebularia</i>)	MiMa, S5	Recorded	Unlikely
Red-necked Stint (<i>Calidris ruficollis</i>)	MiMa, S5	Recorded	Unlikely
Oriental Pratincole (<i>Glareola maldivarum</i>)	MiMa, S5	Likely	Likely
Night Parrot (<i>Pezoporus occidentalis</i>)	En, S1	Possible	Possible
Princess Parrot (<i>Polytelis alexandrae</i>)	Vu	Likely	Likely
Rainbow Bee-eater (<i>Merops ornatus</i>)	Ma, S5	Likely	Likely
Barn Swallow (<i>Hirundo rustica</i>)	Ma, S5	Unlikely	Unlikely

Species	Conservation Status (EPBC ACT, WC ACT & Priority)	May 2107 Survey Likelihood	November 2017 Survey Likelihood
Striated Grasswren (<i>Amytornis striatus striatus</i>)	P4	Likely	Possible
Mammals			
Brush-tailed Mulgara (<i>Dasyercus blythi</i>)	P4	Likely	Likely
Bilby (<i>Macrotis lagotis</i>) (locally called Ninu)	Vu, S3	Likely	Likely
Northern Marsupial Mole (<i>Notoryctes caurinus</i>) (locally called Kararratul)	P4	Likely	Likely

4.2.2 Survey Results

During the field survey, 117 species from 51 families were recorded. This consisted of two amphibian species from one family, 38 reptile species from nine families, 65 bird species from 33 families and 12 mammal species from eight families. Four of the 12 mammal species were introduced - the Red Fox (*Vulpes Vulpes*), the feral cat (*Felis catus*), the European Rabbit (*Oryctolagus cininculus*) and the Camel (*Camelus dromedarius*).

Figure 7 shows the frequency of all species captured at the six trap sites during the May 2017 field survey, across all habitat types using pitfall, Elliott and funnel trap captures. Figure 8 shows the frequency of all species captured at the four trap sites during the November 2017 field survey, across all habitat types using pitfall, Elliott and funnel trap captures. Figure 9 shows the frequency of all species captured at the ten trap sites during both field surveys, across all habitat types using pitfall, Elliott and funnel trap captures. Reptiles were consistently the most frequently recorded group, followed by mammals, with amphibians the least frequently recorded group.

Trap site data can be seen in Appendix 4. This appendix is a record of all captures across the six trap sites in May 2017 and the four trap sites in November 2017. Data was recorded opportunistically throughout the survey and is presented in Appendix 6. This appendix is a record of all species recorded in the overall Survey Area. It includes species that were recorded during spotlighting, when flying between trap sites, driving tracks (where possible) and when walking in a more general nature in the Survey Area.

Photographs of some species captured during the survey can be seen in Appendix 10 including *Strophurus ciliaris* (Northern spiny-tailed Gecko), *Pygopus nigriceps* (Western Hooded Scaly-foot), *Pseudonaja modesta* (Ringed Brown Snake) and *Simoselaps anormalus* (Desert Banded Snake).

Figure 7: Frequency of species captured at trap sites during May 2017 field survey

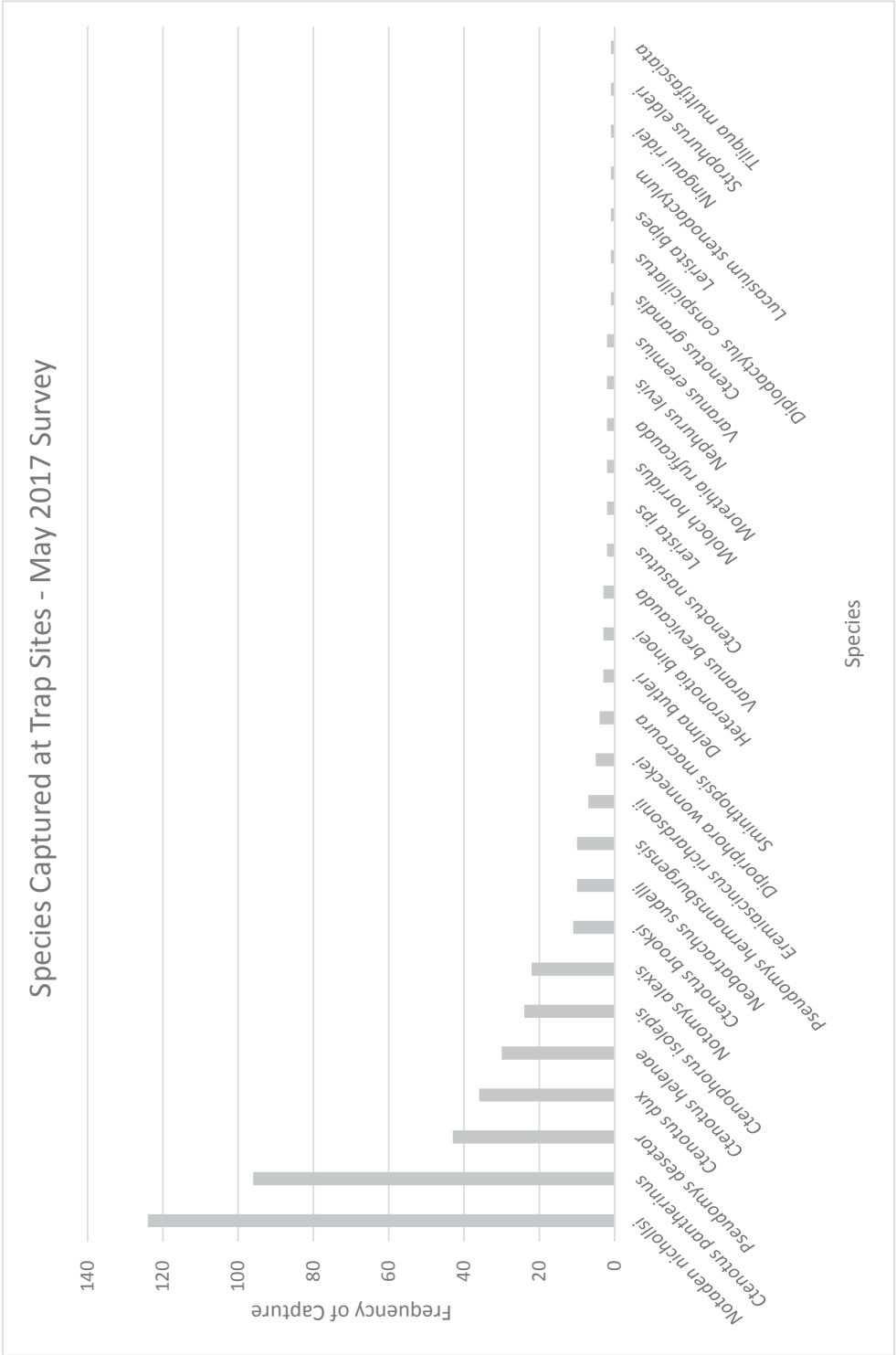


Figure 8: Frequency of species captured at trap sites during November 2017 field survey

