Wodgina Lithium Project:

Level 2 Vertebrate Fauna Survey 2019

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Executive Summary

Introduction

The Wodgina Lithium Project is owned by the MARBL Lithium Joint Venture (MARBL JV) and operated through the managing entity MARBL Lithium Operations Pty Ltd (MARBL). The Wodgina mining area has been the location for various mining operations over the past several decades; therefore, fauna assessments of differing scopes have been undertaken over the years to support environmental assessment and mining approvals.

Lack of a contemporary Level 2 vertebrate fauna survey across the entire mine site has previously been identified as a gap in the fauna knowledge base of the Wodgina area. To address this gap, Western Wildlife were commissioned to carry out an additional two-phase Level 2 fauna survey of the Wodgina mine site (hereafter referred to as the Study Area).

The purpose of the survey was to collate existing data and gather contemporary baseline fauna data where necessary to inform the environmental impact assessment process. This report includes the findings of the two-phase baseline vertebrate fauna survey, conducted in April and October 2019.

Methods

The fauna survey was undertaken in accordance with relevant guidance published by the Australian and Western Australia governments, including:

- *Statement of environmental principles, factors and objectives* (Environmental Protection Authority (EPA) 2016a)
- *Environmental factor guideline – terrestrial fauna* (EPA 2016b)
- *Technical guidance – terrestrial fauna surveys* (EPA 2016c)
- *Technical Guide: terrestrial vertebrate fauna surveys for environmental impact assessment* (EPA and DEC 2010)
- State and Federal guidelines for surveying conservation significant fauna.

The literature review was focused on collating fauna records that had been collected during previous surveys within the Study Area.

The fauna survey comprised two phases, with each field survey carried out by four zoologists between 8 - 19 April 2019 and 16 – 26 October 2019. The fauna survey included:

- trapping at six sites for seven nights, each with ten pitfall traps (six buckets and four PVC pipes), ten funnel traps, 20 Elliott traps and two cage traps
- bird surveys at each trapping site and opportunistically
- bat surveys with acoustic detectors at 7 sites in April and 13 sites in October
- Night Parrot survey with passive acoustic detectors at 6 sites in April
- camera trap survey at 40 sites in April and 42 sites in October, targeting Northern Quoll (*Dasyurus hallucatus*)
- spot-lighting transects and searches
- keeping opportunistic records of fauna.

Species of conservation significance were classified as: **Threatened** if listed as Extinct in the Wild, Critically Endangered, Endangered or Vulnerable under *The Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and/or *Biodiversity Conservation Act 2016* (BC Act); **Migratory** if listed as Migratory under the EPBC Act and/or BC Act, excluding those species also listed as threatened; **Specially Protected** if listed as Other Specially Protected Species or Conservation Dependent Fauna under the BC Act; **Priority** if listed as Priority by DBCA and **Locally Significant** if considered by the author to potentially be of local significance.

Results and Discussion

Six fauna habitats occur in the Study Area:

- Ironstone Ridgetop
- Rocky Ridge and Gorge
- Rocky Foothills
- Stony Rise
- Spinifex Stony Plain
- Drainage Line

Other than the Ironstone Ridgetop and Rocky Ridge and Gorge, the habitats present are widespread in the Pilbara Bioregion. Habitats of importance within the Study Area are the Rocky Ridge and Gorge habitat (as it supports Threatened fauna and is limited in extent) and the Drainage Line habitat (as it supports diverse faunal assemblages and may act as corridors for movement).

The faunal assemblage of the Study Area as a whole is diverse as the Study Area contains a range of habitats. Many of the species that occur in the Study Area are widely distributed through arid Australia. The predicted faunal assemblage includes up to ten frogs, 108 reptiles, 140 birds and 33 native mammals and eight introduced mammals. The observed assemblage thus far includes five frogs, 71 reptiles, 89 birds, 25 native mammals and six introduced mammals. Seventeen conservation significant fauna have either been recorded or are listed as potentially occur in the Study Area. The species are grouped into their conservation significance categories and discussed below.

Threatened species

Six threatened species potentially occur in the Study Area, of which three have been recorded during the current or previous surveys:

- Pilbara Olive Python (*Liasis olivaceous barroni*) - EPBC Act (Vulnerable), BC Act (Vulnerable)
- Grey Falcon (*Falco hypoleucos*) - BC Act (Vulnerable)
- Night Parrot (*Pezoporus occidentalis*) - EPBC Act (Endangered), BC Act (Critically Endangered)
- Northern Quoll (*Dasyurus hallucatus*) - EPBC Act (Endangered), BC Act (Endangered) – **Recorded**
- Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) - EPBC Act (Vulnerable), BC Act (Vulnerable) – **Recorded**
- Ghost Bat (*Macroderma gigas*) - EPBC Act (Vulnerable), BC Act (Vulnerable) – **Recorded**

The Northern Quoll, Pilbara Leaf-nosed Bat and Ghost Bat are all known to occur in the Study Area. The Northern Quoll is likely to be a resident breeding species, albeit one that is less numerous than in previous years, probably due to the impact of bushfires in 2014 and 2016 (Stantec 2017).

The Pilbara Leaf-nosed Bat is known to forage in the Study Area, particularly in the Drainage Line habitat. No permanent diurnal roosts are present or thought likely to be present, though a transitory diurnal roost and nocturnal refuges have been recorded in the western part of the Study Area.

Similarly, the Ghost Bat is likely to forage across the Study Area, with diurnal roosts and potential maternity roosts recorded in the Study Area. Significant numbers of Ghost Bats have been recorded on occasion.

Migratory species

Four Migratory species potentially occur in the Study Area, of which two have been recorded during current or previous surveys:

- Oriental Plover (*Charadrius veredus*)
- Wood Sandpiper (*Tringa glareola*) – **Recorded**
- Common Sandpiper (*Tringa hypoleucos*) – **Recorded**
- Fork-tailed Swift (*Apus pacificus*)

The Common Sandpiper and Wood Sandpiper are known to occur in the Study Area. The Study Area does not provide important habitat for migratory species, however a few individuals may occur at times.

Specially Protected species

A single Specially Protected species potentially occurs in the Study Area:

- Peregrine Falcon (*Falco peregrinus*)

Although not recorded in the Study Area, the Peregrine Falcon potentially occurs as a breeding species or a foraging visitor. Although the Study Area provides habitat for this species, its population is large and secure.

Priority species

Six Priority species potentially occur in the Study Area, of which three have been recorded on the current or previous surveys:

- Black-striped Ctenotus (*Ctenotus nigrilineatus*) – Priority 1
- Gane's Blind Snake (*Anilios ganei*) – Priority 1
- Long-tailed Dunnart (*Sminthopsis longicaudata*) - Priority 4 – **Recorded**
- Spectacled Hare-wallaby (*Lagorchestes conspicillatus*) – Priority 4 - **Recorded**
- Lakeland Downs Mouse (*Leggadina lakedownensis*) – Priority 4
- Western Pebble-mound Mouse (*Pseudomys chapmani*) - Priority 4 – **Recorded**

The Black-striped Ctenotus and Gane's Blind Snake are data deficient and known from only a few locations. They have not been recorded in the Study Area, but the habitats present therein may support these species.

The Long-tailed Dunnart was recorded in 2009 and is likely to be restricted to rocky habitats. The Western Pebble-mound Mouse is likely to be common and widespread within its habitat of Spinifex Stony Plains. The Spectacled Hare-wallaby was recorded in 2018 and is likely to occur in low densities on the Spinifex Stony Plain, favouring long-unburnt areas. Although unrecorded thus far, the Lakeland Downs Mouse may occur, as the Study Area is within its range and potentially suitable habitats are present.

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Tables, Figures and Plates

1. Introduction

The Wodgina Lithium Project is owned by the MARBL Lithium Joint Venture (MARBL JV) and operated through the managing entity MARBL Lithium Operations Pty Ltd (MARBL). The Wodgina mining area has been the location for various mining operations over the past several decades; therefore, fauna assessments of differing scopes have been undertaken over the years to support environmental assessment and mining approvals.

Lack of a contemporary Level 2 vertebrate fauna survey was identified as a gap in the fauna survey coverage of the Study Area. To fill this gap, Western Wildlife was commissioned to carry out an additional two-phase Level 2 fauna survey, and to extend the fauna habitat mapping into an Additional Study Area to the south.

The purpose of the fauna survey was to gather baseline fauna data to inform environmental impact assessment as part of Project approvals. The key objectives of the fauna survey were to:

- Collate existing fauna data and collect contemporary trapping data for the Study Area.
- Extend the fauna habitat mapping to cover the Additional Study Area.
- List the vertebrate fauna that were recorded in and/or have the potential to occur in the Study Area.
- Identify species of conservation significance, or habitats of particular importance for fauna, that may occur.

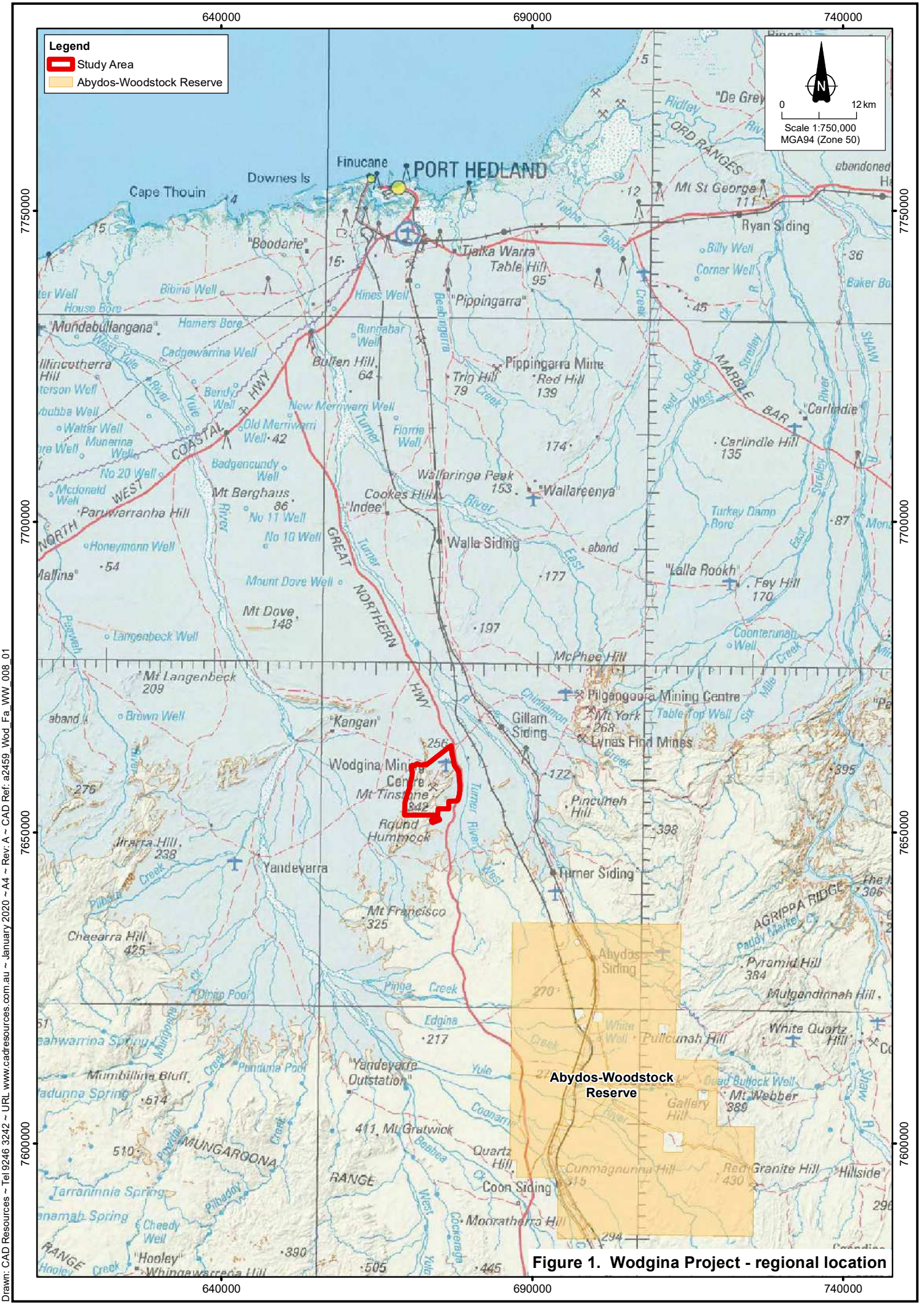
This report includes the findings of the two-phase baseline vertebrate fauna survey, conducted in April and October 2019.

1.1 Regional Context

The Wodgina Project is located 95 km south of Port Hedland in the Pilbara region of Western Australia (Figure 1).

The Interim Biogeographic Regionalisation for Australia (IBRA) classifies Australia's landscapes into 89 Bioregions based on common climate, geology, landform, native vegetation and species information. These Bioregions are further subdivided into 419 subregions.

The Project is situated in the Chichester subregion of the Pilbara Bioregion (DEWHA 2004), which is comprised of undulating plains of Achaean granite and basalt, with basalt ranges (Kendrick and McKenzie 2001). The plains support open shrublands of *Acacia* over spinifex hummock grasslands, and the ranges support an open tree-steppe of *Eucalyptus leucophloia* over spinifex hummock grasslands.



The climate is semi-desert tropical, receiving about 300mm of rain per year (Kendrick and McKenzie 2001). The dominant land-uses are grazing on native pastures, Aboriginal lands and reserves, Unallocated Crown Land and Crown Reserves, Conservation and Mining (Kendrick and McKenzie 2001).

1.2 Study Area

1.2.1 Current Study Area

The Study Area and Additional Study Area for this survey are shown in Figure 2. The operational mining area is situated within the Study Area and was not surveyed. The aim of the current survey was to collate existing fauna data and collect contemporary fauna data in order to describe the terrestrial vertebrate faunal assemblage of the Study Area as a whole. As such, the current survey was focused on the eastern part of the Study Area. The Study Area was extended as part of the October 2019 survey, primarily to increase the extent of the fauna habitat mapping (Additional Study Area).

1.2.2 Extent of Previous Surveys Across the Study Area

Three Level 2 (trapping) fauna surveys have been undertaken across differing extents within the Study Area:

- Wodgina DSO Project in 2009 (Outback Ecology 2009),
- Wodgina Hercules DSO Project in 2011 (Outback Ecology 2012)
- Turner River Hub Project in 2010 (Outback Ecology 2010).

The extent of each of these fauna surveys and the location of the trapping sites is shown in Figure 3.

The Turner River Hub study area was very large, and none of the trapping sites were within the current Study Area. However, the results of the remaining two fauna surveys provide data collected within the Study Area, covering much of the western part of the Study Area. These surveys focused mainly on the rocky upland habitats.

Level 1 and targeted fauna surveys for the Northern Quoll (*Dasyurus hallucatus*), Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) and Ghost Bat (*Macroderma gigas*) were undertaken by Stantec (2018a, 2018b) and 360 Environmental (2018). These surveys cover much of the eastern part of the Study Area (Figure 4), and include searches for potential bat roosting caves.

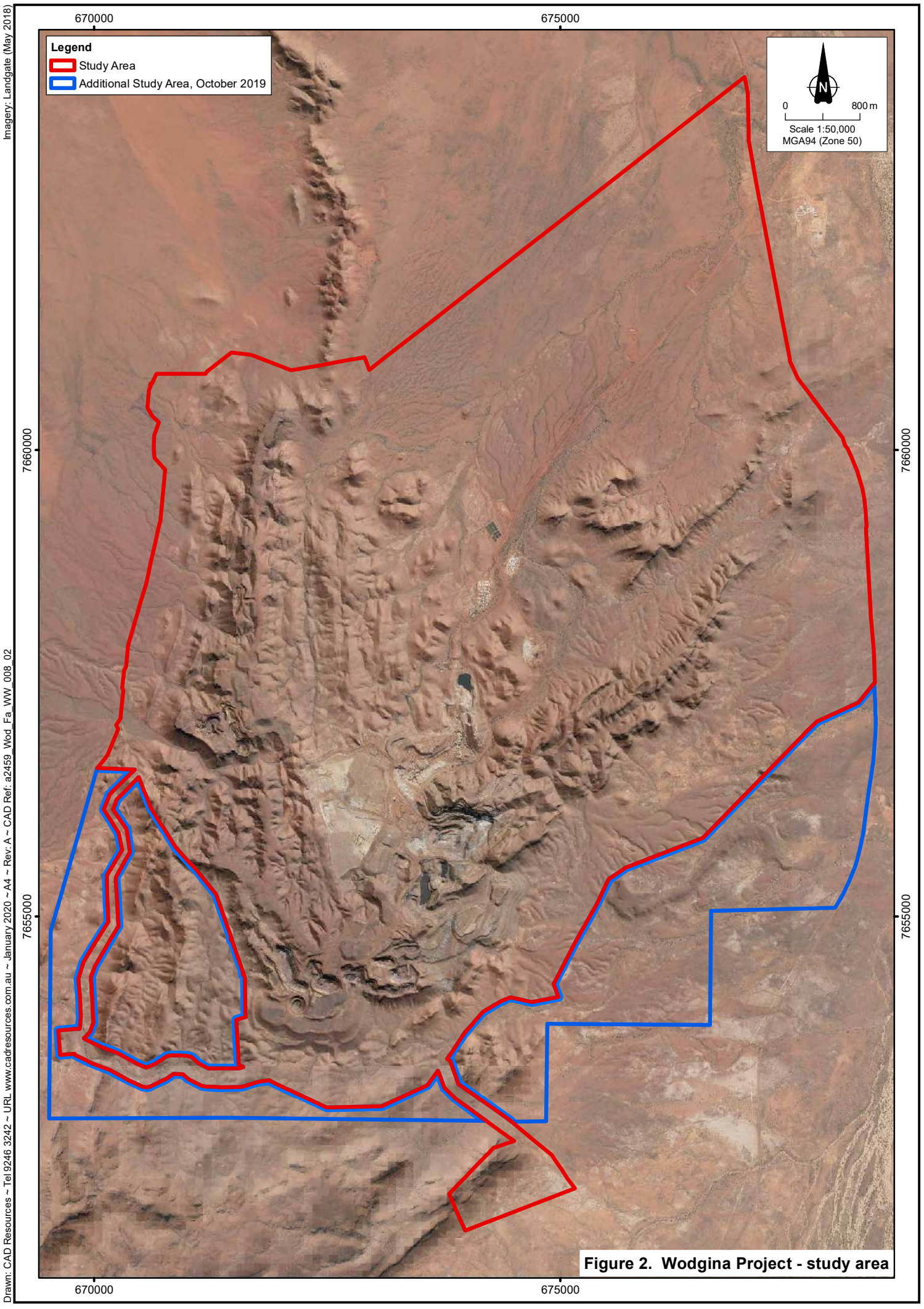


Figure 2. Wodgina Project - study area

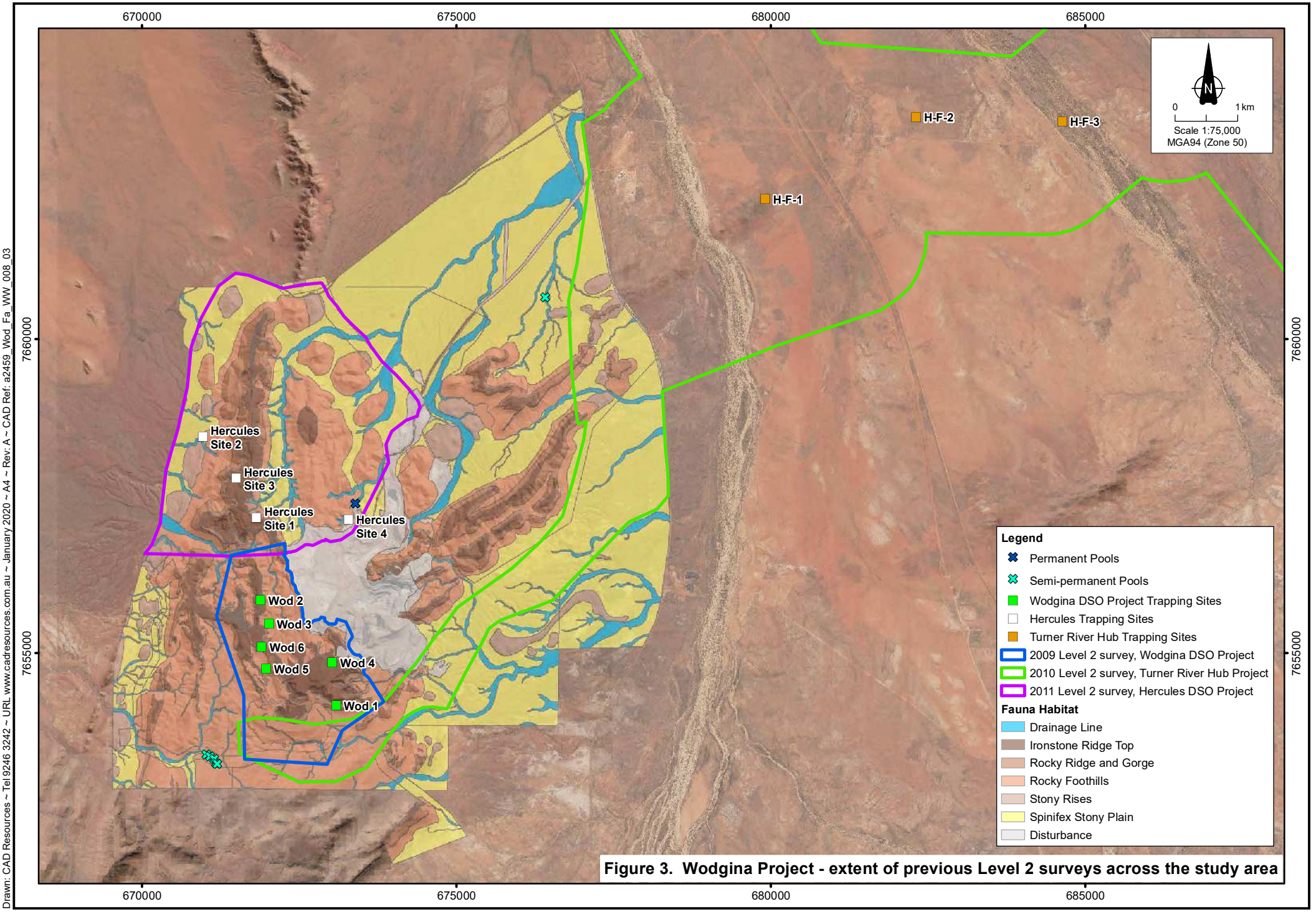


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Figure 3. Wodgina Project - extent of previous Level 2 surveys across the study area

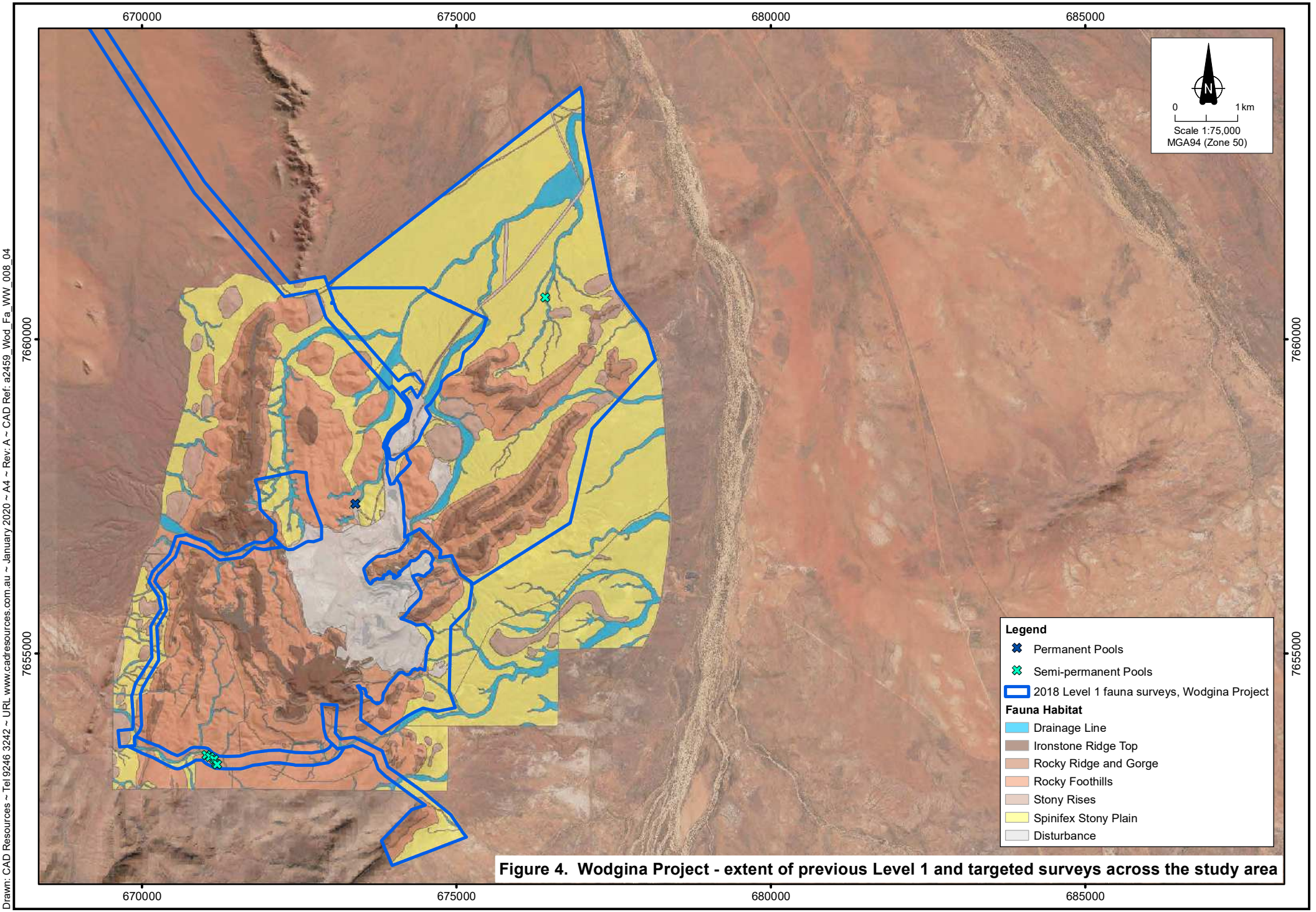

Figure 4. Wodgina Project - extent of previous Level 1 and targeted surveys across the study area

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1.3 Climate and Weather

The nearest weather station is Marble Bar (site number 004106), about 113 km east of the Study Area. The mean monthly maximum and minimum temperatures and rainfall for this weather station is presented in Figure 5. The data indicate that the highest rainfall and temperatures occur in the summer months, though some rain falls throughout the year.

The average annual rainfall for Marble Bar between 2000 and 2019 is 379.3mm (Bureau of Meteorology 2019). However, annual rainfall was higher than average in 2017 (541.6mm) and 2018 (418.2mm). Weather during both surveys was characterised by warm nights, warm to hot days and high humidity.

Prior to the April 2019 field survey, significant rainfall (about 600mm) fell in the area due to Cyclone Veronica, however, conditions were relatively dry prior to the October survey. The daily temperatures and rainfall prior to and during the field surveys (as recorded at Marble Bar), are presented in Appendix 1.

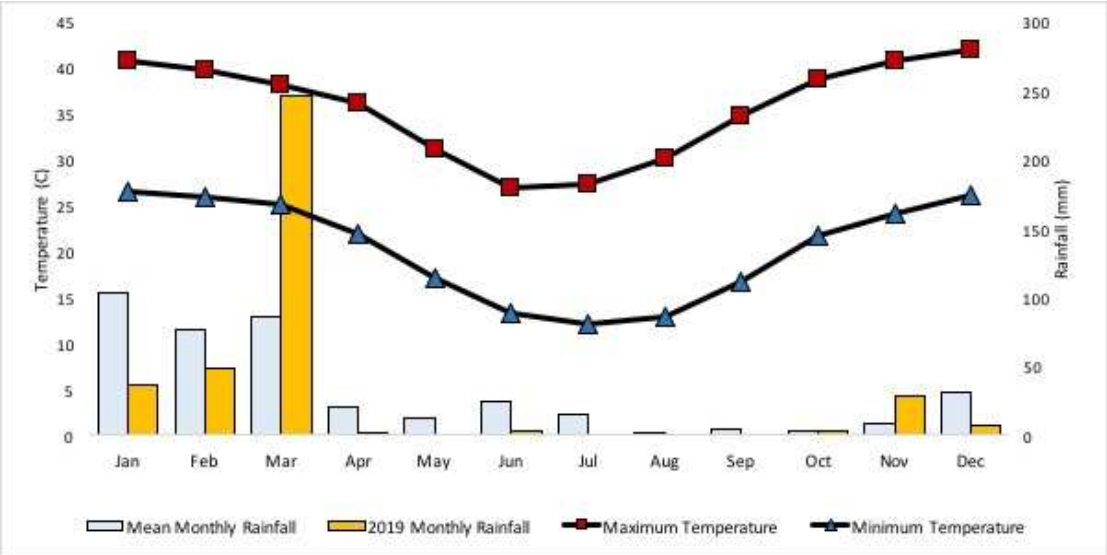

Figure 5. Monthly Climate Statistics for Marble Bar (Bureau of Meteorology 2019).

2. Methods

2.1 Overview

A two-phase Level 2 vertebrate fauna survey was conducted across the eastern portion of the Study Area in April and October 2019. Targeted surveys for Northern Quoll (*Dasyurus hallucatus*) and the Night Parrot (*Pezoporus occidentalis*) were undertaken where there was habitat that potentially supported each species.

As several fauna surveys have been undertaken across the Study Area between 2009 - 2018 (Biologic 2018a and 2018b, Outback Ecology 2009 and 2012, Stantec 2017, 2018a and 2018b, 360 Environmental 2018a and 2018b), the aim of the current survey was to fill any gaps in coverage, gather contemporary data and collate existing data for the Study Area, rather than replicate past survey effort.

The Additional Study Area was added in October 2019, primarily to allow for increasing the extent of the fauna habitat mapping. Note that although some data were collected in the Additional Study Area, the area includes rocky ridges that have not been searched for potential bat roosting habitat.

The methods are further described in the sections below.

2.2 Guidance Documents

The fauna survey was conducted with reference to the following documents:

- Environmental factor guideline: terrestrial fauna (EPA 2016b)
- Technical guidance: terrestrial fauna surveys (EPA 2016c)
- Technical guide: terrestrial vertebrate fauna surveys for environmental impact assessment (EPA and DEC 2010)
- Interim guideline for preliminary surveys of night parrot (*Pezoporus occidentalis*) in Western Australia (DPAW 2017)
- Survey Guidelines for Australia's Threatened Mammals (DSEWPaC 2011a)
- Survey Guidelines for Australia's Threatened Birds (DEWHA 2010)
- Survey Guidelines for Australia's Threatened Reptiles (DSEWPaC 2011b)

2.3 Personnel

Four zoologists undertook each phase of the fieldwork in April and October 2019, with bat call analysis provided by Dr Kyle Armstrong of Specialised Zoological. Details of the survey team and their experience are shown in Table 1. This report was prepared by Ms Jenny Wilcox.

Table 1. Fauna Survey Personnel.

Name	Role	Qualification	Experience	Survey
Jenny Wilcox	Supervising Vertebrate Zoologist (plan and lead fieldwork, analyse data, prepare report)	BSc.Biol/Env.Sci., Hons.	20 years	April & October
Mike Brown	Vertebrate zoologist (fieldwork, SM4 passive acoustic detector analysis)	BSc.Env.Sci.	13 years	April
Cameron Everard	Vertebrate zoologist (fieldwork)	BSc.Env.Sci.	13 years	April
Brenden Metcalf	Vertebrate zoologist (fieldwork)	BSc.Biol., Hons.	20 years	April & October
Amy Griffiths	Vertebrate zoologist (fieldwork)	BSc.Biol., Hons.	9 years	October
Tim Gamblin	Vertebrate zoologist (fieldwork)	BSc.Env.Sci.	12 years	October
Kyle Armstrong	Bat call analysis	PhD. Zool.	21 years	April & October

2.4 Taxonomy and Nomenclature

Taxonomy and nomenclature for fauna species used in this report follow the Western Australian Museum checklists, updated April 2019. In the text, common names are used where appropriate, and all scientific names are given in species lists. Where a species lacks a common name, they are referred to by their scientific name.

Surveys have been undertaken across the Study Area over several years, and there have been taxonomic changes within this time, mainly where a single species has been split into several species. Effort has been made to assign older records to their current names, where possible.

2.5 Literature Review

A comprehensive literature review was undertaken by Stantec (2018b), including a review of other fauna surveys in the region such as those at Mt Dove (34km northwest of the Study Area), Abydos DSO Project (45km east of the Study Area) and North Star (38km east of the Study Area). The review by Stantec (2018b) was undertaken in the context of both the Study Area and an 80km gas pipeline extending to the north of the Study Area. The details of this review are not reproduced here, and may be found in Stantec (2018b).

The review for the current survey focused on the Study Area only. As such, the results of the following surveys undertaken between 2009 and 2018 have been collated:

- 360 Environmental. (2018a). Flora, Vegetation and Fauna Assessment Wodgina Mine and Proposed Airstrip. Unpublished report prepared for Mineral Resources Limited.
- 360 Environmental. (2018b). Wodgina Mine and Additional Gas Pipeline: Flora, Vegetation, Fauna and Northern Quoll Assessment. Unpublished report prepared for Mineral Resources Limited.

- Biologic (2018a). *Wodgina DSO Project: Northern Quoll Monitoring Survey*. Unpublished report to Atlas Iron Limited.
- Biologic (2018b). *Wodgina DSO Project: Pilbara Leaf-nosed Bat and Ghost Bat Monitoring Survey*. Unpublished report to Atlas Iron Limited.
- Outback Ecology (2009). Wodgina DSO Project: Terrestrial Vertebrate Fauna Assessment. Unpublished report prepared for Atlas Iron Limited.
- Outback Ecology (2012). Hercules Project: Terrestrial Vertebrate Fauna Baseline Survey. Unpublished report prepared for Atlas Iron Limited.
- Stantec (2017). Northern Quoll Monitoring Survey 2017. Unpublished report prepared for Atlas Iron Limited.
- Stantec (2018a). *Results of the Wodgina Supplementary Bat Survey*. Unpublished memo to Mineral Resources Limited, November 2018.
- Stantec (2018b). *Wodgina Project: Level 1 fauna Survey, targeted conservation significant fauna survey and desktop assessment*. Unpublished report prepared for Mineral Resources Limited, September 2018.

The databases listed in Table 2 were searched for fauna records in and around the Study Area. In all cases the extent of the database search was larger than the extent of the Study Area in order to pick up records of species in the wider area that may also occur in the Study Area.

Table 2. Databases used in the preparation of Appendices 5 - 8.

Database	Type of records held	Area searched
NatureMap (DBCA 2007-) Note that the NatureMap database collates records from several other databases.	• WA Museum Specimen Databases for reptiles frogs, birds and mammals - records of specimens held in the Western Australian Museum. Includes historical records. • Fauna Survey Returns Database - records collected from fauna surveys carried out in Western Australia. Includes observational and trapping data. • Birds Australia Atlas Database - Records of bird observations in Australia, 1998-2009. • Birdata - records of bird observations in Australia, 2010-current.	40km radius around a point in the center of the Study Area (118° 40' 48'' E,21° 10' 23'' S). Extract obtained April 2019.
DBCA's Threatened and Priority Fauna Database (DBCA 2018)	Information and records on Threatened and Priority species in Western Australia.	15km buffer around the study area (search performed by 360 Environmental 2018)
EPBC Act Protected Matters Search Tool	Information and modelled distributions for matters protected under the EPBC Act, including threatened species and ecological communities, migratory species and marine species.	10km radius around a point in the center of the Study Area (118° 40' 48'' E,21° 10' 23'' S). Extract obtained April 2019.

Where possible, coastal species, vagrants and species that favour habitats absent from the Study Area (e.g. sandplains) have been excluded from the list, unless further discussion is warranted. The lists of fauna expected to occur in the Study Area were reviewed against a number of sources, including publications that provide information on general patterns of distribution of frogs (Tyler *et al*. 2000), reptiles (Wilson and Swan 2017, Storr *et al*. 1983, 1990, 1999 and 2002), birds (Barrett *et al*. 2003; Johnstone and Storr 1998 and 2004) and mammals (Churchill 2008, Menkhorst and Knight 2011; Van Dyck and Strahan 2008).

2.6 Field Survey

2.6.1 Licensing

All fauna works in 2019 were carried out under Regulation 27 Fauna Taking (Biological Assessment) License BA2700041 issued by the Department of Biodiversity, Conservation and Attractions (DBCA). Trapping for Northern Quolls were undertaken under a Section 40 Authorisation to Take or Disturb Threatened Species.

2.6.2 Timing

The fauna survey was undertaken in two phases:

- 8 – 19 April 2019
- 16 – 26 October 2019

This is during the recommended September – April survey period for reptiles in the Eremaean region, and the April survey followed a period of very heavy rainfall, providing ideal timing for birds and mammals (EPA and DEC 2010).

2.6.3 Trapping for Terrestrial Fauna

Trapping for terrestrial fauna (frogs, reptiles and small mammals) was undertaken using a combination of pitfall traps, Elliot traps, funnel traps and cage traps. In previous surveys, trapping was undertaken at 10 sites in the Study Area, six in 2009 as part of the Wodgina DSO Project (Outback Ecology 2009), and four in 2011 as part of the Hercules Project (Outback Ecology 2012) (Figures 3 and 4). These surveys generally covered the eastern part of the Study Area.

Rather than duplicate this work, the placement of trapping sites in the current survey aimed to increase the geographic spread of the survey and sample habitats that were not previously trapped. The ironstone ridgetop and rocky ridge and gorge habitats were not trapped in 2019. The ironstone ridgetop was surveyed extensively in the previous trapping surveys, with half of the ten sites representing this habitat. The rocky ridge and gorge habitat is difficult to survey with standard methods, and was instead targeted with camera traps and large Elliott traps (described further in the following sections).

Six trapping sites were installed in 2019, each trapping site consisting of ten pitfall traps (six buckets and four PVC pipes), ten funnel traps, 20 Elliott traps and two cage traps open for seven nights (Figure 6, Table 3). The number and types of traps were chosen to sample the likely faunal assemblage while allowing for timely checking of traps to preserve animal welfare. Each pitfall trap was placed on a 7m flywire drift fence. Each bucket pitfall trap was a 40cm deep, white 20L bucket and each PVC pipe was a 60cm deep, 150mm diameter pipe. A piece of egg carton was used as shelter for any fauna in the trap. A funnel traps was set along each pitfall trap drift fence, with the fence bisecting the funnel entrances. Funnel traps were shaded with a shade-cloth cover (Plate 1).

Plate 1. Examples of trap line set-up at WL Site 01 (left) and WL Site 06 (right).

Elliot traps were placed in a separate transect with the cage traps at either end. All cage and Elliot traps were placed under vegetation to shade any captured animals and cage traps were covered with a hessian sack. All Elliott and cage traps were baited with a mixture of rolled oats, sardines, peanut butter and vanilla essence.

The number of trap-nights for each trap type are given in Table 4, for both the previous and current survey, and photographs of each site surveyed in 2019 are given in Plates 2 - 7. All animals caught were identified and recorded, and generally released immediately at the site of capture.

Table 3. Trapping site locations 2009 - 2019.