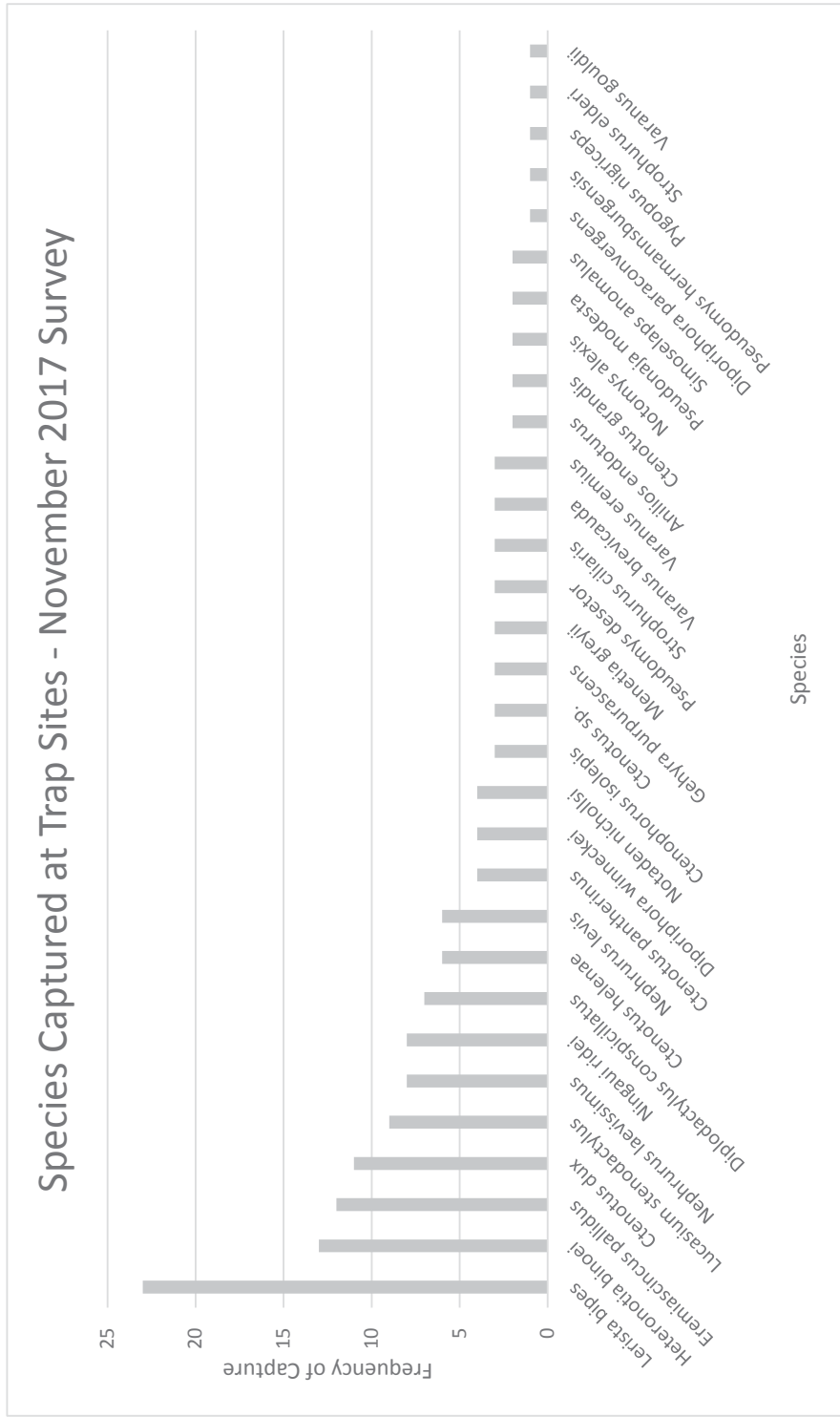


Figure 9: Total frequency of species captured at trap sites when the surveys (May and November 2017) are combined



Amphibians

From the database searches, no amphibians have previously been recorded in the surrounding area (as per the database search parameters defined in section 3.2.1). During the surveys, two amphibian species were recorded. The Desert Spade Frog (*Notaden nichollsi*) was recorded on 128 occasions and Sudell's Frog (*Neobatrachus sudelli*) was recorded on 10 occasions. The Desert Spade Frog was also the most recorded species (at trap sites) overall.

Reptiles

From the database searches, a total of 37 species of reptile have been previously recorded in the surrounding area (as per the database search parameters defined in section 3.2.1). During the field survey, 37 species of reptile were recorded (Appendix 3). The most frequently recorded species was the Leopard Ctenotus (*Ctenotus pantherinus*) with 100 captures in total. This was followed by the Fine Sided-lined Ctenotus (*Ctenotus dux*) with 47 captures in total.

Birds

From the database searches, a total of 36 bird species have been previously recorded in the surrounding area (as per the database search parameters defined in section 3.2.1). During the field surveys (including the Waterbird Survey undertaken by 360 Environmental in April 2017), 65 species of bird were identified including those recorded during the waterbird survey (Appendix 3). Bird species were recorded at all trap sites as well as opportunistically. The most frequently recorded (not necessarily the most abundant) bird species was the Singing Honeyeater (*Lichenostomus virescens*) and the most abundant species was the Zebra Finch (*Taeniopygia guttata*). Both species were recorded at the majority of trap sites as well as opportunistically throughout the Survey Area.

Mammals

From the database searches, 21 species of mammal have previously been recorded in the surrounding area (as per the database search parameters defined in section 3.2.1). During the field survey, 12 species of mammal were recorded (Appendix 3). Of these 12 species, five were recorded at the trap sites, one was recorded opportunistically, two were bat species recorded on the SM2 units and four were introduced species.

During the field survey, the most frequently recorded mammal at the trap sites was the Desert Mouse (*Pseudomys desertor*) which was caught on 46 occasions. This was followed by the Spinifex Hopping-mouse (*Notomys alexis*) which was caught a total of 24 times and the Sandy Inland Mouse (*Pseudomys hermannsbergensis*) which was caught 11 times.

It is important to note that, due to extremely high temperatures during the November 2017 survey, Elliott traps were closed on a number of occasions for animal ethics reasons. This was reflected by the lower capture rate of mammals during this survey.

4.3 Fauna Habitat

Four broad fauna habitats were identified in the Survey Area:

- Dune / Swale
- Claypan Swale
- Lake Margin
- Sandplain.

These habitats are widespread and common in areas adjacent to the Survey Area and, more broadly, across the region.

The fauna habitats are mapped in Figures 5a and 5b and the habitat assessment undertaken in each of the four habitats is detailed in Appendix 5. The extent of each habitat in the Survey Area is presented in Table 10.

Table 10: Fauna habitat in the Survey Area.

Habitat Type	Habitat extent in the Survey Area - May 2017 Survey (Ha)	Habitat extent in the Survey Area - November 2017 Survey (Ha)
Swale	3088.00	N/A
Dune	1078.21	N/A
Claypan Swale	797.73	63.43
Lake Margin	573.91	382.14
Dune and Swale	N/A	1638.52
Sandplain	N/A	335.42
Total	5547.29	2419.51

Of the four habitats types described, Dune and Swale was by far the most extensive fauna habitat occurring in the Survey Area. Descriptions and photographs of fauna habitats are provided below.

4.3.1 Claypan Swale

The Claypan Swale habitat is characterised by the lower areas between the dune slopes and crests in the Survey Area where claypans are present. Claypan Swale habitat is characterised by low open shrubland of *Acacia* sp. and *Melaleuca* sp. over hummock grassland of *Triodia* sp., with some areas of compacted clay soils. Some areas still contain sandy soils, however, they are typically more compact than in Dune and Swale habitat. The Claypan Swale habitat contains areas where fresh water can potentially gather.

Larger areas of *Melaleuca* are present in Claypan Swale habitat, providing important habitat for many bird, mammal and reptile species. A moderate diversity of microhabitats is present, with some leaf litter and debris. Although the soils are the most compact of the Survey Area, they are still suitable for digging and burrowing species.

4.3.2 Lake Margin

Lake Margin habitat is comprised of various *Tecticornia* species over scattered tussock grassland on sandy soils and is found on island edges as well as the edge of the lake on the mainland (see Plates 20-25 for examples of Lake Margin habitat in the Survey Area).

Lake Margin habitat has a limited diversity of microhabitats present, lacking the structure of an over or midstorey and very limited leaf litter.