Survey	Site	Dates open	Location (WGS84, Zone 50)	Habitat
April/May 2009 Wodgina DSO Project; Outback Ecology 2009)	Site 1	21/4/2009 – 28/4/2009	673089 E 7654166 N	Rocky Ridge and Gorge (Ironstone Ridge in Outback Ecology 2009)
	Site 2	22/4/2009 – 29/4/2009	671886 E 7655840 N	Ironstone Ridge Top (Hill crest in Outback Ecology 2009)
	Site 3	24/4/2009 – 1/5/2009	672023 E 7655465 N	Rocky Foothills (Scree slope in Outback Ecology 2009)
	Site 4	25/4/2009 – 2/5/2009	673027 E 7654849 N	Ironstone Ridge Top (minor drainage line in Outback Ecology 2009)
	Site 5	26/4/2009 – 3/5/2009	671973 E 7654752 N	Rocky Foothills (Gully in Outback Ecology 2009)
	Site 6	26/4/2009 – 3/5/2009	671905 E 7655097 N	Ironstone Ridge Top (Open mixed shrubland in Outback Ecology 2009)
March 2011 (Hercules Project; Outback Ecology 2012)	Site 1	Seven nights between 17 – 27/3/2011	671823 E 7657152 N	Ironstone Ridge Top (Rocky Ridge in Outback Ecology 2012)
	Site 2	Seven nights between 17 – 27/3/2011	670970 E 7658443 N	Spinifex Stony Plain (Stony Plain in Outback Ecology 2012)
	Site 3	Seven nights between 17 – 27/3/2011	671498 E 7657783 N	Ironstone Ridge Top (Rocky Ridge in Outback Ecology 2012)
	Site 4	Seven nights between 17 – 27/3/2011	673285 E 7657123 N	Drainage Line
April 2019 (this survey)	WL Site 01	9/4/2019 – 16/4/2019 & 19/10/2019 – 26/10/2019	675087 E 7662336 N	Drainage Line
	WL Site 02	9/4/2019 – 16/4/2019 & 19/10/2019 – 26/10/2019	675676 E 7661767 N	Stony Rise
	WL Site 03	12/4/2019 – 19/4/2019 & 19/10/2019 – 26/10/2019	678203 E 7657191 N	Spinifex Stony Plain
	WL Site 04	10/4/2019 – 17/4/2019 & 19/10/2019 – 26/10/2019	675818 E 7656131 N	Spinifex Stony Plain
	WL Site 05	11/4/2019 – 18/4/2019 & 19/10/2019 – 26/10/2019	675054 E 7658445 N	Rocky Foothills
	WP Site 06	12/4/2019 – 19/4/2019 & 19/10/2019 – 26/10/2019	678203 E 7657191 N	Drainage Line

Table 4. Survey effort at each trap site.

Survey	Site	Number of trap-nights				
		Bucket Pitfalls	PVC Pipe Pitfalls	Funnel traps	Elliot traps	Cage traps
April/May 2009 Wodgina DSO Project; Outback Ecology 2009)	Wod 01	35	35	140	140	14
	Wod 02	35	35	140	140	14
	Wod 03	35	35	140	140	14
	Wod 04	35	35	140	140	14
	Wod 05	35	35	140	140	14
	Wod 06	35	35	140	140	14
	Subtotal:	**210**	**210**	**840**	**840**	**84**
March 2011 (Hercules Project; Outback Ecology 2012)	Site 01	35	35	140	140	14
	Site 02	35	35	140	140	14
	Site 03	35	35	140	140	14
	Site 04	35	35	140	140	14
	Subtotal:	**140**	**140**	**560**	**560**	**56**
April 2019 (this survey)	WL Site 01	84	48	140	280	28
	WL Site 02	84	48	140	280	28
	WL Site 03	84	48	140	280	28
	WL Site 04	84	48	140	280	28
	WL Site 05	84	48	140	280	28
	WL Site 06	84	48	140	280	28
	Subtotal:	**504**	**288**	**840**	**1,680**	**168**
Total:		**854**	**368**	**2,240**	**3,080**	**308**

2.6.4 Trapping for Northern Quoll

In April 2019, two sites (Quoll 1 and Quoll 2) were established to target Northern Quoll, with the aim of detecting females (if present) and determining the population size (Figure 7). Each site consisted of a transect of 20 large Elliot traps, baited with a mixture of rolled oats, peanut butter and sardines, liberally marinated in fish oil (burley oil). Traps were placed in shaded locations, such as rock crevices, small caves or under large spinifex hummocks. All traps were open for seven nights 13 – 19 April 2009.

Any Northern Quoll captured were weighed, sexed and marked to allow identification of recaptures.

Also shown in Figure 7 are the locations of the Northern Quoll monitoring sites established as part of the Wodgina DSO Project. These sites were sampled annually 2010 – 2018, each site consisting of 20 large Elliott or cage traps open for seven nights (Biologic 2018a).

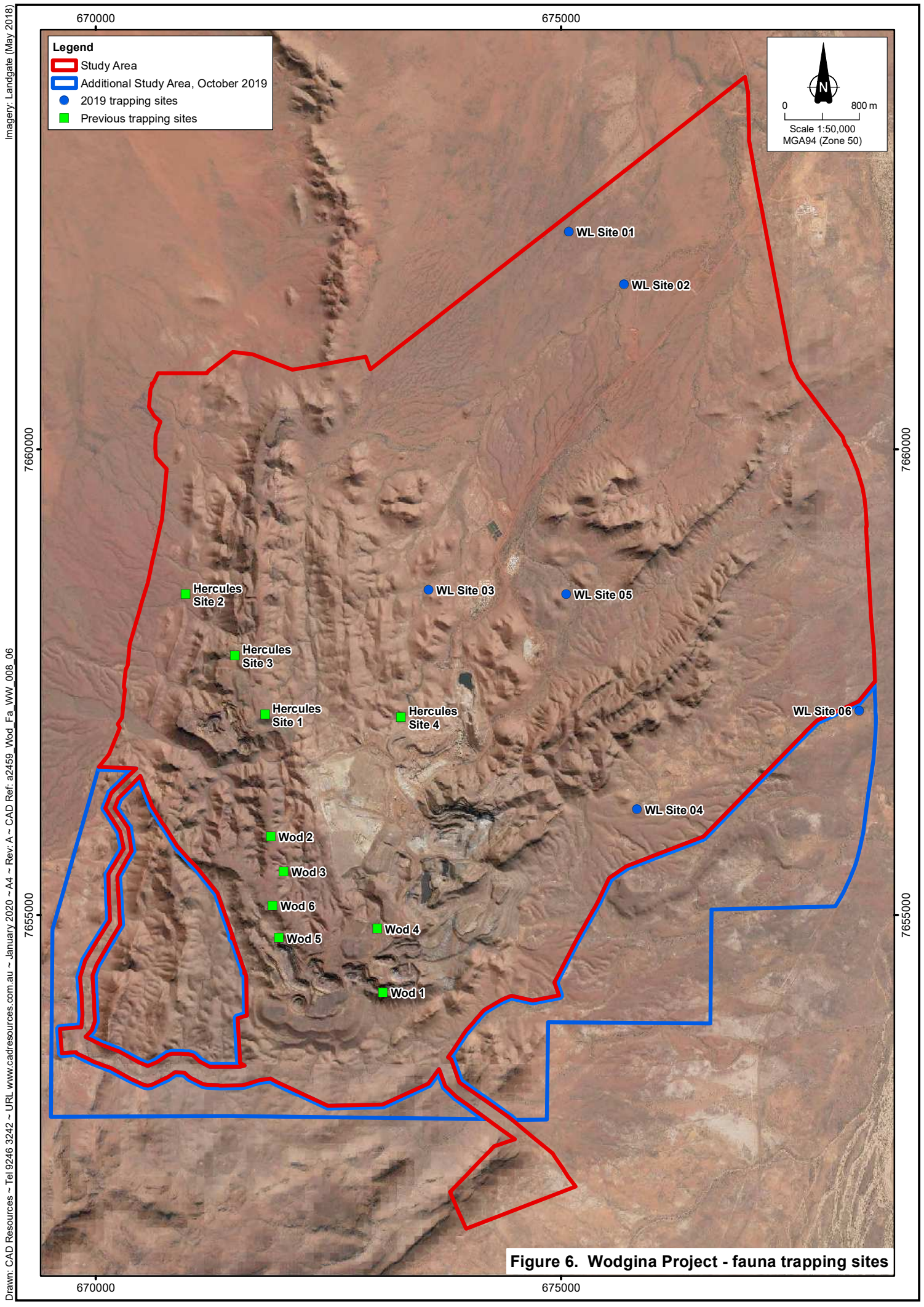

Figure 6. Wodgina Project - fauna trapping sites

Plate 2. WL Site 01.

Plate 3. WL Site 02.

Plate 4. WL Site 03.

Plate 5. WL Site 04.

Plate 6. WL Site 05.

Plate 7. WL Site 06.

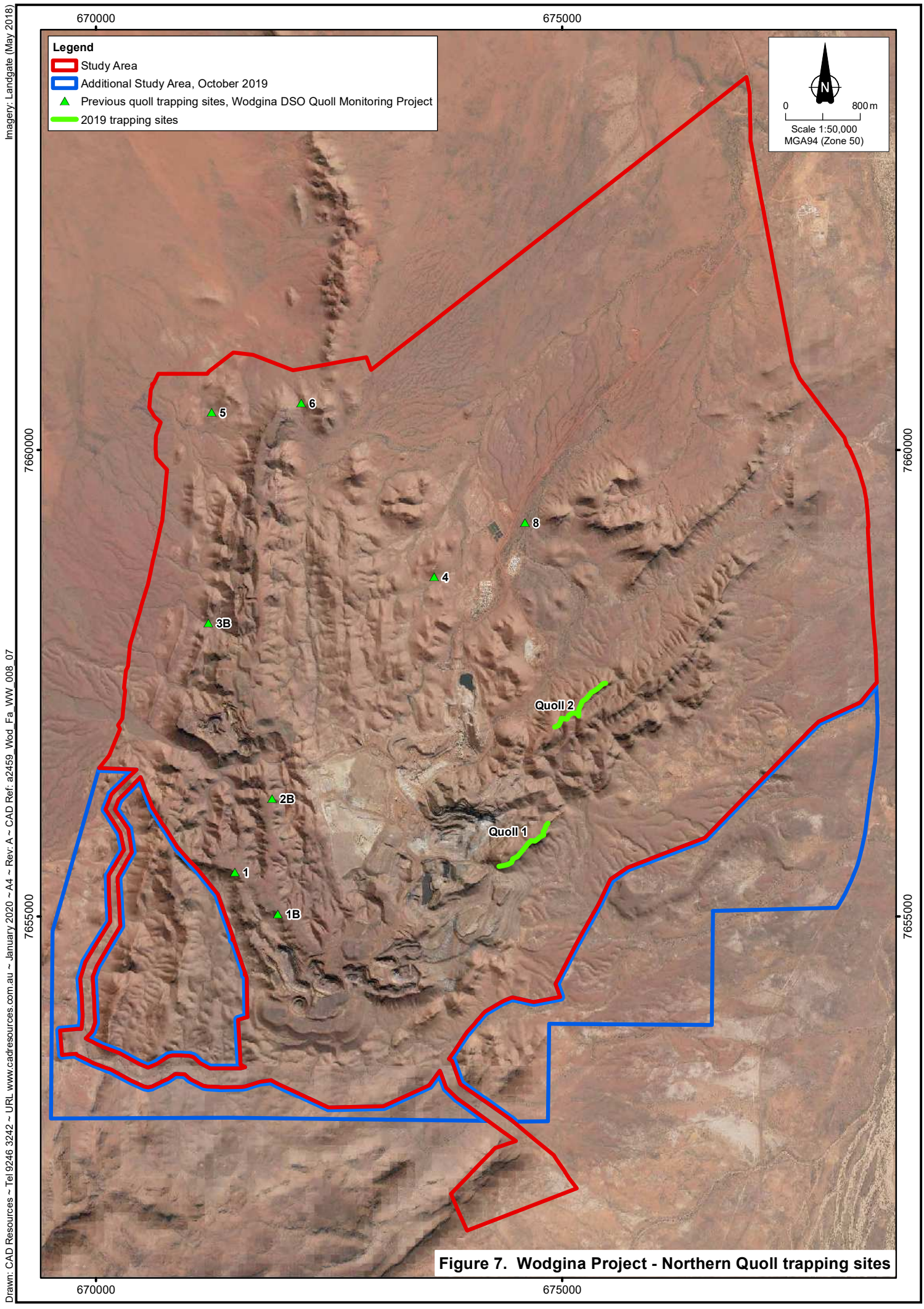

Figure 7. Wodgina Project - Northern Quoll trapping sites

2.6.5 Bird Surveys

Bird surveys were undertaken at each trapping site to give a total of six 20 minute surveys at each site on each of the April and October surveys, resulting in 24 hours of survey across the two phases of survey. Surveys were unbounded, but within 300m of the trapping site. Surveys at trapping sites were undertaken concurrently with morning trap checks, between sunrise and approximately 10am. Birds were recorded if seen or heard. Birds were recorded as present only, and a frequency of occurrence calculated for each site. Birds were also recorded opportunistically.

2.6.6 Bat Survey

Bat calls were recorded using two Anabat Swift call detectors set to record between dusk and dawn. Detectors were deployed overnight at each trap site and then for one to three nights at selected sites around the Survey Area, to give a total of 12 nights of recordings in April and 14 nights of recording in October 2019 (Appendix 2, Figure 8). The calls were then analysed by Kyle Armstrong of Specialised Zoological, and the bat calls identified to species level where possible. The locations of the bat detectors used in the 2018 survey by Stantec (2018b) are also shown in Figure 8.

2.6.7 Night Parrot Survey

In April 2019, after the cyclonic rain experienced in the region, Songmeter 4 (SM4) passive acoustic detectors were deployed in potentially suitable habitat across the target survey area (Appendix 2, Figure 8). Each SM4 was secured to a stake to hold it about 0.5m off the ground, and was set to record between dusk and dawn each night for five or six nights, giving a total of 31 recording nights across six sites. The locations of the SM4 passive acoustic detectors used in the 2018 survey by Stantec (2018b) are also shown in Figure 9. No SM4 passive acoustic detectors were deployed in October 2019, as after the April 2019 survey the habitats present were considered unlikely to be important for the species.

All of the SM4 recordings were analysed in Wildlife Acoustic's Bioacoustic Monitoring System Kaleidoscope Pro. Recordings were broken up into clusters with similar characteristics and the clusters inspected for consistency. Classifiers generated from known recordings of Night Parrots were used to analyse the data for Night Parrot calls. Random noise, vehicles, insects and other non-relevant recordings were removed and the remaining audio clusters containing bird calls further scrutinized via their sonogram and through audio playback. Night Parrot calls, if found, would be referred to the Night Parrot Recovery Team for confirmation.

2.6.8 Spotlighting

Spotlighting was carried out on the 16th and 17th April 2019, from 6:15pm – 8:30pm, then again on the 21st and 22nd October 2019, from 6:15pm – 9:30pm. Two teams of two personnel undertook either road-spotting using vehicle headlights, hand-searching using head-torches or a combination of the two. The routes followed are shown in Figure 10.