Numerous small burrows were recorded in the Lake Margin habitat, indicating the soils is soft enough for species such as the Military Dragon (*Ctenophorus isolepsis*) and Narrow-lined Ctenopus (*Ctenopus dux*) in which to burrow. Lake margin habitat is also where the Brown Songlark (*Cincloramphus cruralis*) was recorded in the *Tecticornia* on many occasions. This habitat has a relatively low potential of supporting conservation significant fauna species, although it may be utilised by migratory species including the Fork-tailed Swift as well as wading birds such as the Common Sandpiper (*Actitis hypoleucos*) and Red-necked Stint (*Calidris ruficollis*) at certain times following large rainfall events. These birds, however, are all more likely to use areas of freshwater during these times. Lake Margin habitat is, therefore, considered to be of medium to low value to fauna in the Survey Area.



Photo 8: An Agamid burrow (most likely a Military Dragon *C. isolepis*) in the western infrastructure area

4.3.3 Dune and Swale Habitat

The Dune and Swale habitat consists of the lower areas lying between the dune slopes and the dune crests. This habitat is characterised by low, open shrubland of *Acacia* sp. and *Melaleuca* sp. over hummock grassland of *Triodia* sp. on sandy soils, with scattered *Allocasuarina decaisneana* (Desert Oak) in some areas.

Soils were typically more compacted in the swale areas than the dune areas and so can potentially support different fauna species. Areas with more compacted soils have the potential to support conservation significant fauna species, including Bilby (*M. lagotis*), Brush-tailed Mulgara (*D. blythi*) and Great Desert Skink (*L. kintorei*), where larger burrows can be constructed in the more compressed sand. Areas with less compact soils have the potential to support burrowing species such as *Delma*, *Lerista* and *Anilius*.

A moderate diversity of microhabitats is present in this habitat. The scattered *A. decaisneana*, (particularly on Island 1 and to the west of WA2) provides habitat for some bird species including the Princess Parrot (*P. alexandrae*), with areas of leaf litter and debris providing shelter for reptile species including *Nephruus*, *Menetia* and *Heteronotia* and small mammals including the Ningai (*Wongai ningai*).

The large, old spinifex hummocks potentially provide habitat for the conservation significant Night Parrot (*Pezoporus occidentalis*). A targeted survey was undertaken for this species and is discussed fully in section 5.2.2.

Due to the structure of this habitat, it is considered to be of moderate to high value to fauna in the Survey Area.

4.3.4 Sandplain

The Sandplain habitat is comprised of Spinifex tussock grassland on sandy soils. This habitat provides shelter for fauna in the form of burrows as a result of the sand in which species can dig. Sandplain habitat also contains relatively large spinifex hummocks in which fauna can shelter and take refuge.

The compacted soil supports burrowing fauna species including the Sand Goanna (*Varanus gouldii*), tracks of which were seen throughout the Survey Area and Pygmy Desert Monitor (*Varanus eremius*). In places, this habitat also potentially supports conservation significant species such as the Bilby, Brush-tailed Mulgara) and Great Desert Skink.

The Spinifex hummocks provide shelter for numerous fauna species. Reptile species utilising this habitat include geckos such as the Smooth Knob-tail (*Nephurus laevissimus*) and the Northern Spiny-tailed Gecko (*Strophurus ciliaris*) as well as skink species including the Western Narrow-banded Skink (*Eremiascincus pallidus*) and dragon species such as the Central Netted Dragon (*Ctenophorus nuchalis*). Larger reptile species such as the Mulga Snake (*Pseudechis australis*) will also utilise the Sandplain habitat.

The large, old spinifex hummocks potentially provide habitat for the conservation significant Night Parrot (*P. occidentalis*). A targeted survey was undertaken for this species and is discussed in section 5.2.2.

4.4 Camera Trap Results

The following species were recorded on the camera traps:

May 2017 Survey:

- Dingo (*Lupus dingo*) – recorded at trap site 4
- Red Fox (*Vulpes vulpes*) – recorded at trap sites 2 and 6
- Spinifex Hopping-mouse (*Notomys alexis*) recorded at trap site 6.

November 2017 Survey:

- Spinifex Hopping-mouse (*Notomys alexis*) - recorded at trap site SA1 (Photo 9)
- Desert Mouse (*Pseudomys desertor*) - recorded at trap site SA1 (Photo 10).

No species of conservation significance were recorded on the motion sensitive cameras during either survey.



Photo 9: Spinifex Hopping-mouse (*Notomys alexis*) at trap site SA1



Photo 10: Desert Mouse (*Pseudomys desertor*) at trap site SA1 – see bottom left.

4.5 Targeted Fauna Survey

No signs of conservation significance species were observed during the targeted field surveys. A brief description of the survey results is given for each species below.

Great Desert Skink (Tjalapa), Bilby (Ninu) and Brush-tailed Mulgara (Murtja)

During the field surveys, targeted searches were made for signs of the Great Desert Skink, Bilby and Brush-tailed Mulgara in 32 of the 2-ha sign plots across both the proposed infrastructure areas (western and southern) and in other locations in the greater Study Area (see Figures 5a and b). No signs of these three conservation significant species were noted in any of the 32 plots.

However, the signs of several other species were recorded at many of the plots and these included the burrows and tracks of Sand Goannas (*Varanus gouldii*), small dragons – most likely Military Dragons and Netted Dragons (*Ctenophorus isoleps* and *Ct. nuchalis*) as these were captured in pitfall traps and were the most commonly seen reptiles across both proposed infrastructure areas. Tracks of the Bustard (*Ardeotis australis*), snakes, and Camels were also observed (see example data sheet and the data recorded in Appendix 7). Tracks of the Dingo, Feral Cat and Fox were also noted in several of the plots.

The Kiwirrkurra IPA Rangers and Ranger Coordinator caught five Feral Cats over a two day period in early December 2017 in the local area, indicating the potential threat that feral animals pose to local native fauna in the area.

Night Parrot

During the Night Parrot survey, SM2 units were placed at 29 locations, 10 in and surrounding the proposed western infrastructure area and 19 in and surrounding the proposed southern infrastructure area (see Figure's 5a and b). Of these 29 locations, 19 were selected by Night Parrot specialist Dr Stephen Murphy, with the remaining 10 sites located along the access track to the Agimin camp including two at Mumu (a freshwater claypan/swamp) and one at the trap site WA1. These sites were chosen because the Helicopter required maintenance and so other sites were inaccessible.

Night Parrot calls were not detected using the preliminary call recogniser system. The data should be re-analysed once the new system is developed as that system should be more effective at detecting a wider range of Night Parrot calls including those from WA (Appendix 9).

Seven non-target bird species were recorded on the SM2s; the most commonly recorded birds were Chiming Wedgebills, Singing Honeyeaters and Pink-eared Ducks. The diversity of non-target species detected by the preliminary recogniser system plausibly demonstrates that it can detect WA Night Parrot calls (especially the *didit* call) (Appendix 9).

Princess Parrot (Kilkintari), Rainbow Bee-eater and Striated Grasswren

No sightings or calls of the Princess Parrot, Rainbow Bee-eater or Striated Grasswren were recorded during the survey.

5. Discussion

5.1 Conservation Significant Fauna

A total of 21 conservation significant fauna species (including Priority species) were either recorded during the surveys or identified during the desktop review of database searches as potentially occurring in the Survey Area. These species have been re-assessed in relation to the latest Survey Area (the southern and western proposed infrastructure areas) and are discussed below, including some brief ecological information for each species and the reasons for their likelihood of occurrence in the Survey Area.

5.1.1 Conservation Significant Fauna Recorded

Five conservation significant species in total were recorded during the Waterbird survey in April 2017. No conservation significant species were recorded during the May 2017 fauna survey or during this November 2017 fauna survey.

5.1.2 Species Considered as Likely to Occur

A total of eleven species of conservation significance are considered as Likely to occur, the Great Desert Skink, Fork-tailed Swift, Oriental Plover, Common Sandpiper, Pectoral Sandpiper, Oriental Pratincole, Princess Parrot, Rainbow Bee-eater, Brush-tailed Mulgara, Bilby and Northern Marsupial Mole.