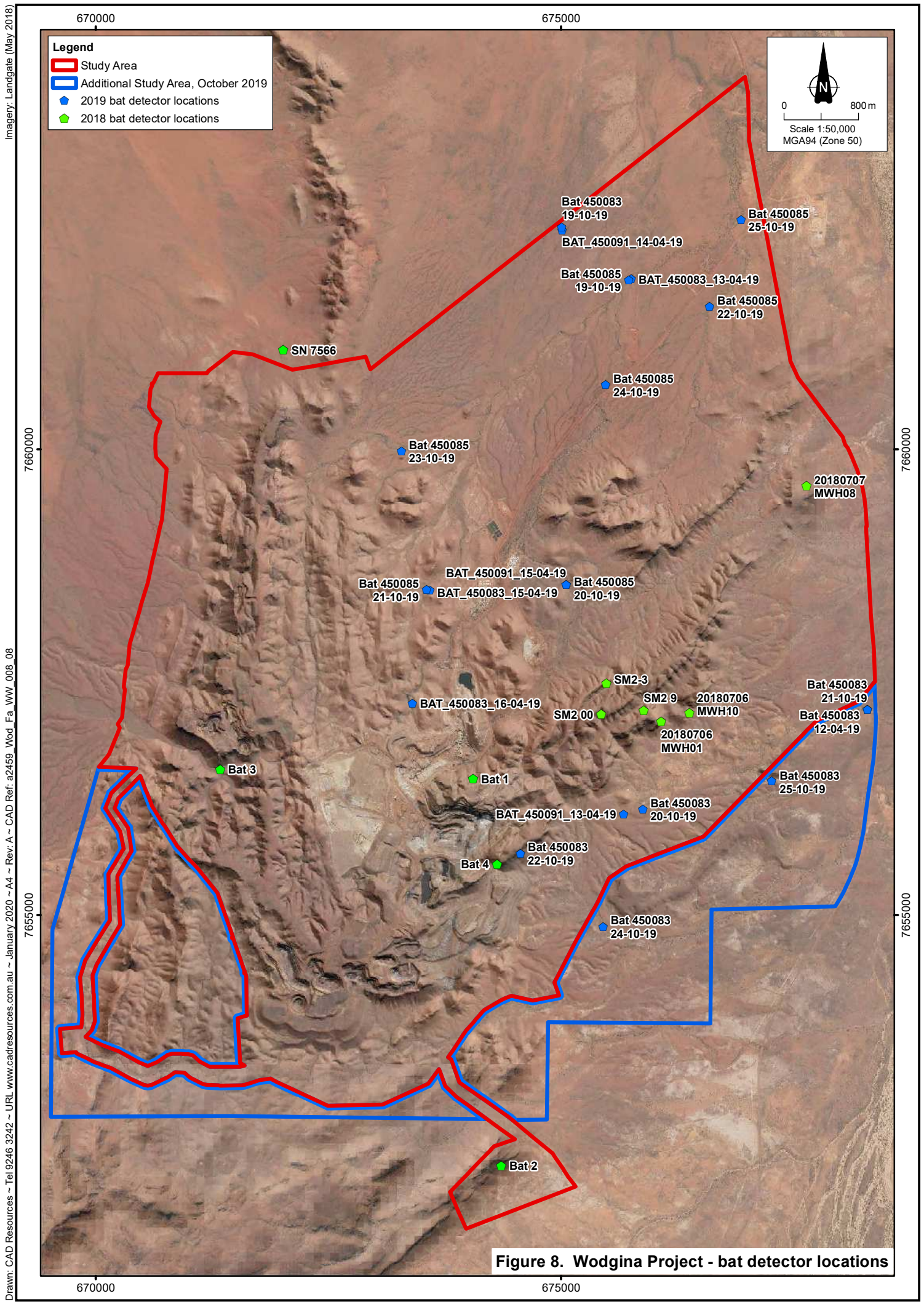

Figure 8. Wodgina Project - bat detector locations

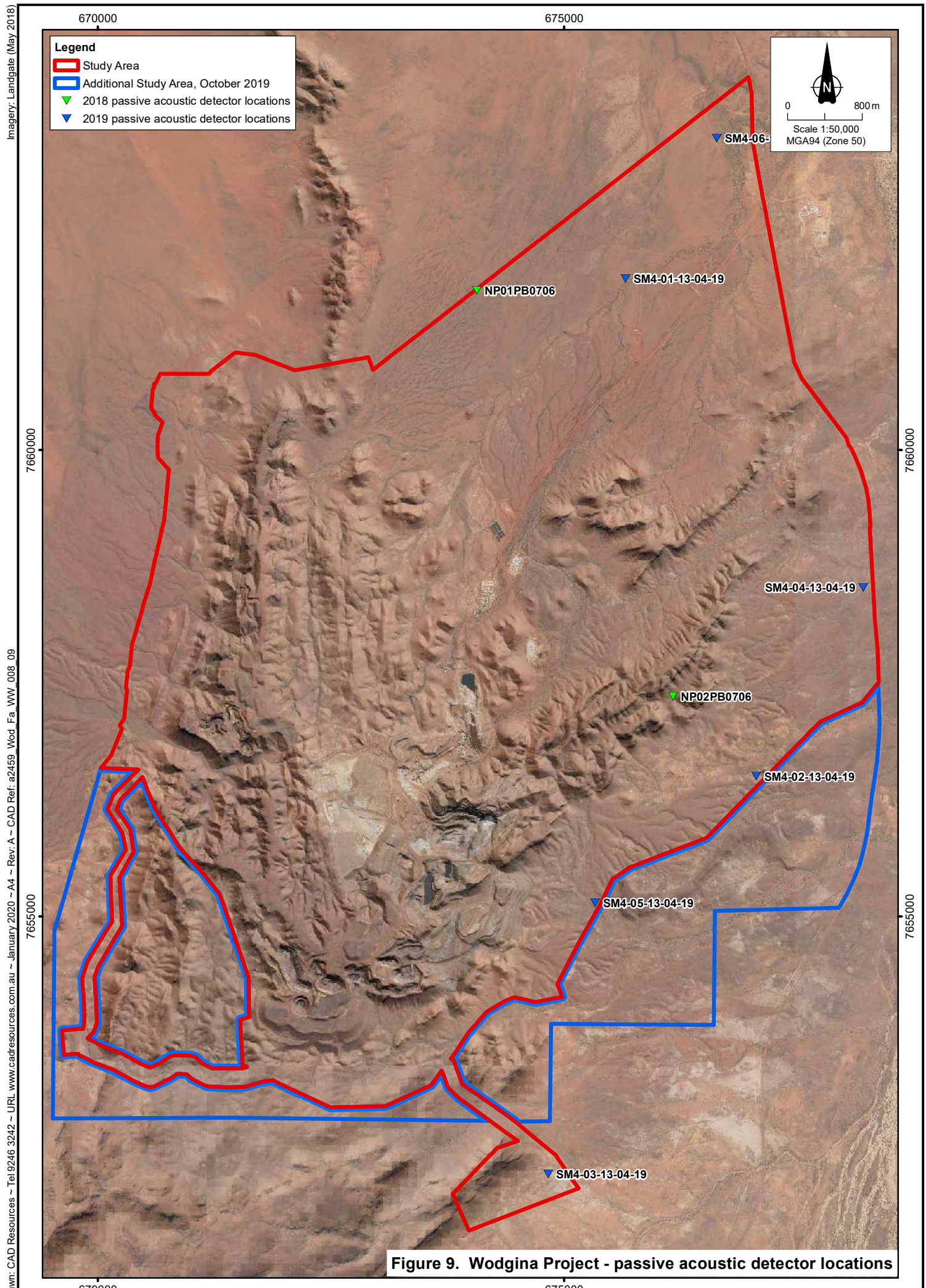

Figure 9. Wodgina Project - passive acoustic detector locations

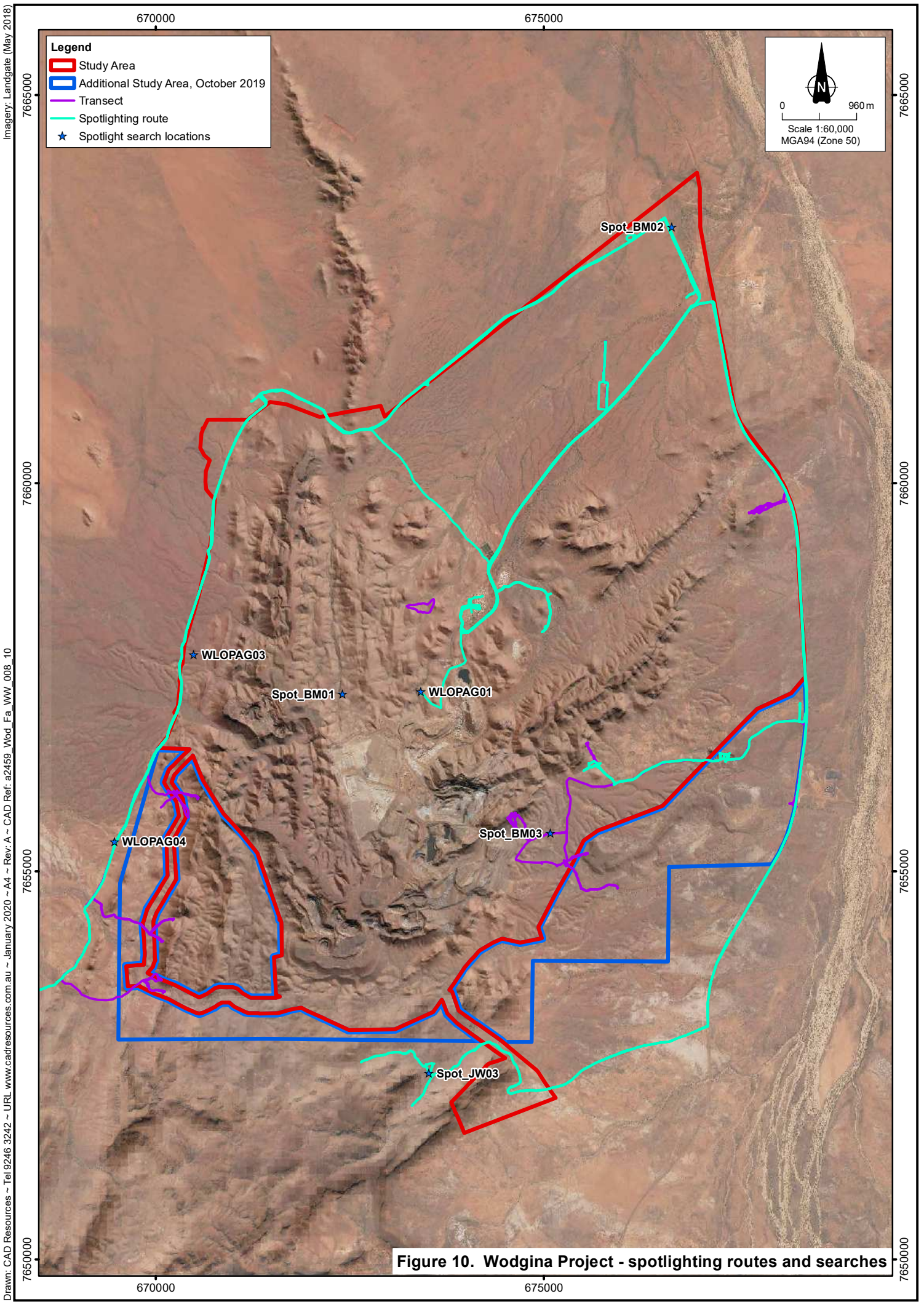

Figure 10. Wodgina Project - spotlighting routes and searches

2.6.9 Camera Trap Survey

Camera traps were deployed at 40 sites during the April field survey, for a total of 169 trap-nights and 42 sites during the October field survey for a total of 208 trap-nights. (Appendix 4, Figure 11). Cameras were primarily deployed to target rocky habitats that may support Northern Quolls, with some consideration given to detecting the Spectacled Hare-wallaby on plains during the October survey. Cameras were baited with a mixture of rolled oats, peanut butter and sardines, liberally splashed with fish oil (burley oil) and each individual camera was set for four or five nights. The locations of the camera traps used in the 2018 survey by Stantec (2018b) are also shown in Figure 11.

2.6.10 Opportunistic Records

At all times, observations of fauna were noted when they contributed to the accumulation of information on the fauna of the site. These included casual observations of reptiles, mammals and birds seen while travelling between sites or while undertaking other activities, such as targeted searches. Opportunistic observations were recorded to a general location for common species, and conservation significant species were recorded with a GPS location. Opportunistc walks and drives were undertaken in some areas in order to gather further records (Figure 10).

2.7 Habitat Mapping

This report uses the standardized habitat names and mapping as produced by Stantec (2018b). Further habitat mapping was undertaken for the Additional Study Area in October 2019. The fauna habitats were identified using interpretation of aerial photography and field observations.

2.8 Assessment of Conservation Significance

2.8.1 Legislative Protection for Fauna

The Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) is the Commonwealth Government's primary piece of environmental legislation. Listed under Part 3 of the EPBC Act are 'Matters of National Environmental Significance' (MNES); these include threatened species, threatened ecological communities and migratory species. Threatened fauna species are assessed against categories based on International Union for Conservation of Nature (IUCN) criteria.

The migratory species listed under the EPBC Act are those recognised under international agreements. These agreements are the China-Australia Migratory Bird Agreement (CAMBA), the Japan-Australia Migratory Bird Agreement (JAMBA), the Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA), or species listed under the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) for which Australia is a range state.

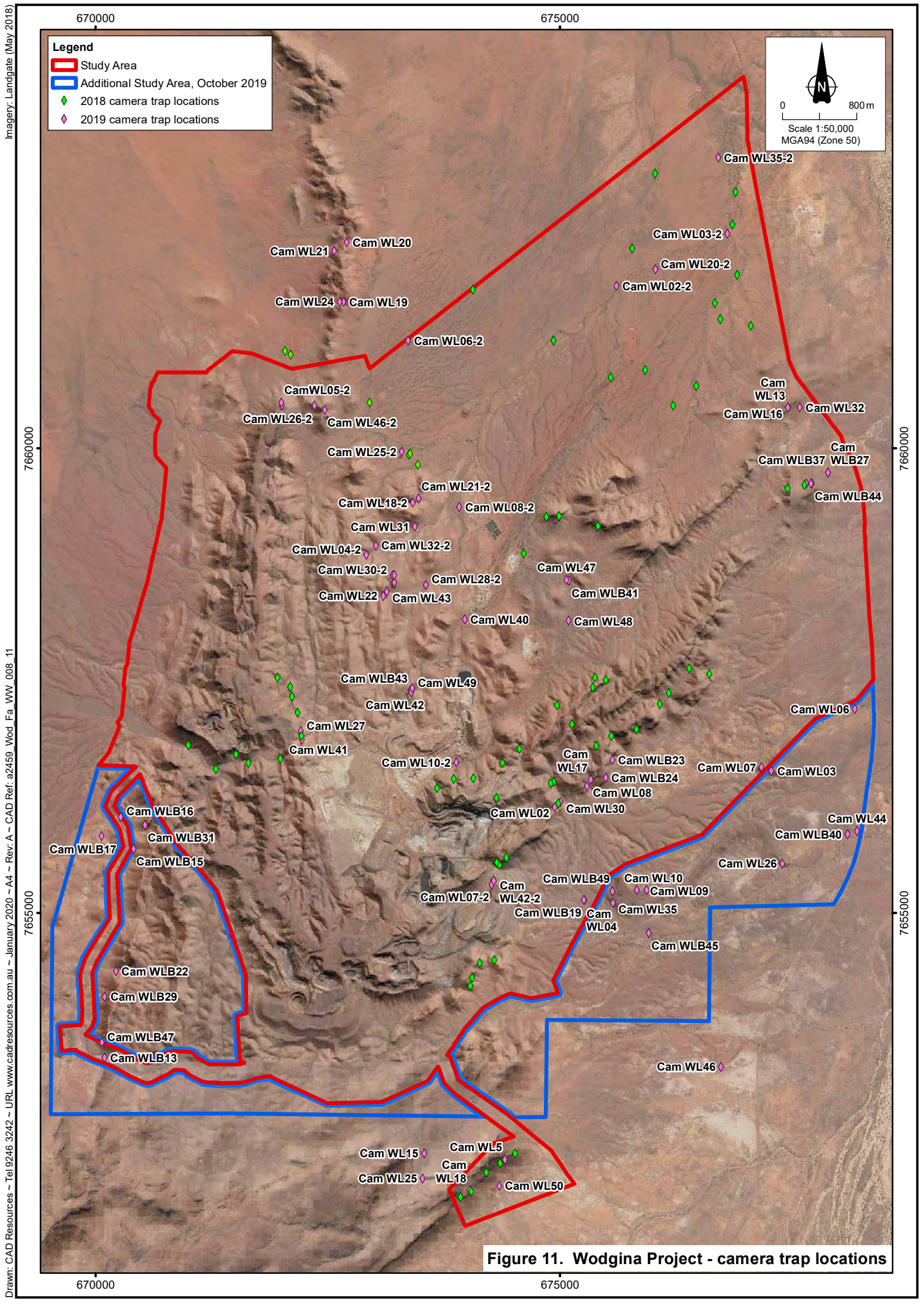

Figure 11. Wodgina Project - camera trap locations

Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ January 2020 ~ A4 ~ Rev: A ~ CAD Ref: a2459_Wod_Fa_WW_008_11
Imagery: Landgate (May 2018)

Matters of National Environmental Significance (MNES) include the following categories:

- **Extinct in the wild (EW)**: Taxa known to survive only in captivity.
- **Critically Endangered (Cr)**: Taxa facing an extremely high risk of extinction in the wild in the immediate future.
- **Endangered (En)**: Taxa facing a very high risk of extinction in the wild in the near future.
- **Vulnerable (Vu)**: Taxa facing a very high risk of extinction in the wild in the medium-term future.
- **Migratory (Mi):** Taxa listed under international agreements to which Australia is a party.

Reports on the conservation status of most vertebrate fauna species have been produced by the federal Department of Environment and Energy (DoEE) in the form of Action Plans. An Action Plan is a review of the conservation status of a taxonomic group against IUCN categories. Action Plans have been prepared for amphibians (Tyler 1998), reptiles (Cogger *et al*. 1993), birds (Garnett *et al*. 2011) and mammals (Woinarski *et al*. 2014). These publications also use categories similar to those used by the EPBC Act. The information presented in some of the earlier Action Plans may be out of date due to changes since publication.

The *Biodiversity Conservation Act 2016* (BC Act) is State legislation that aims to conserve and protect biodiversity and biodiversity components in Western Australia, including threatened fauna. It is administered by the Department of Biodiversity, Conservation and Attractions (DBCA). In addition to threatened fauna, the BC Act has scope to protect threatened ecological communities and important habitats.

Fauna species are listed under the BC Act as threatened species using IUCN categories, or as specially protected species, as described below.

Threatened Species:

- **Extinct in the wild (EW)**: Taxa known to survive only in captivity.
- **Critically Endangered (Cr)**: Taxa facing an extremely high risk of extinction in the wild in the immediate future.
- **Endangered (En)**: Taxa facing a very high risk of extinction in the wild in the near future.
- **Vulnerable (Vu)**: Taxa facing a very high risk of extinction in the wild in the medium-term future.

Specially Protected Species:

- **Migratory (Mi)**: A subset of the migratory fauna that are known to visit Western Australia that are protected under the international agreements or treaties, excluding species that are listed as Threatened species.
- **Conservation dependent fauna (CD):** Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened
- **Other specially protected species (OS):** fauna in need of special protection to ensure their conservation.

The BC Act supersedes the *Western Australian Wildlife Conservation Act 1950* (WC Act).

Priority species are not listed under State or Commonwealth Acts. In Western Australia, DBCA maintains a list of Priority Fauna made up of species that are possibly Threatened but do not meet adequacy of survey requirements or are otherwise data deficient. There are four levels of Priority as defined by DBCA, as listed below.

- **Priority 1:** Poorly known species (on threatened lands)
- **Priority 2:** Poorly known species in few locations (some on conservation lands)
- **Priority 3:** Poorly known species in several locations (some on conservation lands)
- **Priority 4:** Rare, near threatened and other species in need of monitoring

2.8.2 Levels of Conservation Significance in this report

Five levels of conservation significance are used within this report to indicate the level of significance of fauna species, according to the following criteria:

- **Threatened (T):** Taxa listed as Extinct in the Wild, Critically Endangered, Endangered or Vulnerable under the EPBC Act and/or BC Act. These species are grouped as they are all species considered to be at risk of extinction, are often rare and are likely to be subject to on-going threatening processes.
- **Migratory (Mi):** Taxa listed as Migratory under the EPBC Act and/or BC Act, excluding those species also listed as threatened. These species are grouped as they are not necessarily rare, but may be dependent on specific habitats for a portion of their life-cycle. For these species, loss of important foraging, breeding or stop-over sites may have a disproportionately large impact on populations.
- **Specially Protected (SP):** Taxa listed as Other Specially Protected Species or Conservation Dependent Fauna under the BC Act. These species are not necessarily rare, but may be dependent on on-going conservation to ensure their protection.
- **Priority (P):** Taxa listed as Priority by DBCA. These species are grouped as they are either conservation dependent or data deficient and in need of further survey.

- **Locally Significant (LS):** Locally significant taxa are not listed under State or Commonwealth Acts or in publications on threatened fauna or as Priority species by DBCA, but are considered by the author to potentially be of local significance because they are at the limit of their distribution in the area, they have a very restricted range or they occur in breeding colonies (e.g. some waterbirds). This level of significance has no legislative recognition and is based on interpretation of information on the species patterns of distribution. For example, the Government of Western Australia (2000) used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of Bush Forever. Recognition of such species is consistent with the aim of preserving regional biodiversity.

2.9 Species Accumulation Curves

A species accumulation curve at its most simple is a graph of the number of detected species against sampling effort. However, the curve is usually derived through sub-sampling the dataset to find a mean curve, otherwise known as a sample-based rarefaction curve.

Species accumulation curves were calculated for reptiles, mammals and birds in each habitat. For reptiles and mammals, an 'individuals' based approach was used, as sampling methods was not directly comparable between the two surveys. This means that the species richness was graphed against the number of individuals caught, rather than per each sample. The sampling unit for birds was all species observed in a 20 minute bird survey at a trapping site, and only data from 2019 was used.

The statistical package EstimateS (Colwell 2013) was used to find a non-parametric estimator of species richness; either Chao1, ICE (Incidence-based Coverage Estimator) or Chao2. Chao1 uses abundance data to provide an estimation of the lower bound of species richness and is a good estimator of the actual species richness when the sample size is large or the rare species in the sample have similar detection probabilities (Chao and Chiu 2016). ICE or Chao2 are similar, but uses incidence (presence only, no abundance) data only.

EstimateS (Colwell 2013) uses a bias-corrected form of Chao1 and Chao2 as a default, though these become imprecise when the co-efficient of variation or incidence distribution >0.5. In these cases, the classic Chao1 and Chao2 were used, and the larger estimate of Chao1(classic) and ACE (Abundance-based Coverage Estimator) or Chao2(classic) and ICE (Incidence-based Coverage Estimator) is used as the estimate of species richness. For large sample sizes, if Chao 1 or Chao 2 are equal to the observed number of species, then the accumulation of species is assumed to have reached an asymptote (Colwell 2013).

Jackknife estimators of species richness are not used, as they typically underestimate the true species richness when the sample is small, (as is often the case in Level 2 surveys) and overestimate when the sample is large. Thus there is only a small window when the Jackknife estimators are close to the true species richness (Chao and Chiu 2016).

2.10 Likelihood of Occurrence

Fauna of conservation significance were assessed and ranked for their likelihood of occurrence in the study area, according to the following criteria:

- **Very Low:** The study area is outside the current known distribution of the species as presented in the literature; no suitable habitat was identified as being present during the field survey; for some species, individuals may occur occasionally as vagrants, especially if suitable habitat is located nearby, but the study area itself would not the species; includes species generally accepted as being locally extinct.

- **Low:** The study area is within or just outside the current known distribution of the species, as presented in the literature; any habitat present is of either limited in extent or marginal quality at best; no recent or nearby records of the species on databases; the species is generally known to be less common in the vicinity of the study area (e.g. for inland sites, where the species usually occurs on the coast).

- **Moderate:** The study area is within the current known distribution of the species, as presented in the literature; habitat of reasonable quality was identified as being present during the field survey; some recent and/or nearby records of the species of databases;

- **High:** The study area is well within the current known distribution of the species, as presented in the literature; habitat of good quality was identified as being present during the field survey; many recent and nearby records of the species on databases.