A Targeted Survey for the following species was undertaken as part of this report and those species with specific search methods will be discussed in Section 5.2. Please note, as stated in sections 4.1, due to access limitation with the helicopter in the later part of the survey, the Northern Marsupial Mole was not targeted as planned. However, it will still be discussed (briefly) in section 5.2.6.

- The Great Desert Skink (*Glareola maldivarum*)
- Night Parrot (*Pezoporus occidentalis*)
- Princess Parrot (*Polytelis alexandrae*)
- Brush-tailed Mulgara (*Dasycercus blythi*);
- Bilby (*Macrotis lagotis*)
- Northern Marsupial Mole (*Notoryctes caurinus*).

Waterbirds

The following waterbirds are all listed as Marine Migratory under the EPBC Act and as S5 under the WC Act:

- Oriental Plover (*Charadrius veredus*)
- Common Sandpiper (*Actitis hypoleucos*)
- Pectoral Sandpiper (*Calidris melanotos*)
- Oriental Pratincole (*Glareola maldivarum*).

Australia is geographically and ecologically an important location for migratory shorebirds within the East Asian–Australasian flyway. Migratory shorebird species are mostly present during the non-breeding period, from as early as August to as late as April/May each year.

The above-mentioned waterbirds were not recorded during the April 2017 waterbird survey or during both fauna surveys (May and November 2017). There were also no records of them present in the DBCA threatened fauna database. There are records of 25 Common Sandpipers from 10 km east of the north-east corner of Lake Mackay (Duguid 2005). There is also suitable habitat in terms of bare ground and samphire flats next to the lakes edge of both proposed infrastructure areas (western and southern) and in the wider study area (and claypans and swamps that periodically fill after large episodic rainfall events). As such, these waterbirds are considered as Likely to occur on the lake when there are sufficient and suitable resources (i.e. following substantial rainfall events).

Fork-tailed Swift (Apus pacificus)

The Fork-tailed Swift is listed as Migratory under the EPBC Act and as S5 under the WC Act. It is a non-breeding visitor to all states and territories of Australia (Higgins 1999). The Fork-tailed Swift is a summer migrant to Australia usually during the months of October-April. The Fork-tailed Swift is an aerial species which forages high above the tree canopy and is independent of terrestrial habitats. It occurs in flocks of up to 2,000 birds and is often seen accompanying Tree Martins (*Petrochelidon nigricans*) and Masked Wood swallows (*Artamus personatus*) (Johnstone & Storr 1998).

The DBCA threatened fauna database did not return any records of the Fork-tailed Swift. The species was recorded during the May 2017 survey (observed flying overhead on Island 3), however, it was not recorded during the November 2017 survey. While the species will not be reliant on the habitats of the proposed infrastructure areas or greater Study Area, it is likely to visit them as part of its larger foraging home range.

Rainbow Bee-eater (Merops ornatus)

The Rainbow Bee-eater is listed as Marine under the EPBC Act and S5 under the WC Act. This species is one of the most common and widespread birds in Australia with a distribution that covers the majority of Australia (Barrett et al. 2003). The Rainbow Bee-eater is also a common and widespread species in WA, except the drier interior of the State and the far south-west. It occurs in lightly wooded, often sandy country, preferring areas near water. It feeds on airborne insects and nests throughout its range in WA in burrows excavated in sandy ground or banks, often at the margins of roads and tracks (Johnstone & Storr 1998). In WA, this bird can occur as a 'resident, breeding visitor, postnuptial nomad, passage migrant and winter visitor' (Johnstone & Storr 1998).

There is a single record in the DBCA threatened fauna database, but it was not recorded during the May and November 2017 surveys. It was, however, recorded during the Ecologia survey (Ecologia 2017). The Survey Area provides suitable foraging habitat, as such, it is considered as Likely to occur.

5.1.3 Species Considered as Possibly Occurring

Two conservation significant species are considered as Possibly occurring in the Survey Area, the Night Parrot and the Striated Grasswren. The Night Parrot will be discussed below in section 5.2.2.

Striated Grasswren (Amytornis striatus striatus)

The Striated Grasswren is listed as P4 under the DBCA Priority list. The Striated Grasswren was not returned in any of the database searches, however, previous experience indicates that the DBCA records have the subspecies listed incorrectly. *Amytornis striatus striatus* (P4) is known from the Gibson Desert and *Amytornis striatus whitei* is known from the Pilbara. DBCA records appear to have these two-subspecies confused. *Amytornis striatus striatus* has a distribution that includes the greater Study Area, therefore, it has been considered in this report.

The Striated Grasswren inhabits spinifex sand ridges and inter-dunes with spinifex and acacia where it feeds on insects and seeds, including *Triodia* spp.

The two proposed infrastructure areas and greater Study Area is within the known distribution of the species and suitable habitat is present. There have now been several surveys in the area and none have been recorded, therefore this species is considered as Possibly occurring in the proposed infrastructure areas and consequently the greater Study Area.

5.1.4 Species Considered as Unlikely to Occur

A total of eight conservation significant species are considered Unlikely to occur in the Survey Area (i.e. the western and southern infrastructure areas), the Cattle Egret, Eastern Great Egret, Grey Falcon, Australian Painted Snipe, Sharp-tailed Sandpiper, Common Greenshank, Red-necked Stint and Barn Swallow.

Cattle Egret (Ardea ibis)

The Cattle Egret is listed as Migratory Marine under the EPBC Act and Schedule 5 under the WC Act. It occurs in the wetter parts of WA, in particular the Kimberley and the south-west. The species inhabits short grass, especially damp pastures and wetlands, usually in the company of cattle and occasionally other livestock. In WA, it is an irregular visitor, occurring mostly in autumn, and is not thought to breed regularly (Johnstone & Storr 1998).

The DBCA threatened fauna database returned no records for the Cattle Egret and records were from the EPBC PMST only. This search is based on broader information, for example bioclimatic distribution models and the results are, in some cases, less accurate, particularly at a local scale (see section 4.2.1 above). The Cattle Egret was not recorded in the Waterbird survey (360 Environmental 2017c), or the other previous fauna surveys (see Table 5 above) and, therefore, the Cattle Egret is considered Unlikely to occur.

Eastern Great Egret (Ardea modesta)

The Eastern Great Egret is listed as migratory under the EPBC Act and Schedule 5 under the WC Act. It is not listed by IUCN. It occurs in the Kimberley, Pilbara and on the west coast from the Murchison River south, throughout the south-west, and east to Cape Arid (Johnstone & Storr 1998). This species is an uncommon to very common visitor, usually in ones, twos or small flocks and, occasionally, in very large aggregations (up to 1,200), e.g. in Mandora Marsh in October 1999 and June 2000, and Fortescue Marsh in June 2000 (Johnstone et al. 2013).

The DBCA threatened fauna database returned no records for the Eastern Great Egret. Records were from the EPBC PMST only. This search is based on broader information, for example bioclimatic distribution models and the results are in some cases less accurate, particularly at a local scale (see section 4.2.1 above). The Survey Area is outside of the known distribution of the Eastern Great Egret and in addition, it was not recorded in the Waterbird survey, or the fauna surveys. As such it is considered Unlikely to occur.

Grey Falcon (Falco hypoleucos)

The Grey Falcon is listed as Vulnerable under the EPBC Act and as S3 under the WC Act. It is a poorly known endemic of inland Australia and is considered Australia's rarest Falcon and among the rarest Falco species in the world (Schoenjahn 2013).

The species is a resident or nomadic visitor to inland parts of all states (except Tasmania) from a range of habitats, but is mainly found where annual rainfall is <500 mm, except when wet years are followed by drought and then they are more widespread (Garnett et al. 2011). Nesting has been recorded from River Red Gum (*E. camaldulensis*) and Coolibah (*E. coolabah*) trees up to 15 m above ground level (Johnstone and Storr 1998; Garnett et al. 2011).