- **Known to Occur:** The species was positively identified in the study area during this field survey, or recorded as occurring in the study area on previous recent field surveys. Note that for a species 'known to occur', the habitat may still be marginal and therefore the population may be small or the species may visit the site irregularly.

3. Survey Limitations

Various factors can limit the effectiveness of a fauna survey. Pursuant to EPA Technical Guidance (EPA 2016c), these factors have been identified and their potential to impact on the effectiveness of the surveys has been assessed in Table 5 below. All fauna surveys have limitations, and not all fauna species present on the site are likely to be sampled during a survey. Fauna may not be recorded because they are rare, they are difficult to trap or observe, or because they are only present on the site for part of the year.

Table 5. Fauna survey limitations.

Potential Limitation	Extent of limitation for the fauna survey	
Competency /experience of the team carrying out the survey	Not limiting	Supervising zoologist has 20 years' experience with fauna surveys in Western Australia. Field zoologists have more than 10 years' experience each. The field team included personnel experienced in Pilbara fauna.
Proportion of fauna identified, recorded and/or collected.	Not limiting	More than half of the fauna expected to occur (based on literature review) were recorded during this survey or the 2009 - 2018 surveys.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data	Not limiting	Several fauna studies have been undertaken within the Study Area between 2009 and 2019, including two Level 1 surveys, two Level 1 surveys and targeted surveys for conservation significant taxa.
Timing/weather/season/cycle	Not limiting	The field survey was undertaken at a suitable time to trap reptiles, and the warm, humid conditions post-cyclone in April were ideal for trapping and bird surveys.
Disturbances (e.g. fire, flood, accidental human intervention etc.), which affected results of survey	Minor limitation	Access to the western portion of the Study Area, including parts of the range to the south of the Study Area, was limited in April as the track was washed out by heavy rains in the weeks prior to the field survey. Several areas to the south of the Study Area were affected by fire, so unsuitable for regional quoll camera trapping as quoll populations can drop to undetectable levels after fire.
Intensity (in retrospect, was the intensity adequate)	Not limiting	Sufficient time was allowed to survey all habitats.
Completeness (e.g. was relevant area fully surveyed)	Not limiting	A representative proportion of all habitats were able to be accessed and surveyed, using trapping and a range of supporting survey methods.
Resources (e.g. degree of expertise available in animal identification to taxon level)	Not limiting	Almost all vertebrate fauna could be identified to species. A minor exception was species of *Neobatrachus* frogs that are difficult to distinguish on morphology alone.
Remoteness and/or access problems	Minor limitation	Entire Study Area accessible by vehicle or on foot. Access to the western portion of the Study Area, including parts of the range to the south of the Study Area, was limited as the track was washed out by heavy rains in the weeks prior to the April field survey. This resulted in no camera traps being deployed in the southern part of the range. The western portion of the Additional Study Area is rugged and lacks access in parts, and no surveys for bat caves were undertaken due to safety concerns with long traverses in hot weather >40°C.
Availability of contextual (e.g. biogeographic) information on the region	Not limiting	The Pilbara is a relatively well-studied region due to the prevalence of mining activities. The Pilbara Biological Survey also gives context to fauna studies in this region.

4. Fauna Habitats of the Study Area

Six fauna habitats were identified in the Study Area by Stantec (2018b). These are summarised in Table 6 and shown in Figure 12. Of these habitats, Stantec (2018b) considered all habitats to be widespread in the region except for the Ironstone Ridgetop and Rocky Ridge and Gorge habitats, both considered to be limited in extent. The fauna habitat mapping was extended within the Additional Study Area in October 2019, covering an additional 1,234.2ha. No new fauna habitats were identified and the majority of the Additoanl Study Area was Spinifex Stony Plain and Rocky Foothills.

Table 6. Fauna habitats in the Study Area.

Habitat	Key Habitat Elements	Total Area currently remaining (ha)		
		Study Area	Additional Study Area	Total
Ironstone ridge top	• Small stones suitable for Western Pebble-mound Mouse.	208.2	12.4	220.6
Rocky ridge and gorge	• Outcropping rocky areas, fallen boulders, caves, overhangs and rock crevices.	371.3	46.1	417.4
Rocky foothills	• Occasional rocky outcrops.	1,329.2	393.1	1,722.3
Stony rises	• Occasional rocky outcrops.	172.5	95.2	267.7
Spinifex stony plain	• Many minor drainage lines (not mapped separately) provides shelter for fauna. • Small stones suitable for Western Pebble-mound Mouse. • Tree hollows.	2,297.9	548.0	2,845.9
Drainage line	• May function as a corridor for fauna movement. • Permanent and semi-permanent pools. • Tree hollows. • Leaf litter accumulations.	328.1	139.4	467.5
Disturbed areas		722.0	0.0	722.0
	Total:	**4707.2**	**1,234.2**	**6,663.4**

Disturbance to most habitats was limited to past mining and pastoral activities (e.g. drilling access tracks, station tracks, livestock and current mine activities). Areas around drainage lines were invaded by Buffel Grass and showed trampling by livestock (cattle).

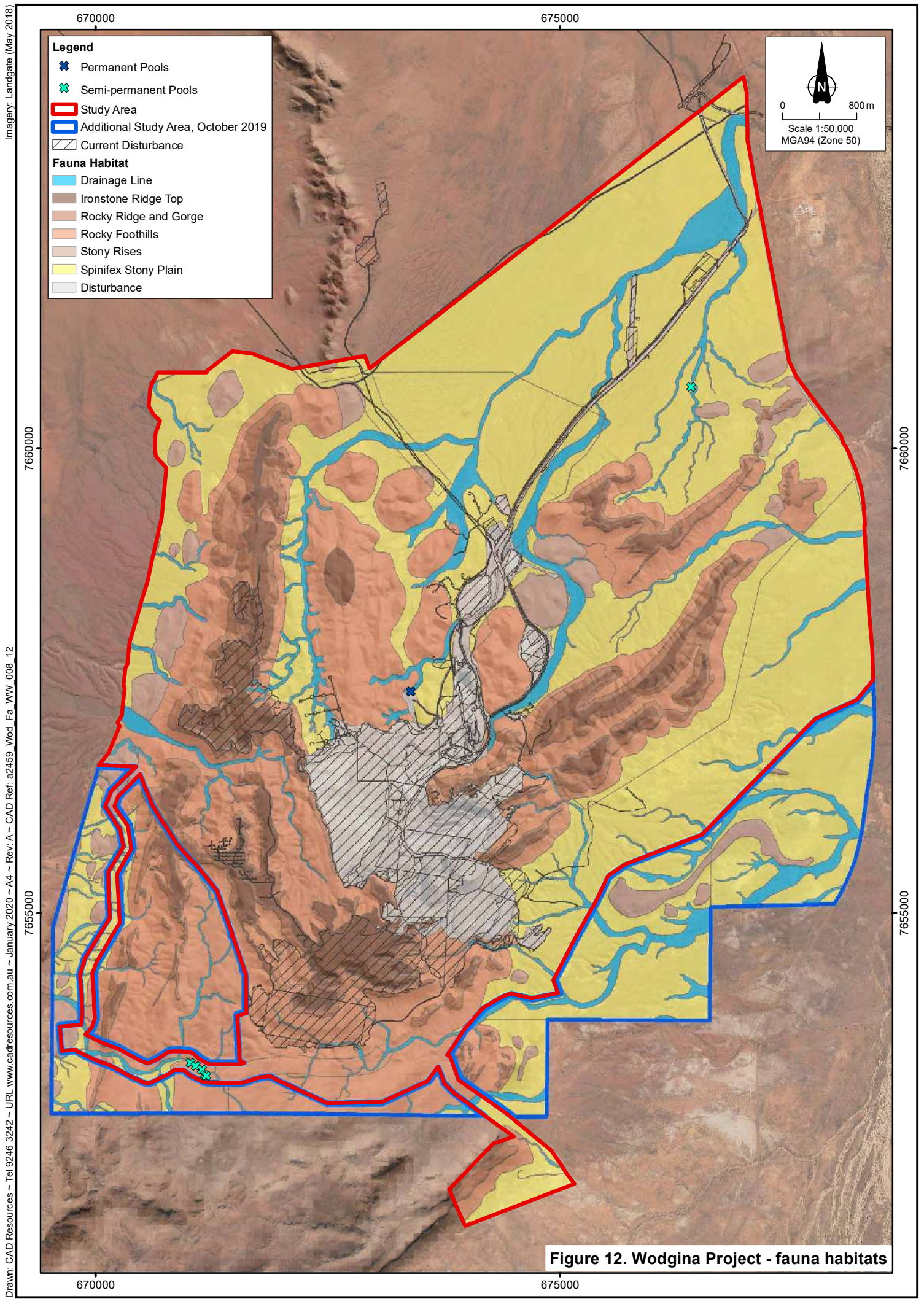

Figure 12. Wodgina Project - fauna habitats

Plate 8. Ironstone Ridgetop.

Plate 9. Rocky Ridge and Gorge.

Plate 10. Rocky Foothills.

Plate 11. Stony Rise.

Plate 12. Spinifex Stony Plain.

Plate 13. Drainage Line.

5. Faunal Assemblage of the Study Area

The results of the literature review and field survey were combined to create a list of all the vertebrate fauna potentially occurring at in the Study Area (Appendices 5 - 8). Indicated in the fauna lists are all the species observed during the fauna survey, those recorded in the Study Area on previous surveys between 2009 and 2018, and those recorded in the region as part of the literature review.

The potentially occurring faunal assemblage is summarised in Table 7. The overall vertebrate faunal assemblage is likely to be largely intact, with the exception of species that are extinct or greatly reduced in their distribution in the Bioregion. The faunal assemblage and conservation significant species likely to occur are further discussed in the sections below.

Table 7. Summary of vertebrate fauna potentially occurring in the Study Area.

Taxon	Total Species (predicted)	Introduced species	Conservation significant species				
			Threatened (T)	Migratory (Mi)	Specially Protected (SP)	DBCA Priority (P)	Locally significant (LS)
Amphibians	10	0	-	-	-	-	-
Reptiles	108	1	1	-	-	2	-
Birds	140	0	2	4	1	-	-
Mammals	41	8	3	-	-	4	-
Freshwater Fish	8	0	-	-	-	-	-
Totals:	**307**	**9**	**6**	**4**	**1**	**6**	**0**

The conservation significant fauna recorded within 15km of the Study Area on DBCA's Threatened and Priority Fauna Database are shown in Figure 13. The results of the EPBC Act Protected Matters search are given in Appendix 10. The significant fauna potentially occurring in the Study Area are discussed in the following sections and summarised in Table 14, with the individual records collected on this survey presented in Appendix 11. The analysis of the bat call data collected on the field survey is given in Appendix 12.

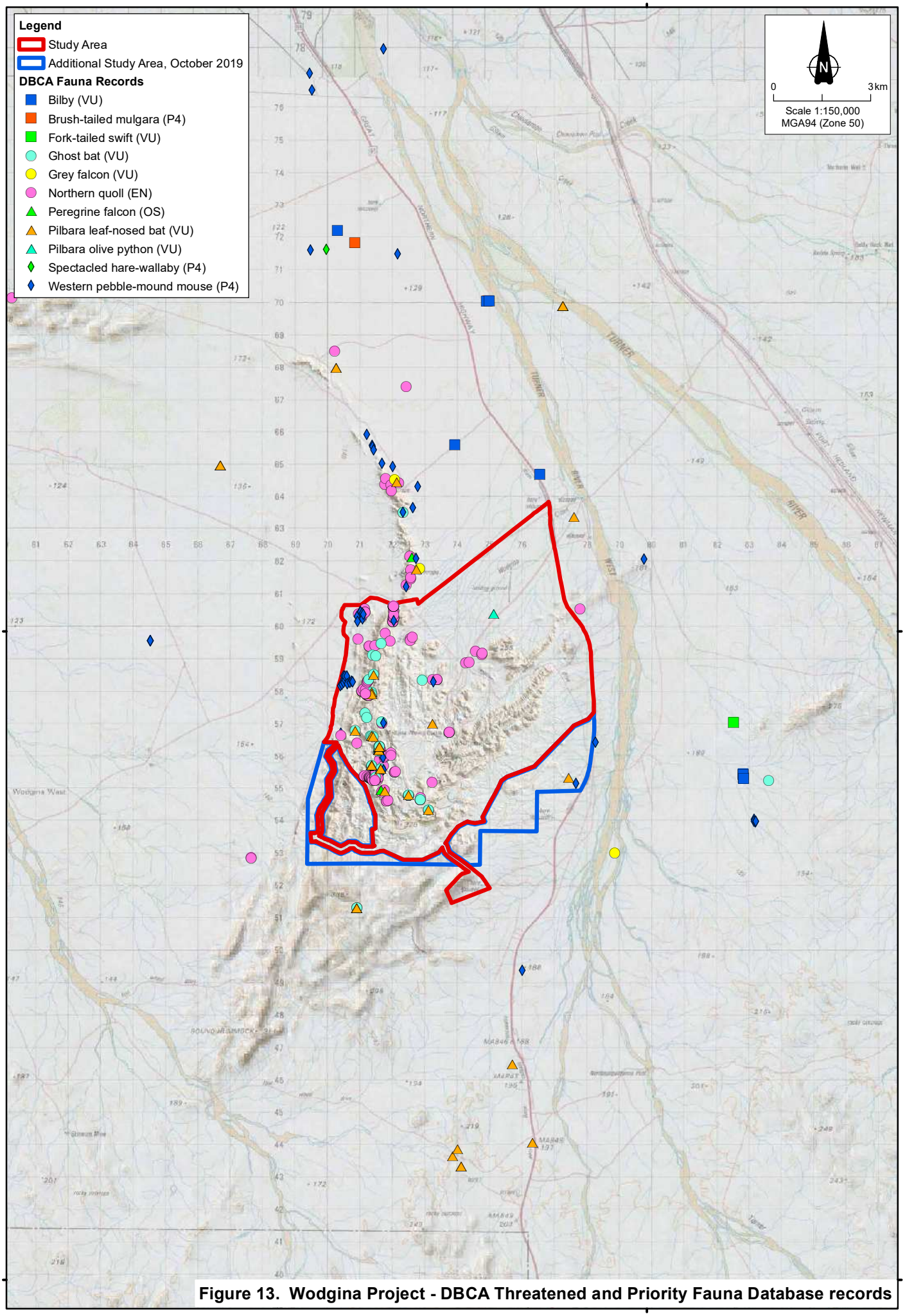

Figure 13. Wodgina Project - DBCA Threatened and Priority Fauna Database records

Imagery: Landgate (May 2018)

Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ January 2020 ~ A4 ~ Rev: A ~ CAD Ref: a2459_Wod_Fa_WW_008_13

5.1 Amphibians

Ten species of frog potentially occur, of which four have been recorded in the Study Area between 2009 and 2019 and a fifth species identified to genus level only (Table 8, Appendix 5). Five frogs were recorded during the 2019 survey, though one of these (*Neobatrachus sp*.) was represented by juveniles only, and these were unable to be identified to species level. The frog species that potentially occur in the Study Area are common and widely distributed in the semi-arid zone.

The Desert Tree Frog (*Litoria rubella*) is likely to be common, occurring in rocky areas near drainage lines as well as around waterholes. Burrowing species aestivate underground when conditions are dry, so are difficult to sample except immediately after wet conditions. These species breed opportunistically after rainfall and are likely to occur in the Drainage Line habitat, though they can also forage in terrestrial habitats when conditions are suitable. Frogs are likely to occur throughout the study area, potentially breeding anywhere that holds relatively fresh water after rainfall, including man-made depressions. Many species develop from tadpoles into frogs very quickly, and can make use of ephemeral pools in minor drainages.

Table 8. Frogs recorded in the Study Area, 2009 - 2019.

Species	Survey, site and habitat												
	2009[1]	2011[2]					2019 Apr / Oct						
	All 6 sites and habitats combined	1 - Ironstone Ridge Top	2 - Spinifex Stony Plain	3 - Ironstone Ridge Top	4 - Drainage Line	Opportunistic	1 - Spinifex Stony Plain	2 - Drainage Line	3 - Rocky Foothills	4 - Spinifex Stony Plain	5 - Stony Rise	6 - Drainage Line	Opportunistic
Water-holding Frogs													
Cyclorana maini	+	6	14	1	92			1/-	2/-	1/-	2/-	2/-	
Litoria rubella	+	2			35								+
Ground Frogs													
Notaden nichollsi												3/-	
Neobatrachus sp.												6/-	
Uperoleia saxatilis					10						1/-		
Total species:	**2**	**2**	**1**	**1**	**3**		**-/-**	**1/-**	**1/-**	**1/-**	**2/-**	**3/-**	
		3					**5**						

[1] Wodgina DSO (Outback Ecology 2009), [2] Hercules DSO (Outback Ecology (2012)

5.1.1 Amphibians of Conservation Significance

No frogs of conservation significance are likely to be present in the Study Area.

5.2. Reptiles

There are 108 species of reptile that have the potential to occur, of which 71 were recorded in the Study Area between 2009 and 2019 (Table 9, Appendix 6). The reptile assemblage of the Pilbara Bioregion is very diverse, including a suite of endemic species associated with rocky surfaces (Doughty *et al*. 2011). As the reptile assemblage is generally informed by the ground surface (e.g. sandy, clayey or rocky surfaces) the Study Area is likely to support an assemblage dominated by species that occur on stony and rocky habitats. Species that favour sandy soil are only likely to occur in association with Drainage Lines.

A total of 57 species were recorded during this survey, 49 captured in trapping sites and eight observed opportunistically (Table 9, Plate 14). This survey added several new species to the list of those previously known to occur in the Study Area, as most of the previous trapping sites were in rocky upland habitats and this survey sampled habitats such as Drainage Lines.

Between eight and 22 species were recorded at each trapping site in 2019. The sites in the Drainage Line habitat recorded the highest species richness. This is likely due to a number of factors, including the higher productivity associated with water courses, the habitat complexity (e.g. the presence of woody debris, leaf litter, trees and shrubs) and the presence of sandy colluvial soils that are absent from other habitats in the Study Area.

The sites in the Spinifex Stony Plains also recorded a relatively large number of species in both 2019 and 2011. This habitat is also relatively complex, as it includes many minor drainage lines. The spinifex is also relatively long-unburnt, and the large hummocks provide shelter for reptiles. The site in the Rocky Foothills showed the lowest species richness. This habitat generally lacks shelter such as rock or tree crevices, and was more recently burnt. The spinifex hummocks were small and did not provide as much shelter as in long-unburnt sites. Similarly, the Ironstone Ridgetop sites sampled in 2011 are relatively exposed and lacking in shelter.

Plate 14. *Egernia cygnitos* trapped at WL Site 4 and *Heteronotia spelea*.

Table 9. Reptiles recorded in the Study Area, 2009 - 2019.