The DBCA threatened fauna database returned four records of the Grey Falcon, all from 1980. The Survey Area is within the species known distribution, however, it lacks the lightly wooded coastal and riverine plains the species inhabits and lacks the large River Red Gum trees required for nesting. The Grey Falcon is, therefore, considered Unlikely to occur in the proposed infrastructure areas and greater study area.

Australian Painted Snipe (Rostratula australis)

The Australian Painted Snipe (Painted Snipe) is listed as Endangered under the EPBC Act and is considered one of Australia's rarest waterbirds. It inhabits shallow, vegetated, temporary or infrequently filled inland wetlands of Australia. Numbers of the Painted Snipe are thought to have declined substantially since European settlement, particularly over the last 50 years, due to the loss and alteration of wetlands (Garnett et al. 2011).

Migration patterns of the Painted Snipe are poorly known (Pringle 1987), although the species is believed to disperse widely as evidenced by irregular and infrequent occurrences and breeding throughout Australia (Marchant & Higgins 1993). Movements have been attributed to local conditions - birds move to flooded areas, from drying to permanent wetlands and away from areas affected by drought.

There are no records of the Australian Painted Snipe in the DBCA threatened fauna database for the Survey Area, however, one Australian Painted Snipe was recorded during the Waterbird survey in April 2017 (360 Environmental 2017c). It is important to note that this individual was observed approximately 60 km to the east of the proposed western infrastructure area at a claypan. Aerial imagery, together with many hours of observations from helicopter survey flights across the proposed infrastructure areas and greater study area during the waterbird survey and the other fauna surveys (including the May and November 2017 surveys) showed that potentially 1,000s of similar potential claypan habitats occur around Lake Mackay.

However, the proposed western infrastructure area has no claypans or other suitable habitat and there is very limited habitat present in the proposed southern infrastructure area (Figures 8a and b). Consequently, the Australian Painted Snipe is now considered Unlikely to utilise either of the proposed infrastructure areas.

Waterbirds

The following waterbirds are all listed as Marine and Migratory under the EPBC Act and as S5 under the WC Act:

- Sharp-tailed Sandpiper (*Calidris acuminata*)
- Common Greenshank (*Tringa nebularia*)
- Red-necked Stint (*Calidris ruficollis*).

These three species were recorded at claypans and on the edge of the lake during the April 2017 Waterbird survey (360 Environmental 2017c). It is important to note that they were recorded outside of the proposed infrastructure areas. The proposed western infrastructure area has no claypans and limited lake margin habitat while there is very limited habitat present in the proposed southern infrastructure area (Figures 5a and b). Consequently, these three species are considered Unlikely to utilise either of the proposed infrastructure areas.

Barn Swallow (Hirundo rustica)

The Barn Swallow is listed as Migratory under the EPBC Act and as S5 under the WC Act. The Barn Swallow is a widespread house swallow of the northern hemisphere, visiting coastal northern Australia south to Learmonth and appears as a vagrant further south. It inhabits open country, agricultural land, especially near towns and wetlands including sewage and saltwork ponds, river pools, swamps, tidal creeks and reservoirs (Johnstone and Storr 1998).

The DBCA threatened fauna database returned no records for the Barn Swallow. Records were from the EPBC PMST only. This search is based on broader information, for example bioclimatic distribution models and the results are, in some cases, less accurate, particularly at a local scale (see section 4.2.1 above). The Survey Area lacks suitable wetland habitat such as river pools, tidal creeks or reservoirs and, therefore, the Barn Swallow is considered Unlikely to occur.

5.2 Targeted Fauna

The following discussion focusses on the six species of conservation significance (Great Desert Skink, Night Parrot, Princess Parrot, Brush-tailed Mulgara, Bilby and Northern Marsupial Mole) that are considered Likely to occur in the proposed infrastructure areas and greater Study Area.

5.2.1 Great Desert Skink (*Liopholis kintorei*)

The Great Desert Skink is listed as Vulnerable under the EPBC Act and as Schedule 3 under the WC Act. The species is a large burrowing skink that grows to about 440 mm total length and weighs up to 350 g. The tail is slightly longer than the head and body and, in good seasons, becomes swollen at the base where fat is stored. The dorsal surface ranges from a bright orange/brown colour, like the desert sand, through to dull brown or light grey in some northern specimens. The ventral surface of adults ranges from a brilliant lemon-yellow in southern specimens to cream or grey in northern specimens. Adult males tend to have blue-grey flanks while females and juveniles may have either plain brownish flanks or vertically barred with orange and cream. Males attain greater body weight than females and have a broader head. Newborn juveniles measure 70-80mm snout to vent length and weigh about 9-13 g (McAlpin 2001).

The Great Desert Skink constructs large burrow systems to a depth of over 1 m and up to 10 m in diameter. The burrow may start as a simple single tunnel with one entrance. New tunnels are added progressively and over a period of two summers a complex with 5-10 entrances and a network of connected tunnels five or six metres across may develop. A burrow system that is inhabited for many years may become very large. On the surface, the burrow system of the Great Desert Skink is identifiable by at least one large external latrine. Scats are deposited in the latrine by the occupants of the burrow system and many scats may accumulate over an area of one to three square metres (McAlpin 2001).

Burrows of other animal species (many of which were recorded during the May and November 2017 fauna surveys) are also sometimes taken over, adapted and enlarged. The burrows of the Mulgara (*Dasycercus cristicauda*), Spinifex Hopping Mouse (*Notomys alexis*), Night Skink (*Egernia striata*), and Sand Goanna (*Varanus gouldii*) have been recorded as being appropriated and adapted by Great Desert Skinks (McAlpin 1997). Conversely, Mulgara, Dunnarts (*Sminthopsis* spp.) and Ningai (*Ningai ridei*) have also been recorded using the burrows systems of the Great Desert Skink, and the occupancy of a single burrow may transfer from one species to another (McAlpin 1997, 1998).

Despite the seemingly large effort that goes into constructing a burrow system, occupancy appears to be dynamic, with some lizards moving between burrow systems (McAlpin 1998) and some burrows eventually becoming deserted. The reasons for this dynamism are not well understood, but may relate to the search for a mate, formation of new pair bonds, mortality, or predation pressure. A large burrow is generally occupied by an adult pair and juveniles from the current and previous year and up to 10 individuals may inhabit one burrow system (McAlpin 2001).

Great Desert Skinks are omnivorous, eating a wide range of invertebrates (principally termites) and also any vertebrates small enough to be swallowed. During good seasons they consume leaves, flowers and fruits from several species of plants including Bush Tomato (*Solanum* spp.) fruits, Parakeelya (*Calandrinia* spp.) leaves and Paper Daisy (*Leucochrysum stipitatum*) flowers (McAlpin 1997). Young Great Desert Skinks grow rapidly and during good seasons reach sexual maturity in their second year. Maximum size is reached in the third year but young males are unlikely to participate in breeding until they are fully grown and living in a well-established burrow system. Great Desert Skinks may live to a considerable age, as other species in the genus appear to live for over 20 years in captivity (McAlpin 2001).

Although incomplete distribution data make it currently impossible to define critical habitat for the Great Desert Skink in terms of specific geographic locations, prescriptive fire-age, or structural detail of vegetation, it is possible to describe commonalities in the habitats occupied by known populations.

Great Desert Skinks occupy a variety of habitat types within the western deserts region. They generally occur on hummock grass sandplains and some adjacent dune field swales. Sandplain vegetated by spinifex (*Triodia* spp.) and scattered shrubs is the habitat type most widely used, the extent of which ranges in size from a few hundred hectares to tens of thousands of hectares. They are characterised by a dominant cover of spinifex grasses, usually *Triodia basedowii*, but also *T. pungens* and *T. schinzii* (all of which were recorded in the Survey Area). Growing among the spinifex hummocks are scattered shrubs and occasional trees including *Acacia*, *Eremophila*, *Grevillea*, *Hakea*, and occasionally *Eucalyptus* (McAlpin 2001).