Species	Survey, site and habitat												
	2009[1]	2011[2]					2019 Apr / Oct						
	All 6 sites and habitats combined	1 - Ironstone Ridge Top	2 - Spinifex Stony Plain	3 - Ironstone Ridge Top	4 - Drainage Line	Opportunistic	1 - Spinifex Stony Plain	2 - Drainage Line	3 - Rocky Foothills	4 - Spinifex Stony Plain	5 - Stony Rise	6 - Drainage Line	Opportunistic
Geckoes													
Nephrurus levis								5/2				1/5	
Diplodactylus bilybara								-/2				-/2	
Diplodactylus conspicillatus			1		1		1/-	1/1					
Diplodactylus galaxias										1/-	2/1	1/-	
Diplodactylus laevis												1/-	
Diplodactylus savagei	+	1	1		1								
Lucasium stenodactylum	+		1					-/5	-/2				
Lucasium wombeyi			3		2				1/-	3/1			
Rhynchoedura ornata								3/2					
Oedura fimbria				1									
Gehyra kimberleyi									-/1				
Gehyra pilbara						+							
Gehyra punctata		1	1						1/-	1/-			
Gehyra variegata						+	1/1	1/2					
Heteronotia binoei	+		11	1	11			2/-	1/-	6/3	3/1	4/3	
Heteronotia spelea	+	2											+
Strophurus elderi			1	4	1		1/-				-/1	-/1	
Legless Lizards													
Delma butleri	+												
Delma nasuta	+	4	1	1	1					-/2			
Delma pax	+		1		3						1/-		
Delma tincta										-/1			
Lialis burtonis								1/-		1/-			
Dragon Lizards													
Ctenophorus caudicinctus	+		3				-/1	-/1	1/10	4/2	-/1	-/1	
Ctenophorus isolepis							-/4	1/5		-/1	-/2	2/2	
Diporiphora valens[3]													
Pogona minor								1/-				2/-	
Gowidon longirostris	+					+							+
Skink Lizards													
Carlia munda	+				3			-/1					
Carlia triacantha	+	2		1	5				-/1		-/1		
Ctenotus duricola							4/5	1/1		2/-		2/1	

Table 9. (cont.)

Species	Survey, site and habitat												
	2009[1]	2011[2]					2019 Apr / Oct						
	All 6 sites and habitats combined	1 - Ironstone Ridge Top	2 - Spinifex Stony Plain	3 - Ironstone Ridge Top	4 - Drainage Line	Opportunistic	1 - Spinifex Stony Plain	2 - Drainage Line	3 - Rocky Foothills	4 - Spinifex Stony Plain	5 - Stony Rise	6 - Drainage Line	Opportunistic
Ctenotus grandis			26				4/7	19/8	1/-		10/3	41/16	
Ctenotus hanloni							-/3	1/1					
Ctenotus helenae							4/-	2/2		1/-		3/-	
Ctenotus leonhardii			2										
Ctenotus pantherinus							3/2	1/-					
Ctenotus rubicundus	+												
Ctenotus saxatilis	+	21	41	15	30		12/4	8/5	5/2	20/13	28/12	10/7	
Cyclodomorphus melanops	+									1/-	1/-		
Egernia cygnitos										1/-			
Egernia epsisolus[4]													
Egernia pilbarensis[4]													
Eremiascincus pallidus													
Lerista bipes								13/29				24/23	
Lerista jacksoni					2		2/1	-/5	-/3		-/3		
Lerista muelleri	+				2								
Menetia greyi								-/2					
Menetia surda							-/1						
Morethia ruficauda	+	2			4		-/3	-/2		-/1	1/-	-/2	
Tiliqua multifasciata			2							1/-			
Goannas													
Varanus acanthurus	+	9	2	4	5			2/-			4/-	1/1	
Varanus brevicauda						+	-/1					-/3	
Varanus eremius								1/-		1/-			
Varanus giganteus	+												+
Varanus gouldii							-/1	3/-			-/1	1/-	
Varanus panoptes	+												+
Varanus pilbarensis													+
Blind Snakes													
Anilios ammodytes							1/1	2/1					
Anilios grypus	+	2	4	9	3		4/-	2/1	2/-		2/-	1/1	
Anilios pilbarensis			1		1								
Pythons													
Antaresia perthensis													+
Antaresia stimpsoni	+	1		1									+
Aspidites melanocephalus													+

Table 9. (cont.)

Species	Survey, site and habitat												
	2009[1]	2011[2]					2019 Apr / Oct						
	All 6 sites and habitats combined	1 - Ironstone Ridge Top	2 - Spinifex Stony Plain	3 - Ironstone Ridge Top	4 - Drainage Line	Opportunistic	1 - Spinifex Stony Plain	2 - Drainage Line	3 - Rocky Foothills	4 - Spinifex Stony Plain	5 - Stony Rise	6 - Drainage Line	Opportunistic
Elapid Snakes													
Brachyurophis approximans					2			1/-		1/-			
Brachyurophis fasciolatus								-/1					
Demansia psammophis							1/-	1/-					
Demansia rufescens	+				1				2/1		-/1	1/-	
Furina ornata	+											-/1	
Pseudechis australis											1/-		
Pseudonaja mengdeni								-/2					
Pseudonaja modesta	+												
Suta fasciata			1										
Total species:	**24**	**10**	**18**	**9**	**18**	**4**	**19**	**31**	**12**	**19**	**17**	**21**	**8**
		32					**57**						

[1] Wodgina DSO (Outback Ecology 2009), [2] Hercules DSO (Outback Ecology (2012), [3]360 Environmental (2017), [4]Stantec (2017).

5.2.1 Reptiles of Conservation Significance

There are three reptiles of conservation significance that potentially occur in the Study Area, as listed and discussed below.

Threatened Species

Pilbara Olive Python *Liasis olivaceus barroni*
This species is listed as Vulnerable under the EPBC Act and Vulnerable under the BC Act.

The **Pilbara Olive Python** is restricted to ranges in the Pilbara and islands in the Dampier Archipelago and is known from relatively few localities. This very large python inhabits rock outcrops, usually close to waterholes, which it uses to hunt. Though not recorded during fauna surveys, there is a single DBCA record of this species within 15km (Figure 13). Although this record falls within the Study Area, it is likely that the true location is outside the Study Area, as the locality information is given as 'Roy Hill Railway'. However, as there are suitable habitats present (e.g. rocky drainage lines, permanent and semi-permanent pools) and the Study Area is within the range of this species, it is considered likely to occur.

Priority Species

Black-lined Ctenotus *Ctenotus nigrilineatus*
This species is listed as Priority 1 by DBCA.

Gane's Blind Snake *Anilios ganei*
This species is listed as Priority 1 by DBCA.

The **Black-lined Skink** was originally collected from Spinifex at the base of a granite outcrop near Woodstock (Wilson and Swan 2017). This species has been recorded within 40km on NatureMap, and is also known from watercourses near Meentheena Conservation Park and Nullagine. This species is known from very few records, so its distribution and habitat requirements are poorly known. It possibly occurs in the Study Area.

The habitat requirements for **Gane's Blind Snake** are poorly known, as this species is known from relatively few records and was only formally described in 1998. It is endemic to the Pilbara, occurring between Newman and Pannawonica. This species is tentatively associated with moist gorges and gullies, though some of the early specimens are from the Newman townsite and Mt Whaleback waste dump (Aplin 1998). The habitats of the Study Area may be suitable for Gane's Blind Snake, and it is likely that the Study Area falls within the range of this species. Therefore, this species possibly occurs in the Study Area.

5.3 Birds

There are 140 species of bird that potentially occur in the Study Area, of which 89 species were recorded in the Study Area between 2009 and 2019 (Table 10, Appendix 7). The terrestrial bird fauna of the Pilbara region is thought to be generally uniform, with a higher species richness where there is riparian vegetation such as tall *Eucalyptus* or *Melaleuca* trees (Burbidge *et al*. 2010). Many of the species present are likely to use a range of habitats across the Study Area, although the bird assemblage is likely to vary between more wooded habitats, such as Drainage Lines and open habitats, such as Rocky Foothills.

A total of 76 species were recorded across the two phases of the current survey, with a similar number of species recorded at each trapping site (Table 10). Many species were only represented by one or two records or were only observed opportunistically. Several new records were made for the Study Area during this survey, including the Star Finch (*Neochmia ruficauda*) (Plate 15), Black-shouldered Kite (*Elanus caeruleus*), Australian Ringneck (*Platycercus zonarius*) and Bush Stone-Curlew (*Burhinus grallarius*).

Particularly common in April (occurring at all or most sites) were the Black-faced Cuckoo-shrike (*Coracina novaehollandiae*), Budgerigar (*Melopsittacus undulatus*), Painted Finch (*Emblema pictum*), Rainbow Bee-eater (*Merops ornatus*), Spinifexbird (*Eremiornis carteri*) and Zebra Finch (*Taeniopygia gutatta*). In October, the Budgerigar was absent, but the remaining species remained common.

Table 10. Birds recorded in the Study Area 2009 - 2019.

Species	Previous surveys		This survey 2019 Frequency of occurrence (n=6) at each site Apr / Oct						
	2009[1]	2012[2]	1 - Spinifex Stony Plain	2 - Drainage Line	3 - Rocky Foothills	4 - Spinifex Stony Plain	5 - Stony Rise	6 - Drainage Line	Opp.
Australasian Grebe		+							+
Australian Bustard				-/1					
Australian Hobby	+								
Australian Kestrel	+	+			-/1	-/1			+
Australian Magpie		+							
Australian Owlet-nightjar	+								+
Australasian Pipit		+			-/2				
Australian Reed-warbler		+							
Australian Ringneck								2/-	
Black-breasted Buzzard[3]									
Black-faced Cuckoo-shrike	+	+	2/1	3/3	2/1	1/2	1/3		
Black-faced Woodswallow	+	+		-/1	-/2		1/1		
Black-fronted Dotterel	+	+							+
Black-necked Stork	+								
Black-shouldered Kite									+
Black Honeyeater	+								
Black Falcon	+								
Black Kite	+			-/1				-/1	
Blue-winged Kookaburra								-/1	
Brown Falcon	+			2/-	2/1				
Brown Goshawk	+		1/1						
Brown Honeyeater	+	+			5/2	1/-	6/6	2/-	
Brown Songlark							5/-		
Budgerigar	+	+	2/-	1/-	2/-	1/-	1/-	1/-	
Bush Stone-curlew									+
Cockatiel	+	+			1/-				
Common Bronzewing									+
Common Sandpiper **(Mi)**									+
Crested Bellbird				1/-					
Crested Pigeon		+	-/3	-/1				-/1	
Crimson Chat									+
Diamond Dove	+	+	1/3	1/2	-/1	1/-	1/6	-/2	
Eurasian Coot									+
Fairy Martin	+	+		-/1					
Galah	+	+	-/1				-/3	1/-	

Table 10. (cont.)

Species	Previous surveys		This survey 2019 Frequency of occurrence (n=6) at each site Apr / Oct						
	2009[1]	2012[2]	1 - Spinifex Stony Plain	2 - Drainage Line	3 - Rocky Foothills	4 - Spinifex Stony Plain	5 - Stony Rise	6 - Drainage Line	Opp.
Grey Butcherbird						-/2			
Grey Shrike-thrush	+	+			1/-	-/1			
Grey Teal									+
Grey-crowned Babbler								-/1	
Grey-headed Honeyeater	+	+	2/3		2/4	5/5	3/6		
Grey-fronted Honeyeater		+							
Hardhead									+
Horsfield's Bronze-cuckoo			1/-					1/-	
Little Button-quail	+	+	1/-						
Little Corella	+						-/1	-/1	
Little Crow			1/-						
Little Woodswallow	+	+							+
Magpie-lark	+	+		2/-	1/-		1/-	2/-	
Pacific Black Duck									+
Painted Finch	+	+	1/-		4/6	5/2	5/1	3/1	
Pallid Cuckoo	+								
Peaceful Dove									+
Pied Butcherbird	+	+			3/1	1/1	-/3	1/-	
Pied Honeyeater	+						1/-		
Purple Swamphen									+
Rainbow Bee-eater	+	+	1/-	4/1	3/1	1/-	6/2	-/2	
Red-backed Kingfisher									+
Red-browed Pardalote			1/-	1/2			2/1		
Rufous Songlark		+		1/-	-/1		1/-		
Rufous Whistler			-/1				3/1	-/1	
Sacred Kingfisher	+								
Singing Honeyeater	+	+	2/-	1/1	1/1	-/1		3/1	
Spinifex Pigeon	+	+	-/1	1/-	1/5	5/1	-/1	1/1	
Spinifexbird	+	+	5/4	2/3	3/4	5/6	2/2	2/5	
Spiny-cheeked Honeyeater								1/-	
Spotted Harrier			-/1						
Spotted Nightjar	+	+	1/-						
Southern Boobook[3]									
Star Finch									+
Striated Grasswren	+	+							+

Table 10. (cont.)

Species	Previous surveys		This survey 2019 Frequency of occurrence (n=6) at each site Apr / Oct						
	2009[1]	2012[2]	1 - Spinifex Stony Plain	2 - Drainage Line	3 - Rocky Foothills	4 - Spinifex Stony Plain	5 - Stony Rise	6 - Drainage Line	Opp.
Striated Pardalote	+								
Tawny Frogmouth									+
Torresian Crow	+	+	1/1	1/7	2/-	1/-		-/1	
Tree Martin	+	+					-/1		
Variegated Fairy-wren	+	+	3/-	2/2		1/-	-/1	3/3	
Wedge-tailed Eagle				-/1			-/1	-/1	
Welcome Swallow		+							
Western Bowerbird	+	+							+
Western Gerygone[4]									
Whistling Kite		+		-/2				-/2	
White-faced Heron									+
White-necked Heron									+
White-plumed Honeyeater			2/-				3/4	4/-	
White-winged Fairy-wren								-/1	
White-winged Triller	+			-/1	-/5		1/-		
Willie Wagtail	+	+		1/-	4/-	4/-	-/1		
Wood Sandpiper **(Mi)**									+
Yellow-throated Miner	+	+	-/1	1/3	4/3		-/1	3/-	
Zebra Finch	+	+	5/-	4/1	5/2	4/2	6/3	5/2	
Total species:	**44**	**39**	**24**	**25**	**24**	**18**	**27**	**28**	**24**
			75						

[1] Wodgina DSO (Outback Ecology 2009), [2] Hercules DSO (Outback Ecology (2012), [3]Stantec (2018b), [4]360 Environmental (2017a).

The bird assemblage is likely to include a core suite of species that are resident in the Study Area, a second group that makes regular or nomadic movements into and through the Study Area and a third group of vagrants that may occur in the Study Area on occasion. Resident species include many of the small insectivores such as fairywrens, whistlers and robins. Resident species are present all year, though their populations may fluctuate in response to rainfall and fire.

Birds that make regular seasonal movements include the Rainbow Bee-eater (*Merops ornatus*), cuckoos and some birds of prey. Honeyeaters are also likely to make seasonal or nomadic movements to take advantage of flowering events. Although not present all year, these species are likely to use the Study Area for foraging, breeding or shelter on a seasonal basis or when conditions are suitable.

Wetland dependent bird species, (e.g. ducks, swans, herons, grebes and migratory shorebirds), are also likely to occur as visitors to the Study Area. Several species were recorded during the current survey, but as the habitat available is limited, only a few individuals are likely to be present at any time.

Plate 15. Star Finches recorded in the Study Area, October 2019.

5.3.1 Birds of Conservation Significance

Three terrestrial birds listed as Migratory under the EPBC Act were listed on databases for the area; the Barn Swallow (*Hirundo rustica*), Grey Wagtail (*Motacilla cinerea*) and Yellow Wagtail (*Motacilla flava*). These species are considered unlikely to occur except as occasional vagrants. They occur around wetlands and are generally recorded in the north of the State (Johnstone and Storr 2004, DoE 2015). They are not included in the list in Appendix 7 and are not discussed further. Five wetland birds listed as Migratory were also listed on databases for the area; the Curlew Sandpiper (*Calidris ferruginea*), Sharp-tailed Sandpiper (*Calidris acuminata*), Pectoral Sandpiper (*Calidris melanotos*), Eastern Curlew (*Numenius madagascariensis*) and Australian Painted Snipe (*Rostratula australis*). These species require wetland habitats that are absent from the Study Area and are not included in the list in Appendix 7, nor are they discussed further.

There are seven birds of conservation significance that have been recorded or potentially occur in the Study Area, two threatened species, one specially protected species and four Migratory species. Each species is listed in the boxes below, and discussed.

Threatened Species

Grey Falcon *Falco hypoleucos*
This species is listed as Vulnerable under the BC Act.

Night Parrot *Pezoporus occidentalis*
This species is listed as Endangered under the EPBC Act and as Critically Endangered fauna under the BC Act.

The **Grey Falcon** may number fewer than 1000 individuals, though it occurs across a large portion of arid and semi-arid Australia with its distribution centered on inland drainages (Garnett *et al*. 2011). It forages over timbered plains, including *Acacia* shrublands, also ranging out onto treeless plains. The Grey Falcon nests in tall trees on watercourses (Garnett *et al*. 2011) and occasionally on man-made structures such as transmission line towers (pers. obs.). Threats to this species are unknown, but may include habitat degradation due to overgrazing or clearing and provision of water in arid areas favouring the closely related Peregrine Falcon (Garnet *et al*. 2011). The Study Area lacks suitable breeding habitat for this species, though potential breeding habitat occurs nearby on the Turner River. The Grey Falcon has been recorded nearby on DBCA's Threatened and Priority Fauna Database (Figure 13) and is likely to occur as a foraging visitor to the Study Area.

Historically, the **Night Parrot** was recorded across a large range in the arid and semi-arid interior of Australia (Garnett *et al*. 2011). In recent times however, there are very few verified records of the species. Reliable records in recent times are from two main areas, one in western Queensland and one Western Australia (TSSC 2016b). Western Australia records are from Lake Gregory in the north, a site near Wiluna and near the Fortescue Marsh in the Pilbara (NPRT 2019, Davis and Metcalf 2008). The key habitats for the Night Parrot are thought to be chenopod shrublands and Spinifex grasslands, with the chenopod shrublands a refuge during dry conditions (Garnett *et al*. 2011). Nesting sites are in mature Spinifex, often large ring-forming clumps (DPAW 2017). Foraging habitats are likely to vary across Australia, but include herbs, grasses, grass-like plants, *Sclerolaena spp*. and other chenopods (DPAW 2017). With the reasons for its decline unknown, potential threats to the species remain unconfirmed (TSSC 2016b). Possible threats include predation by feral cats or foxes, human-induced fire and degradation of soil around watering points (TSSC 2016b). Knowledge about the current distribution and habitat requirements of the Night Parrot in Western Australia is based on very few records. Therefore, there is considerable uncertainty when assessing the likelihood of occurrence of this species. The survey with passive acoustic detectors across six sites on this survey and two sites by Stantec (2018b) failed to detect the Night Parrot. Although long-unburnt spinifex is present, much of this is more heavily wooded than at known Night Parrot sites. Therefore, this species is considered unlikely to occur.

Specially Protected Species

Peregrine Falcon *Falco peregrinus*
This falcon is listed as Other Specially Protected Fauna under the BC Act.

The **Peregrine Falcon** is a widespread bird of prey that globally has a very large range and a very large population that appears to be secure (BirdLife International 2018). In Western Australia the population is secure, though this species may experience reductions at a local level due to human disturbance at nesting sites (Debus 1998). The Peregrine Falcon nests mainly on ledges on cliffs or rocky outcrops, and it may also use tall trees (Johnstone and Storr 1998). This species often takes advantage of man-made structures such as abandoned open pits or quarries. The species has been recorded nearby on DBCA's Threatened and Priority Fauna Database (Figure 13). The Peregrine Falcon is considered likely to occur and may breed on the Rocky Ridge and Gorge habitat, or forage in the Study Area if breeding nearby.

Migratory Species

Oriental Plover *Charadrius veredus*
This species is listed as migratory under the EPBC Act and migratory under the BC Act.

Wood Sandpiper *Tringa glareola*
This species is listed as migratory under the EPBC Act and migratory under the BC Act.

Common Sandpiper *Tringa hypoleucos*
This species is listed as migratory under the EPBC Act and migratory under the BC Act.

Fork-tailed Swift *Apus pacificus*
This species is listed as migratory under the EPBC Act and migratory under the BC Act.

The **Oriental Plover**, **Wood Sandpiper** and **Common Sandpiper** are migratory shorebirds that occur on inland waterbodies, as well as in coastal habitats. The Oriental Plover favours dry grasslands and open plains, including recently burnt areas (Geering *et al*. 2007). These species are non-breeding summer visitors to Australia, migrating from Siberia and east China through the East Asian-Australasian Flyway (Geering et al. 2007). The Study Area is only likely to be an internationally significant site for these species if it supports 20,000 birds or 1% or more of the flyway population of a species, or a nationally significant site if it supports 2,000 birds or 0.1% or more of the flyway population of a species (DoEE 2017). This equates to 230 Oriental Plover, 190 Common Sandpiper and 130 Wood Sandpiper to be nationally significant (Hansen *et al*. 2016). Single individual Common Sandpipers and Wood Sandpipers were recorded at Wodgina in October 2019. The Study Area is only likely to support one or two birds on an irregular basis and is not considered important habitat for migratory shorebirds.

The **Fork-tailed Swift** is a non-breeding visitor to Australia between September and April (Boehm 1962, Johnstone and Storr 1998). The bird is primarily observed foraging for insects in proximity to cyclonic weather (Boehm 1962). Although a migratory species, the Fork-tailed Swift has a large range and a large population that appears to be stable (BirdLife International 2019). This species was recorded nearby on DBCA's Threatened and Priority Fauna Database (Figure 13), and is considered likely to occur in the Study Area. The Fork-tailed Swift is a largely aerial species and is unlikely to be affected by changes to the Study Area.

5.4 Mammals

There are 41 species of mammal that have the potential to occur in the Study Area, of which 33 are native and eight introduced (Appendix 8). A total of 31 species were recorded from the Study Area between 2009 and 2019, of which 25 are native and six are introduced. The mammal assemblage is likely to be relatively intact, with the exception of species that are extinct in the Bioregion. Australia has a history of mammal extinctions since European settlement, most likely due to changed fire regimes and the impacts of feral Cats and Foxes (Woinarski *et al*. 2015). Of the mammals known from the Bioregion, 15% are now extinct (McKenzie *et al*. 2009).

Twenty-five mammal species (21 native) were recorded during the current survey. Between one and five species were recorded in trapping grids, but most species were recorded by other methods including targeted quoll trapping, camera trapping, bat call records and opportunistic observation (Table 11, Plates 16 and 17).

A small suite of species favour rocky habitats, including Woolley's False Antechinus (*Pseudantechinus woolleyae*), Long-tailed Dunnart (*Sminthopsis longicaudata*), Common Rock-rat (*Zyzomys argurus*), Rothschild's Rock-wallaby (*Petrogale rothschildi*) and Northern Quoll (*Dasyurus hallucatus*) (Plates 16 and 17). These species are strongly associated with rocky habitats in the Pilbara region, and the Rocky Ridge and Gorge habitat in the Study Area is likely to provide important habitat for these species. Many bats also roost in caves and rock crevices, though they may forage more widely at night. Species that favour sandier habitats are generally absent, though some, such as the Spinifex Hopping Mouse (*Notomys alexis*) occur on the sandier soils along the Drainage Line habitat.

Plate 16. Woolley's False Antechinus and Northern Quoll recorded on camera trap.

Although the mammal fauna of the Pilbara is relatively well-studied, there are still taxonomic issues to be resolved, for example there are several undescribed species of *Planigale* present (Westerman *et al*. 2016). Although this example does not impact the outcomes of this survey, it provides an indication that despite the many surveys that are undertaken in the region, there are still knowledge gaps.

Table 11. Mammals recorded in the Study Area 2009 - 2019.

Species	Survey, site and habitat													
	2009[1]	2011[2]					2019 Apr / Oct							
	All 6 sites and habitats combined	1 - Ironstone Ridge Top	2 - Spinifex Stony Plain	3 - Ironstone Ridge Top	4 - Drainage Line	Opportunistic	1 - Spinifex Stony Plain	2 - Drainage Line	3 - Rocky Foothills	4 - Spinifex Stony Plain	5 - Stony Rise	6 - Drainage Line	Opportunistic
Echidnas														
Tachyglossus aculeata													+
Dasyurid marsupials														
Dasyurus hallucatus	+	1											+
Dasykaluta rosamondae							23/12			1/-		1/2	
Ningaui timealeyi										1/-	1/-	2/-	
Planigale sp. 1	+	3	1		2				-/3		3/2		
Pseudantechinus woolleyae	+												+
Sminthopsis longicaudata **(P4)**	+												
Sminthopsis macroura[3]													
Kangaroos														
Lagorchestes conspicillatus **(P4)**[4]													
Osphranter robustus	+					+							+
Petrogale rothschildi	+												+
Bats														
Austronomus australis	+												+
Chaerephon jobensis	+												+
Chalinolobus gouldii	+					+							+
Macroderma gigas	+					+							
Rhinonicteris aurantia	+					+							+
Saccolaimus flaviventris	+					+							+
Scotorepens greyii	+					+							+
Taphozous georgianus	+					+							+
Vespadelus findlaysoni	+					+							+
Rodents														
Notomys alexis												1/-	
Pseudomys chapmani **(P4)**	+					+							+
Pseudomys desertor								2/-				-/1	
Pseudomys hermannsburgensis							3/3	1/-		-/2	1/-	2/3	
Zyzomys argurus	+												+

Table 11 (cont.)

Species	Survey, site and habitat												
	2009[1]	2011[2]					2019 Apr / Oct						
	All 6 sites and habitats combined	1 - Ironstone Ridge Top	2 - Spinifex Stony Plain	3 - Ironstone Ridge Top	4 - Drainage Line	Opportunistic	1 - Spinifex Stony Plain	2 - Drainage Line	3 - Rocky Foothills	4 - Spinifex Stony Plain	5 - Stony Rise	6 - Drainage Line	Opportunistic
Introduced species													
Mus musculus							1/-	10/1					
Felis catus	+						1/1						
Vulpes vulpes[3]													
Canis familiaris dingo													+
Equus caballus[5]													
Bos taurus	+					+							+
Total species:	**19**	**2**	**1**	**0**	**1**		**4**	**3**	**1**	**3**	**3**	**5**	
		12					**25**						

[1] Wodgina DSO (Outback Ecology 2009), [2] Hercules DSO (Outback Ecology (2012), [3]Stantec (2018b), [4]Biologic (2018a), [5]360 Environmental (2017).

Plate 17. Rothschild's Rock-wallaby and Echidna recorded on camera trap.

5.4.1 Mammals of Conservation Significance

There are seven mammals of conservation significance that may occur in the Study Area. Each species is listed and discussed below. Two species are known to occur in the surrounding area, but have been excluded from the list based on the habitats available in the study area. Both the Bilby (*Macrotis lagotis*, Vulnerable) and Brush-tailed Mulgara (*Dasycercus blythi*, Priority 4) favour sandplain habitats that are absent from the Study Area. These species have been excluded from the list in Appendix 8 and are not discussed further.

Threatened Species

Northern Quoll *Dasyurus hallucatus*
This species is listed as Endangered under the EPBC Act and the BC Act.

Pilbara Leaf-nosed Bat *Rhinonicteris aurantia*
This species is listed as Vulnerable under the EPBC Act and the BC Act.

Ghost Bat *Macroderma gigas*
This species is listed as Vulnerable under the EPBC Act and the BC Act.

The **Northern Quoll** was recorded in the Study Area on the first phase (April 2019) of this survey and on previous surveys between 2009 and 2018 (Figure 14, Plate 16). The Northern Quoll occurs in a variety of habitats across its range, but in the Pilbara favours dissected rocky escarpments (Hill and Ward 2010, Van Dyck and Strahan 2008). Where shelter habitat occurs within the Northern Quolls predicted range, it is considered 'habitat critical to the survival of the species' (Commonwealth of Australia 2016). In the Pilbara, shelter and denning habitat consists of rocky habitats such as ranges, escarpments, mesas, gorges, breakaways, boulder fields and major drainage lines (Commonwealth of Australia 2016). In the Study Area, shelter habitat is primarily the Rocky Ridge and Gorge habitat (Figure 15).

Little is known about Northern Quoll foraging and dispersal habitats, However, the EPBC Act referral guidelines recognise that all native vegetation within 1km of shelter habitat or Northern Quoll records may be considered foraging and dispersal habitat (Commonwealth of Australia 2016). In the Study Area the Drainage Line habitat may also be important for foraging and dispersal, as it contains shelter such as tree hollows and is likely to be a higher productivity foraging environment. Despite the lack of data on usage of dispersal and foraging habitat, it is known that the Northern Quoll is highly mobile and capable of dispersing over long distances. For example, 2.5km in one day (Schmitt *et al*. 1989), 3.5km in seven days (King 1989), 2 – 3km at Poondano (Process Minerals International, unpublished data) and 2km at the Buckland Project (Phoenix Environmental Sciences 2012).

The Northern Quoll was recorded on three of the 82 camera traps deployed in April and October 2019. The two April 2019 quoll trapping sites only resulted in a single capture of a male quoll. The Northern Quoll has been subject to monitoring at eight sites across the western portion of the Study Area by Stantec (2017) since 2010 (see Figure 7 for site locations). Although initially relatively abundant (14 captures of eleven females and three males), the number of quolls caught during annual monitoring dropped significantly after widespread bushfires in 2014 and 2016 (Stantec 2017, MWH 2014). Low capture rates were experienced in 2016 and 2015 and only a single female was trapping in 2017. In 2018, Northern Quoll numbers appeared to be increasing again, with seven individuals captured (Biologic 2018a).

The presence of females in the population indicate that the Rocky Ridge and Gorge habitat in the Study Area support a breeding population of Northern Quoll. Though impacted by bushfire, Stantec (2017) concluded that the quoll population had not been significantly impacted by mining of iron ore at the Wodgina DSO Project. It appears that quolls are still present throughout the area and there are contemporary records of this species throughout the rocky range (Figure 14).

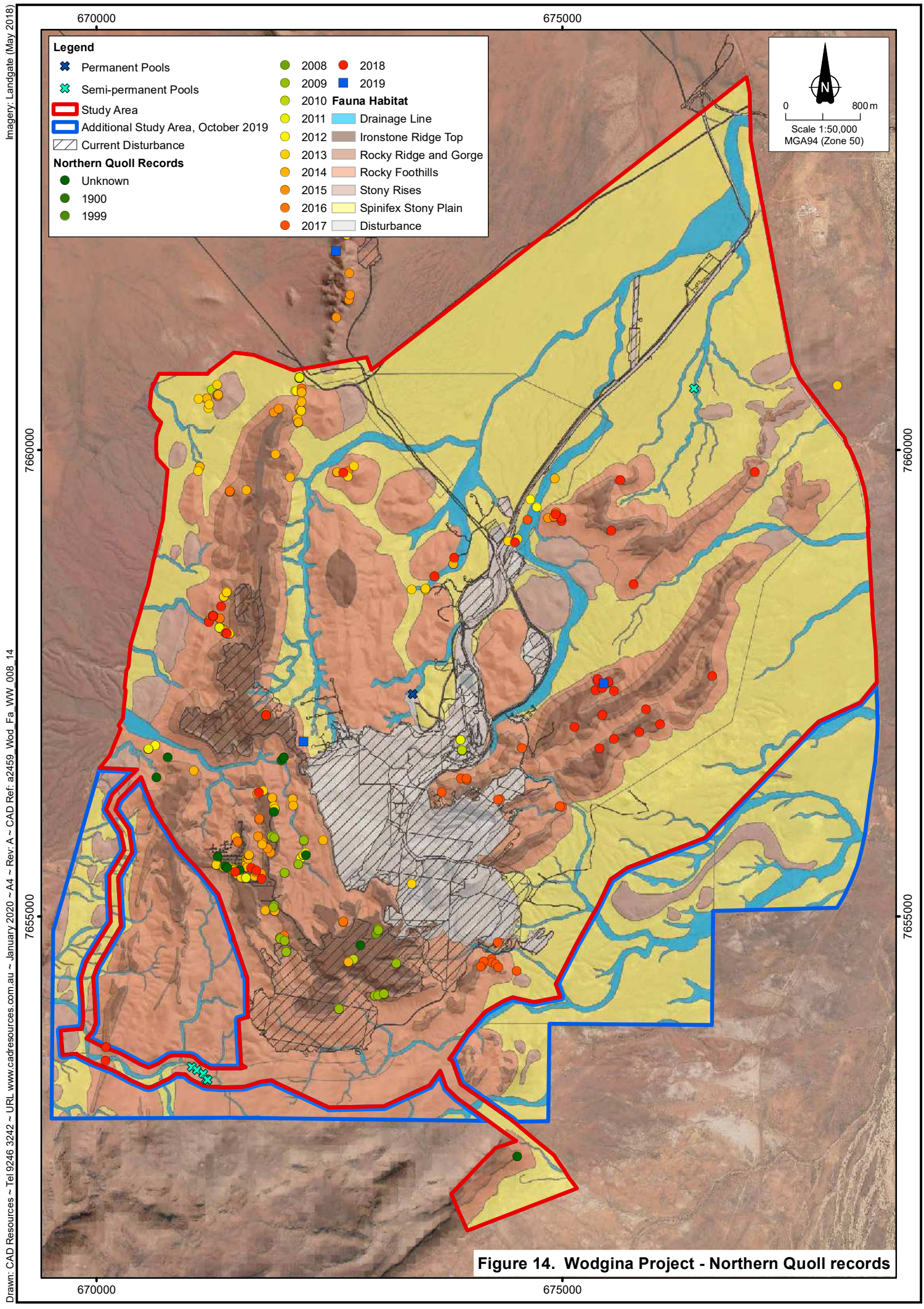

Figure 14. Wodgina Project - Northern Quoll records

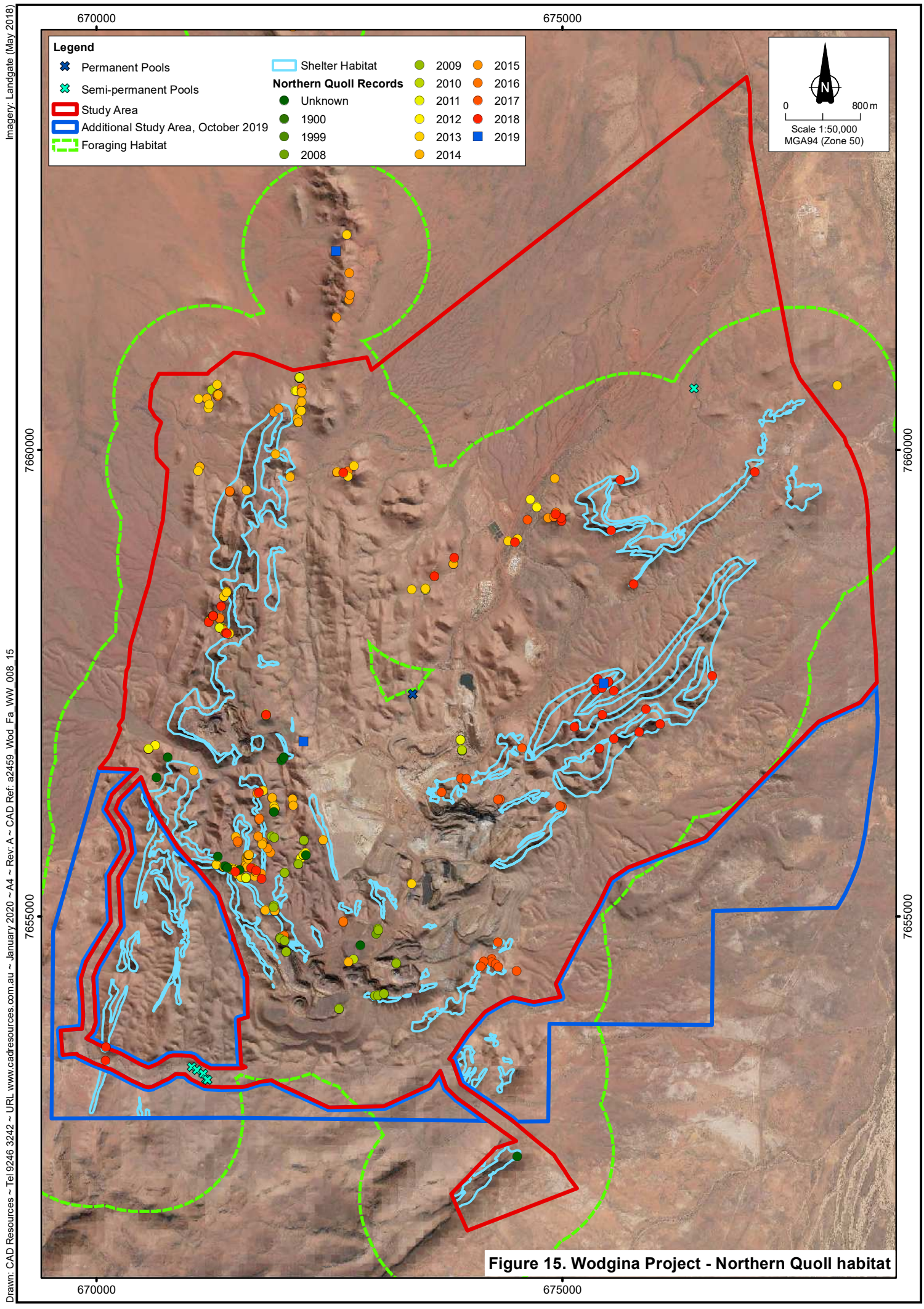

Figure 15. Wodgina Project - Northern Quoll habitat

The **Pilbara Leaf-nosed Bat** requires warm, humid daytime roost sites and forages in gorges, along watercourses and over low Spinifex-covered hills (TSSC 2016c). This species has been recorded on this and previous fauna surveys in the Study Area (Figure 16), and has been subject to targeted surveys. The Pilbara Leaf-nosed Bat is likely to forage throughout the study areas, particularly along major creeklines. When foraging it typically flies very low to the ground, so it is vulnerable to road mortalities (Van Dyck and Strahan 2008). Shallow caves and simple vertical shafts are unlikely roost sites, as they are restricted to sites that maintain warm, humid conditions all year, usually deep within a mine or cave structure, and often over pools of water (Armstrong 2001).

No permanent diurnal roosts are known from the Study Area (Stantec 2018b). Three permanent diurnal roosts are located about 25km from the Study Area; the East Turner River Roost to the northeast, the Yule River Roost to the West and the Glacier Valley Roost to the southeast (Stantec 2018b). A transitory diurnal roost (a roost used for daytime roosting for part of the year only) is located in the Study Area on the western part of the range (Figure 17). Transitory diurnal roosts potentially support long-distance dispersal and are critical habitat for this species. Several nocturnal refuges have also been identified across the survey area. These are used for feeding at night and are not considered critical habitat.

The **Ghost Bat** is a large carnivorous bat that occurs across northern Australia. Though not recorded during the current survey, this species has been recorded across the Study Area on previous surveys (Figure 18). The Pilbara population has been estimated at up to 2000 individuals, with the Chichester subpopulation (of which the colony in the Study Area is a part) comprising 1500 individuals (TSSC 2016a), though this species also occurs across north and north-east Australia with the total population estimated at about 10,000 individuals (Woinarski *et al*. 2014, TSSC 2016a).

Ghost Bats roost in both natural structures (such as caves), and old mine shafts. Intermittent roosts used by a few individuals, and may be relatively shallow caves, rock crevices or smaller mines (Armstrong and Anstee 2000, Woinarski *et al*. 2014). Maternity roosts are situated in caves with a high relative humidity, often with a small entrance opening into a larger chamber. Deep mines are also known to be maternity roosts, including those at Bamboo Creek Mine in the Marble Bar shire (Armstrong and Anstee 2000).

Ghost Bats are threatened by loss of roosting habitat (mostly in the Pilbara), disturbance at roost sites, degradation of foraging habitat, mortality on barbed wire fences near roost sites and poisoning by Cane Toads (Woinarski *et al*. 2014, TSSC 2016a).