The DBCA threatened fauna database returned 33 records of the Great Desert Skink in the search area (as per the database search parameters defined in section 3.2.1), all from the vicinity of Kiwirrkurra. Except for three records, they are all from 2014 and 2016. A Bushblitz Survey undertaken near Kiwirrkurra and Lake Mackay in 2015 also recorded the Great Desert Skink (Bushblitz 2015). According to the Recovery Plan for the Great Desert Skink, the upper limit population estimation for the Kiwirrkurra community and surrounds including Lake Mackay area is thought to be <500 individuals.

Although no Great Desert Skinks were recorded in both proposed infrastructure areas or greater Study Area, the areas are within its known distribution and there is suitable habitat present. The Great Desert Skink is therefore considered Likely to occur.

5.2.2 Night Parrot (*Pezoporus occidentalis*)

The Night Parrot is listed as Endangered under the EPBC Act and Schedule 1 under the WC Act. It is an enigmatic species thought possibly to be extinct until the recent recoveries of two dead specimens from Queensland (and new locations more recently). The type specimen and many early sightings, however, came from WA (Johnstone et al. 2013). Night Parrots are cryptic, nocturnal and endemic to Australia's arid interior. Until the late 19th century, they were widespread and relatively easily found at least at some locations. For instance, 14 of the 25 museum specimens in existence came from the Gawler Ranges in South Australia between 1871 and 1881 (Murphy et al. 2017). The last Night Parrot collected intentionally was in Western Australia in 1912 (Wilson 1937). Then followed 78 years of unconfirmed reports spanning all mainland states and the Northern Territory, until in 1990 a desiccated bird was found by a roadside in western Queensland (Boles et al. 1994, Murphy et al. 2017). In 2006, another dead bird was discovered by a Ranger 200 km to the south-east of the 1990 specimen (McDougall et al. 2009, Murphy et al. 2017). In 2013, the first photographs of a living night parrot were captured close to the site of the 2006 specimen (Dooley 2013, Murphy et al. 2017). Their cryptic nature, remote distribution and apparently rapid decline mean that there is scant ecological information about night parrots.

A more recent sighting of the Night Parrot in WA comes from the Pilbara (12 April 2005) at a well near the Fortescue Marshes (Davis & Metcalf 2008). There was also a sighting near Matuwa (Lorna Glen), north-east of Wiluna, in 2009 (Hamilton et al. 2017).

DBCAs threatened fauna database has no records of the Night Parrot in the search area (as per the database search parameters defined in section 3.2.1) and there is very limited ecological information available for this species such as its preferred habitat (only very broad information). However, with increasing conservation focus being given to this species, more information is likely to become available, e.g. the discovery of Night Parrot nests in large Spinifex hummocks in Queensland (Murphy et al. 2017) which is a common and widespread habitat type throughout much of south-east Queensland and WA, including the Lake Mackay area.

No Night Parrot calls were recorded during this November 2017 targeted fauna survey. It is important to note, however, that conditions during at least some of the sample period were very windy and the likelihood of detecting Night Parrots in such conditions is considered practically zero (Appendix 9). A more sophisticated recogniser system is currently being developed that will include a wider range of calls, including the Western Australian Night Parrot calls. Until the Lake Mackay acoustic data can be analysed using this new method, the results presented here should be treated cautiously and in this sense, are preliminary (Appendix 9).

Furthermore, preliminary analyses based on acoustic data from Queensland show that Night Parrot calling behaviour varies significantly in relation to precedent rainfall (Appendix 8). Specifically, when rainfall exceeds one standard deviation from the long-term mean, calling rates increase and more calling occurs through the night and calls are detected over a wider area away from the roosting area (Appendix 8). During dry times, calling is mostly limited to the core roosting areas and occurs mostly in the first hour after sunset and before sunrise.

Evidently, rainfall affects the detectability of Night Parrots. During dry times, when birds call less over a much smaller area, detection rates are low (Appendix 8). Birds can typically only be detected at the roost site, and sample sites must be selected that provide comprehensive spatial coverage. In contrast, sampling during post-wet periods can have greater spatial separation because birds call over a wider area (Appendix 8).

Based on rainfall data collected at Walungurru Airport conditions during the survey are at the dry end of the spectrum. While there has been some recent rain, totals have not exceeded the one-standard deviation threshold that is known to increase detectability in Queensland. Rainfall did exceed this threshold in December 2016 (360 Environmental 2017a and c), but the increase in detectability is likely to have only lasted until mid-2017 (Appendix 8). It should be noted that SM2 acoustic units were deployed close to the Survey Area in May 2017, i.e. within the potential increased detectability period, and no Night Parrot calls were identified. However, habitat selection may not have been optimal for Night Parrots at this time.

Given suitable habitat in the proposed infrastructure areas and greater Study Area, together with several Night Parrot records in the region (including one recently confirmed record 240 km NW of Lake Mackay [Murphy and Leseberg 2017 – Appendix 8]) suggests that Night Parrots are considered Possible to occur. Based on the Likelihood criteria in section 4.2.1 a species such as the Night Parrot would usually be considered Likely to occur, however, based on the limited ecological information available on the species habitat use and preference we have given it a Likelihood of Possible.

5.2.3 Princess Parrot (*Polytelis alexandrae*)

The Princess Parrot is listed as Vulnerable under the EPBC Act and P4 under the DBCA Priority list. It is a slim, colourful, medium-sized parrot that grows to 40 to 45 cm in length, and weighs 90 to 120 g (Higgins 1999).

The species is scattered and occurs irregularly across the arid regions from near Oodnadatta in South Australia, west to near Coolgardie and the east Murchison River in WA and north to near the Fitzroy River in WA and Howell Ponds in the Northern Territory. It may be concentrated in the Great Sandy Desert, Gibson, Tanami and Great Victoria Deserts and in the Central ranges (Higgins 1999, Garnett *et al.* 2010).

The movements of the Princess Parrot are poorly known. It is said to be highly nomadic or irruptive (Carter 1993), and it may possibly be both (Higgins 1999). The available evidence suggests that it may be dispersive, but any assessment of the movement patterns is purely speculative due to a lack of information (Higgins 1999). The core range is believed to be in the Great Sandy Desert (Higgins 1999), but the movement of birds within the core range, and movements associated with records outside of the core range, are not known (Higgins 1999). It has been speculated that movements are governed by seasonal changes in conditions, and by the availability of food (Garnett *et al.* 2010). It has also been speculated that movements are governed by the occurrence of ephemeral water, and the flowering of Acacia shrubs (Garnett *et al.* 2010).

Historical records include reports of large scale flocks and large breeding colonies (Garnett *et al.* 2010). Contemporary records are mostly of very small numbers, with significant numbers only recorded twice: up to 300 on the Canning Stock Route in the early 1990's (Carter 1993) and several hundred west of Alice Springs in 2010, extending to the eastern Gibson Desert where the population may have been in the low thousands (Carter 1993, Garnett *et al.* 2010). It is suspected that the total population probably varies with season and may be as low as 1000 mature individuals in poor years (Garnett *et al.* 2011).

No known threats exist, but the Princess Parrot may be adversely affected by the same habitat changes that led to the extinction of many central Australian mammals over the 20th century (Burbidge & McKenzie 1989). Throughout their range, habitat may have been degraded and food availability reduced by altered fire regimes with a coarser mosaic of fire history and the introduction of sheep and feral herbivores such as Rabbits, and Camels. Loss of tree hollows from intense fire may affect breeding success and increased availability of water in areas grazed by domestic stock have allowed other, more water-dependent parrots, to expand into the arid zone and compete with the Princess Parrot (Garnett *et al.* 2011).

The species inhabits shrublands and savanna woodlands in swales between sand dunes, with occupied sites typically consisting of *Triodia* spp. and a variety of shrubs and scattered emergent trees. The Princess Parrot feeds on the seeds of grasses, including spinifex, and nests have been found in Desert Oak (*Allocasuarina decaisneana*) (Higgins 1999), a tree species recorded in the proposed western infrastructure area.

The Princess Parrot is said to breed from September to January, however, dependent young have been recorded in July (Carter 1993), and it is possible that breeding may occur at any time of the year following rainfall (Garnett *et al.* 2011). The Princess Parrot nests in hollows or holes in Eucalyptus trees (including *E. camaldulensis*) close to watercourses, or occasionally in *A. decaisneana* trees away from water (Forshaw & Cooper 2002). The nest consists of a pile of decaying wood dust, upon which it lays a clutch of three to six white eggs (Forshaw & Cooper 2002).

Although the Princess Parrot was not recorded in the Survey Area, the DBCA threatened fauna database returned a single record of the Princess Parrot from Kiwirrkurra in 2012. Because of its known distribution and the presence of suitable habitat in the Survey Area, the Princess Parrot is considered Likely to occur.

5.2.4 Brush-tailed Mulgara (*Dasyurus blythi*)

The Brush-tailed Mulgara is listed as Priority 4. Brush-tailed Mulgara habitat is bound broadly by the Tanami Desert in the north, the Simpson Desert in the east, the Great Victoria Desert in the south and the Carnarvon, Murchison and Pilbara IBRA regions in the west (Woinarski *et al.* 2014). It is distributed across inland Australia with a population that fluctuates somewhat in response to seasonal conditions, but is probably substantially >10,000 individuals even at its lowest point. The population size has declined historically but may now be stable. If still declining, this is at a rate of <10% over ten years (Woinarski *et al.* 2014).

The Brush-tailed Mulgara is associated mostly with hummock (spinifex) grasslands but also uses other vegetation types (often sandplains, grasslands and woodlands) when mixed with or adjacent to hummock grasslands. It is mainly nocturnal and shelters during the day in excavated burrow systems. Brush-tailed Mulgara burrows typically contain between two and nine entrances with tunnels mostly found on a single level at a below ground depth of about 300 mm. The lumen for a burrow entrance is typically an arch over a flat bottom with a height of 70-80 mm and a width of 80-100 mm at the base (Thompson & Thompson 2007). The diet of the Brush-tailed Mulgara comprises a broad range of invertebrates and small vertebrates (Woinarski *et al.* 2014).

The DBCA threatened fauna database returned 13 records (seven records were labelled as secondary signs in the database, i.e. most likely burrows) for the Brush-tailed Mulgara from Kiwirrkurra and Lake Mackay from 2012 to 2016, six of which were from a survey undertaken at Lake Mackay in 2012 (most likely Outback Ecology 2012).

The Survey Area contains suitable habitat in terms of sandy areas in which Brush-tailed Mulgara can construct burrows. This suitable habitat is the Dune and Swale and Claypan Swale habitat where the sand is sufficiently compact in which to construct burrows (Figures 8a and b). Although in some areas such as dune tops, it is likely to be too soft to allow Brush-tailed Mulgara to construct their burrows i.e. they would likely collapse.

During the survey, no Brush-tailed Mulgara were captured in traps, none were recorded on camera traps and no signs such as scats were observed and none have been recorded in the previous surveys (see table 5). However, although no signs of the Brush-tailed Mulgara were recorded, due to the number of records in the vicinity, as well as suitable habitat being present, the Brush-tailed Mulgara is considered Likely to occur.

5.2.5 Bilby (*Macrotis lagotis*)

The Bilby is listed as Vulnerable under the EPBC Act and as S3 under the WC Act. Before European settlement, the Bilby was found in over 70% of the Australian mainland. Contraction in its geographic range means it is now only found in a few locations in Australian sandy deserts and the Pilbara. The population size is estimated to be fewer than 10,000 mature individuals and is undergoing continuing decline estimated to exceed 10% over the last three generations (12 years) and that is likely to continue (Woinarski *et al.* 2014).

The Bilby has become emblematic of the threats facing small and medium-sized mammals throughout Australia's arid and semiarid interior, and is perhaps one of the most highly recognised species of conservation significance to the Australian public. Its contraction to the driest and least fertile parts of its former range in Western Australia, the Northern Territory and Queensland contrasts with that of other medium sized mammals that have become restricted to the more temperate parts of their range (Southgate *et al.* 2007).

Throughout most of its range, the Bilby occurs in low densities, shows low site fidelity and can be highly mobile in response to resource availability (Southgate *et al.* 2007, Woinarski *et al.* 2014). This mobility and temporary use of habitat means that there is a high chance of non-detection of Bilbies in any survey, and individuals and groups are, therefore, difficult to locate and follow over time (Cramer *et al.* 2016).

While Bilby populations in the south-west of Queensland and the Tanami Desert of the Northern Territory have been comparatively well studied, the status of Bilbies in large parts of Western Australia is unclear. Bilbies previously occurred across most of Western Australia, including suitable areas of open forest and woodland in the northern and eastern jarrah forests in the south of the state (Abbott 2001). The current extent of occurrence of Bilbies in Western Australia has reduced significantly and understanding of the ecology and best practice management within this vast region is still rudimentary because of its size, the sparse human population and the dramatic changes to faunal communities that have occurred since European settlement (Cramer *et al.* 2016).

Apart from general and targeted survey work to determine Bilby presence, there have been few studies of the Bilby in the north of the state. There is little information on the number or density of Bilbies occurring within various biogeographical regions; how they use habitat and food resources within the wide variety of substrate and vegetation types in which they have been recorded; or which areas are likely to act as population sources and sinks. No reliable information is available on the population size, the number of subpopulations in the state, and how these populations are structured spatially across the western deserts (Great Sandy, Little Sandy and Gibson deserts), Kimberley and Pilbara (Cramer *et al.* 2016).

Bilbies occupy a variety of habitats including Mitchell Grass and stony downs country of cracking clays, desert sandplains and dune fields sometimes containing laterite, hummock grasslands (Spinifex) and massive red earths with Acacia shrubland (Southgate *et al.* 2007, Van Dyck 2008). Free surface water is not typically available in the Bilby's range. As a result, they derive most of their water from the food that they consume. They are omnivorous and have a diet consisting of insects and their larvae, seeds, fruit and fungi, the proportions of which can vary depending on location (Southgate & Carthew 2006).

Male Bilbies have been found to have a home range of 3.2 km (Moseby & O'Donnell 2003). They are mostly solitary and typically occur at low densities of < 1 km². They are also relatively mobile, moving between a series of scattered burrows that can be more than 1 km apart (Moseby & O'Donnell 2003). Male Bilbies can also move up to 5 km between burrows on consecutive nights (Southgate *et al.* 2007). These factors make it difficult to detect their presence i.e. detectability is low for this species.

The Survey Area contains suitable habitat in terms of sandy areas in which Bilbies can construct burrows. This suitable habitat is most likely the Swale and Claypan Swale habitat where the sand is sufficiently compact in which to construct burrows. Although Dune habitat may be suitable in places, it is likely too soft in most areas to allow Bilbies to construct their burrows.

The DBCA threatened fauna database returned 70 records for the Bilby from Kiwirrkurra from 2000 to 2016. Except for four camera trap records, all were secondary signs. During the survey, no Bilbies were captured in traps, none were recorded on camera traps and no signs, such as scats, were observed. In addition, no Bilbies were recorded in the Level 1 survey undertaken by Ecologia (Ecologia 2017). A Bushblitz Survey undertaken near Kiwirrkurra and Lake Mackay in 2015, however, did return Bilby records. During this survey, Bilbies were recorded on camera traps and through signs such as burrows (Cowan *et al.* 2015).

Although no signs of the Bilby were recorded in this survey, recent local records, together with the presence of suitable habitat in the proposed infrastructure areas and greater study area means that the Bilby is considered as Likely to occur.

5.2.6 Northern Marsupial Mole (*Notoryctes caurinus*)

DBCA lists the Northern Marsupial Mole as Priority 4. The species occurs in the Great Sandy, Little Sandy and the northern Gibson Deserts of WA. It is also likely to occur in the western Tanami of WA and the western Northern Territory.

The distribution of the Northern Marsupial Mole follows that of the sand dune country which they seem to prefer. The connectivity of dunes in determining distribution appears important, i.e. mole signs are less common where there is low dune connectivity and isolated areas of dunes may not be inhabited (Woinarski *et al.* 2014).

The Northern Marsupial Mole inhabits sand dunes and to a lesser extent adjacent swales where there is suitable deep, loose sand. It spends almost its entire life underground, only very occasionally coming to the surface and remaining on the surface for a very short time (Woinarski *et al.* 2014).

DBCA's threatened fauna database returned a single record of the Northern Marsupial Mole from a survey undertaken in 2012. Ecologia (2017) recorded old signs (tunnel in a dune) during their assessment. The Survey Area is within the known distribution of the species and suitable habitat is present. The Northern Marsupial Mole is, therefore, considered Likely to occur in both proposed infrastructure areas and the greater Study Area.

6. Conclusion

The following fauna surveys have been undertaken in and around the Lake Mackay Survey Area over the past two years:

- Level 2 and Targeted Fauna Survey in November 2017 (Strategen 2017)
- Level 2 Vertebrate Fauna Baseline Survey in May 2017 (360 Environmental 2017a)
- Waterbird Survey in April 2017 (360 Environmental 2017c)
- Level 1 Fauna Survey in September 2016 (Ecologia 2016)
- Kiwirrkurra Indigenous Protected Area (IPA) Bushblitz Survey in September 2015 (Cowan *et al.*, 2015).

Collectively, these surveys have assessed the fauna assemblage and likely presence of conservation significance species at Lake Mackay. Consideration has been given primarily to proposed infrastructure areas, however, a greater Study Area has been considered, which has included several islands in the lake.

When taking into consideration the accumulated data from these five surveys, the following conclusions have been made:

- a total of 21 conservation significant fauna species (including Priority species) were either recorded during the surveys or identified during the desktop review of database searches as potentially occurring
- of these 21 conservation significant species, a total of nine species have been directly or indirectly observed over the course of the five surveys:
 - * Fork-tailed Swift (*Apus pacificus*)

- * Australian Painted Snipe (*Rostratula australis*)
- * Sharp-tailed Sandpiper (*Calidris acuminata*)
- * Common Greenshank (*Tringa nebularia*)
- * Red-necked Stint (*Calidris ruficollis*)
- * Rainbow Bee-eater (*Merops ornatus*)
- * Great Desert Skink (*Liopholis kintorei*)
- * Northern Marsupial Mole (*Notoryctes caurinus* [signs])
- * Bilby (*Macrotis lagotis*).

Of these nine conservation significant species recorded above, five species (the Fork-tailed Swift, Australian Painted Snipe, Sharp-tailed Sandpiper, Common Greenshank and Red-necked Stint) are listed as migratory shorebirds/waterbirds. Four of these species were recorded in Claypan habitat outside of any of the proposed infrastructure areas and the Fork-tailed Swift was recorded flying over the islands. Claypan habitat is not present in the currently proposed western infrastructure area and is very limited in the proposed southern infrastructure area. It is important to note that these migratory bird species are likely to only visit the lake and its claypans when episodically significant rainfall events occur and fill these waterbodies, including the lake. They will, therefore, likely utilise parts of the Survey Area sporadically and are unlikely to depend exclusively on habitat present in and surrounding the proposed infrastructure areas. This habitat is also widespread and common in the greater Study Area and, importantly, it is also more broadly represented around the lake and across the region.

Of the 21 conservation significant species identified across the field surveys and desktop reviews, a total of seven species are currently considered Likely to occur in the Survey Area, two are considered Possible and 12 are considered Unlikely to occur in the Survey Area. The likelihood of these species occurring has been refined over time as the survey effort has increased, which has consequently increased knowledge of the habitat types present and the distribution of species.

The remaining five species considered Likely to occur in the Survey Area include:

- Great Desert Skink (*Liopholis kintorei*)
- Princess Parrot (*Polytelis alexandrae*)
- Brush-tailed Mulgara (*Dasycercus blythi*)
- Bilby (*Macrotis lagotis*)
- Northern Marsupial Mole (*Notoryctes caurinus*).

Regarding these five species, the proposed infrastructure areas contain large sections of suitable habitat that is within their known distribution. Across the five surveys to date, effort has been undertaken primarily in discrete patches (i.e. proposed infrastructure areas) due to limited access in what is a very remote location (a very limited number of tracks). The proposed southern infrastructure area has now been surveyed twice (May and November 2017), however, the proposed western infrastructure area has been surveyed just once. A lack of observation, therefore, does not mean a lack of presence and so they are still considered Likely to occur in the Survey Area.

The Great Desert Skink occupies a variety of habitat types within the western deserts region. The species generally occurs on spinifex hummock grass sandplains and some adjacent dune field swales, the extent of which ranges in size from a few hundred hectares to tens of thousands of hectares. The proposed infrastructure areas have large areas of suitable habitat. Limited ecological knowledge of the species also makes detection difficult and as such the species is still considered as Likely to occur.

At this stage, the Night Parrot survey is preliminary. There is very limited ecological information on the species, but habitat is known to be long-unburnt, large spinifex hummocks. Therefore, large areas of suitable Night Parrot roosting, breeding and feeding habitat in and near the proposed infrastructure areas are present. The proposed infrastructure areas and the greater Study Area and the region in general, has a "parrot-friendly" fire history and nearby records (including one 240 km from Lake Mackay), suggest the likelihood of the Night Parrot occurring is Possible.

The Princess Parrot also inhabits areas with large spinifex hummocks and Desert Oak. Large areas of roosting, breeding and feeding habitat in and near the proposed infrastructure areas are, therefore, present and so the species remains as Likely to occur.

There is little information on the number or density of Bilbies occurring within various biogeographical regions including the Great Sandy Desert. Bilbies have large home-ranges, are mostly solitary and at low densities. In addition, they are also highly mobile, moving between a series of scattered burrows up to 5 km apart on consecutive nights. These factors make detectability low for this species. Detail regarding habitat use and food resources, population size, subpopulations and how these populations are structured spatially across the Great Sandy Desert is limited. They are, however, known to inhabit desert sandplains and dune fields sometimes containing laterite and spinifex hummock grassland. Large areas of suitable Bilby habitat in and near the proposed infrastructure areas are, therefore, present and so the species remains Likely to occur.

Due to time constraints and restricted helicopter access, the Northern Marsupial Mole was not surveyed for. This species is not an EPBC listed species, however, and so survey effort was focused on those species above primarily listed under the EPBC Act. If deemed necessary, the Northern Marsupial Mole could be addressed in any potential future surveys.

In conclusion, a lack of observation of these conservation significant species does not mean a lack of presence. Relatively limited survey effort, limited access, limited database results (due to few previous ecological studies), remoteness of the location and suitable habitat make it difficult to dismiss these species, particularly as detectability is low for many of them. Possible further survey effort may potentially be required, particularly in the proposed western infrastructure area, or any further potential areas of disturbance that may be considered and are so far un-surveyed. In addition, for certain species such as the Night Parrot, this may need to be guided by climatic factors such as large rainfall events.

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Survey team and SOP project staff at Agrimin camp, November 2017

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