The Ghost Bat uses the Study Area for foraging and roosting. Outback Ecology (2009) conducted an aerial serach for caves identifying several diurnal roosts and Biologic (2018b) identified several caves that may be maternity roosts (Figure 19). The numbers of bats recorded has generally been low (Stantec 2018b). However, the colony of bats that uses the Study Area is likely to move between caves both inside and outside the Study Area, according to prevailing weather conditions, and significant numbers of bats have been recorded on occasion. For example, a roost of 65 bats with young was recorded at cave C2 in 2012, 23 bats in cave C1 in 2014 and 14 bats at cave C7a in 2017. Additionally, 60 bats were recorded at both caves C5 and AC-80 in 2009, caves 4km to the south of the Study Area (Figure 19). Roosts of this size represent a large proportion of the known population in the Chichester region. A small roost of 2 bats was recorded in the eastern range at cave SC-10 in 2009 (Outback Ecology 2009). When revisited in October 2019, it was determined that cave SC-10 was not a significant roost as the cave was relatively shallow and only likely to be used by small numbers of bats on occasion. Several nocturnal refuges have also been identified, and these are not considered critical habitat.

Priority Species

Long-tailed Dunnart *Sminthopsis longicaudata*
This species is listed as Priority 4 by DBCA.

Spectacled Hare-Wallaby *Lagorchestes conspicillatus*
This species is listed as Priority 4 by DBCA.

Lakeland Downs Mouse *Leggadina lakedownensis*
This species is listed as Priority 4 by DBCA.

Western Pebble-mound Mouse *Pseudomys chapmani*
This species is listed as Priority 4 by DBCA.

The **Long-tailed Dunnart** is associated with breakaways and scree slopes, but also occurs on gravel or stony plains (Van Dyck and Strahan 2008). Although not recorded during the current survey, this species was trapped in Rocky Foothill habitat at Wodgina in 2009 (Outback Ecology 2009), so is known to occur in the Study Area (Figure 20). This species is likely to favour the Rocky Ridge and Gorge habitat, but may also occur in the Rocky Foothills, Stony Rise and Spinifex Stony Plain habitats throughout the Study Area.

The mainland form of the **Spectacled Hare Wallaby** occurs across northern Australia, with an isolated population in the Pilbara (Van Dyck and Strahan 2008). The Pilbara population has declined significantly, possibly due to frequent fires preventing large Spinifex clumps from forming, as well as predation by foxes (Van Dyck and Strahan 2008). The mainland form of the Spectacled Hare-Wallaby is listed as 'Near Threatened' in the Action Plan for Australian Mammals 2012 (Woinarski *et al*. 2014). There are DBCA Threatened and Priority Fauna Database records of this species nearby (Figure 13), and a single dead individual was recorded in the Study Area in 2018 (Biologic 2018a) (Figure 20). This species is likely to occur in low densities in the Spinifex Stony Plain habitat, particularly where there are large long-unburnt spinifex hummocks in which to shelter.

The **Lakeland Downs Mouse** favours cracking and gilgaied clays (Gibson and McKenzie 2009), but it also occurs in a range of other habitats, including spinifex grasslands and stony ranges (Van Dyck and Strahan 2008). The Lakeland Downs Mouse has not been recorded in the Study Area and there are no nearby records on DBCA's Threatened and Priority Fauna Database (Figure 13). However, it has been recorded on NatureMap within 40km of the Study Area and populations of this species can fluctuate dramatically (Van Dyck and Strahan 2008), so it may be common in one year and virtually absent in another. The Lakeland Downs Mouse may occur in the Study Area.

The **Western Pebble-Mound Mouse** occurs in the ranges of the central and southern Pilbara, and the smaller ranges of the Little Sandy Desert. It inhabits gentle stony slopes where it constructs its pebble mounds, often situating them near *Acacia*-lined minor drainages (Van Dyck and Strahan 2008). This species has disappeared from parts of its range along the Pilbara coast, Murchison and Gascoyne, possibly due to the fox and introduced herbivores (Van Dyck and Strahan 2008). Despite this, mining is not considered to be a threatening process for this species, as its habitat is relatively widespread (Woinarski *et al*. 2014). Both active and inactive mounds of this species were found on spinifex stony plains in the study areas (Figure 20, Plate 18). The Western Pebble-mound Mouse is likely to occur throughout the Spinifex Stony Plain habitat of the Study Area and in the wider region.

Plate 18. Active Western Pebble-mound Mouse mound.

5.4.2 Feral Mammals

Six feral mammal species were recorded in the Study Area (Table 11, Appendix 8). Evidence of cows (livestock) was common, particularly in the Drainage Line habitat. Cats (*Felis catus*) were recorded on camera traps at eight of the 40 locations in April and four of the 42 locations in October 2019 (Plate 19), and Dogs/Dingo (*Canis familiaris*) were recorded on a single camera trap in April 2019.

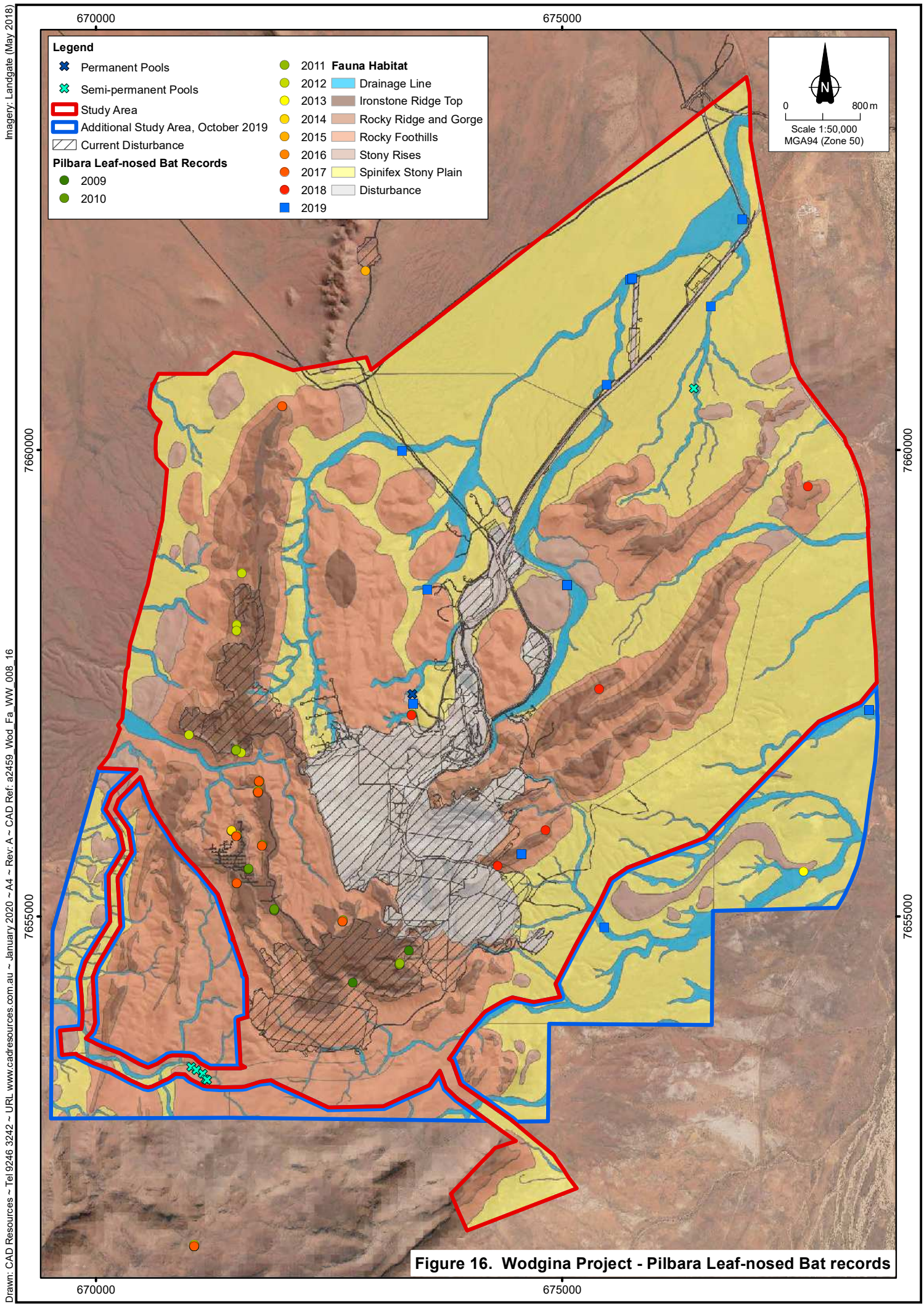

Figure 16. Wodgina Project - Pilbara Leaf-nosed Bat records

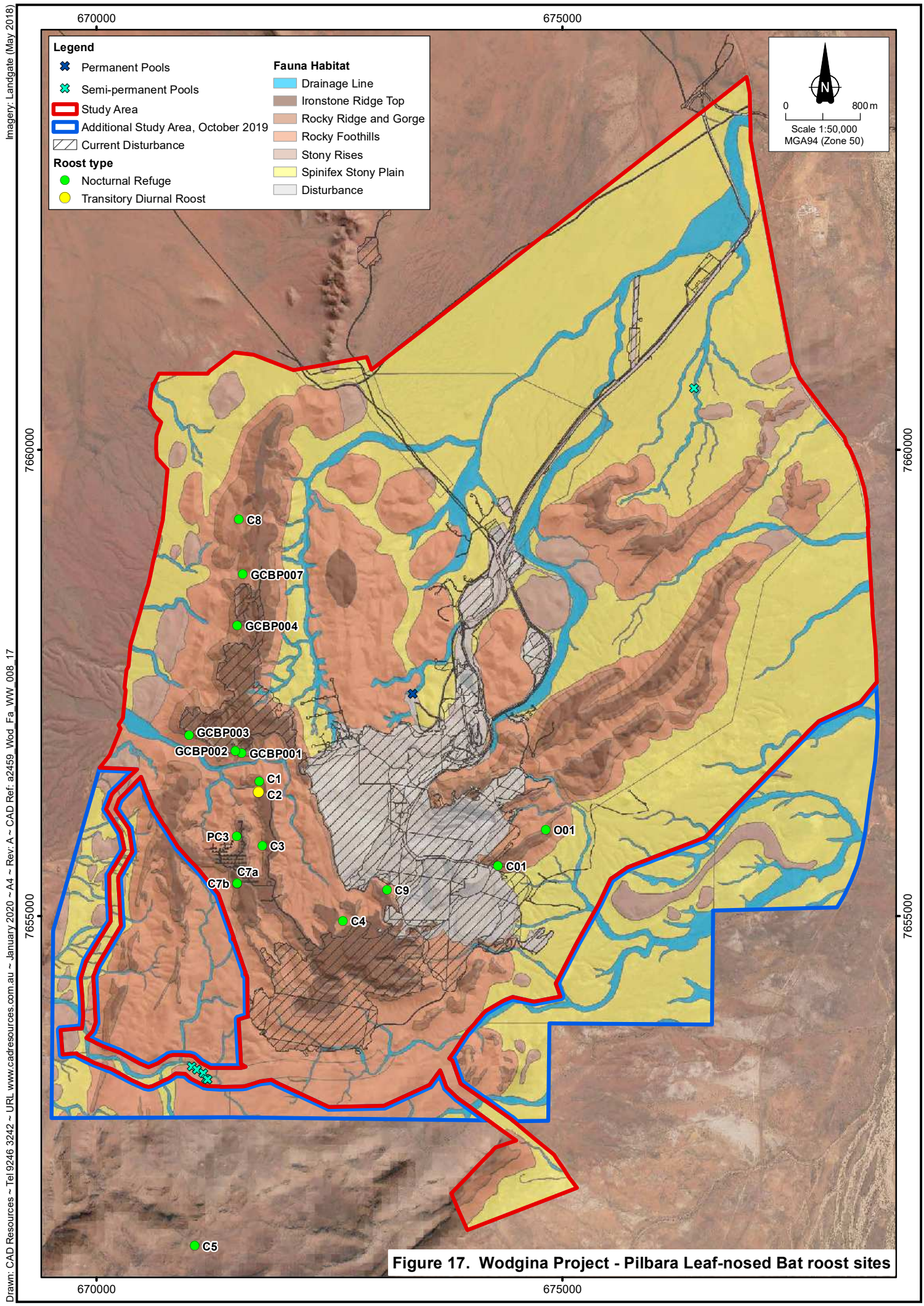

Figure 17. Wodgina Project - Pilbara Leaf-nosed Bat roost sites

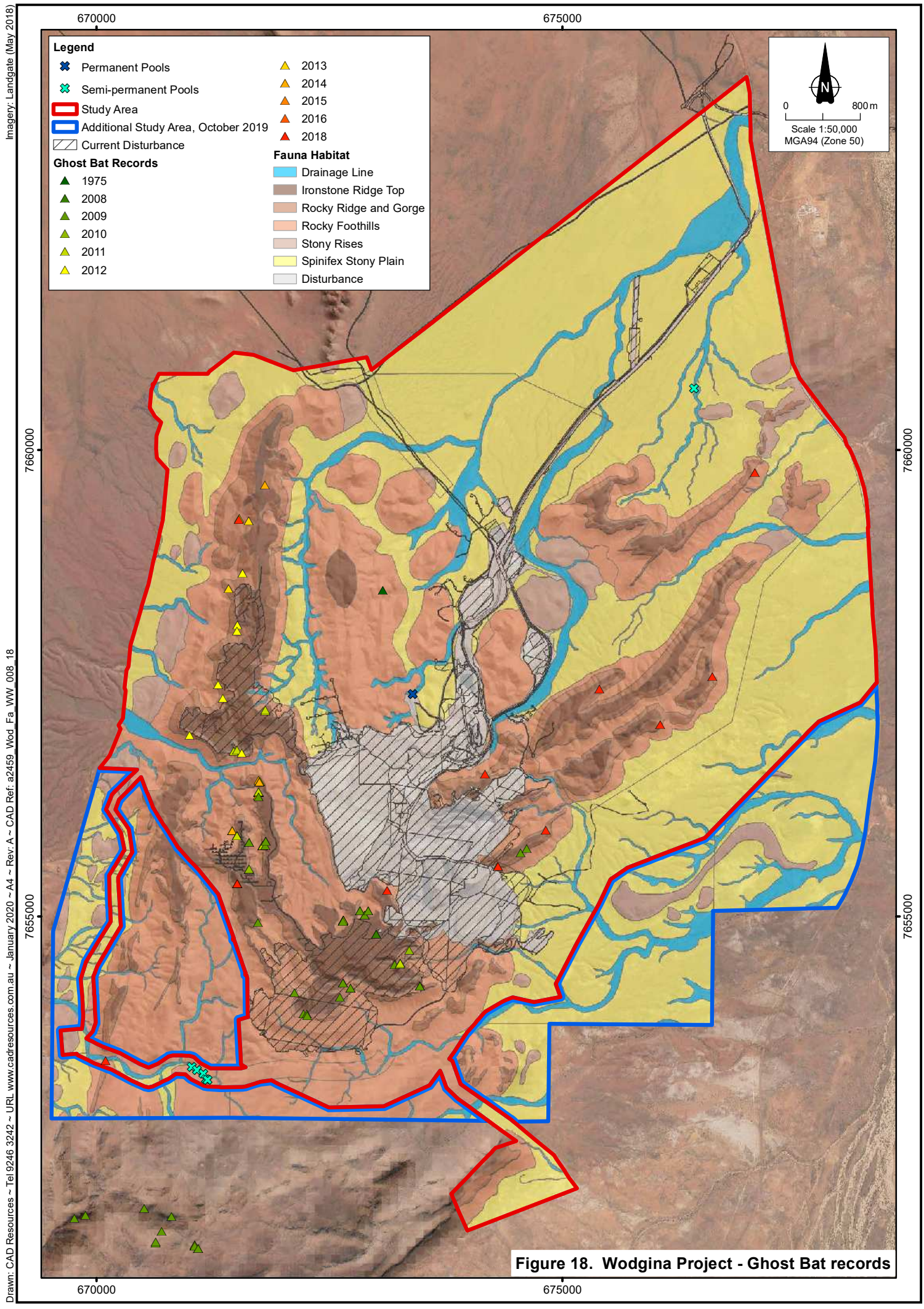

Figure 18. Wodgina Project - Ghost Bat records

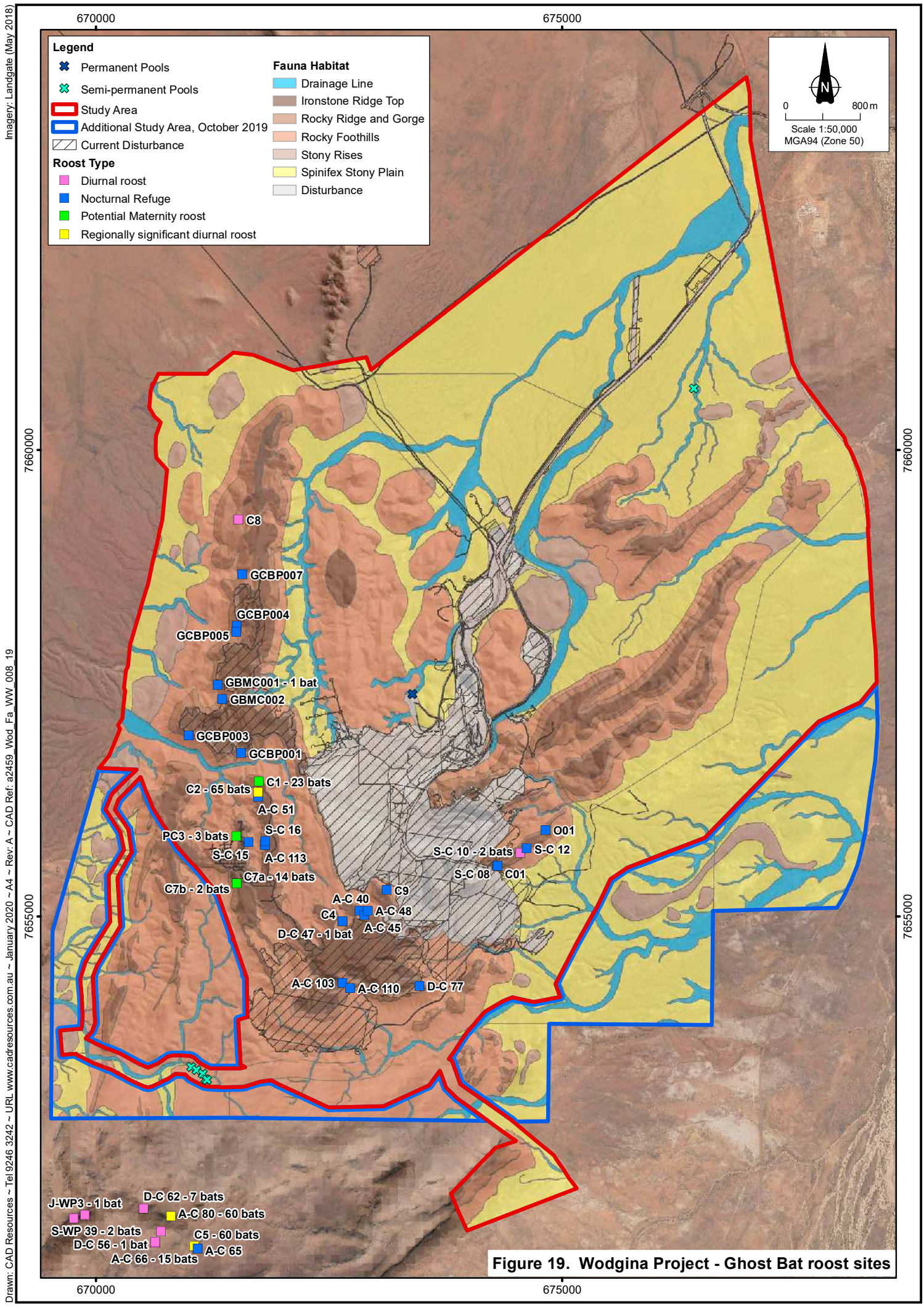

Figure 19. Wodgina Project - Ghost Bat roost sites

Imagery: Landgate (May 2018)

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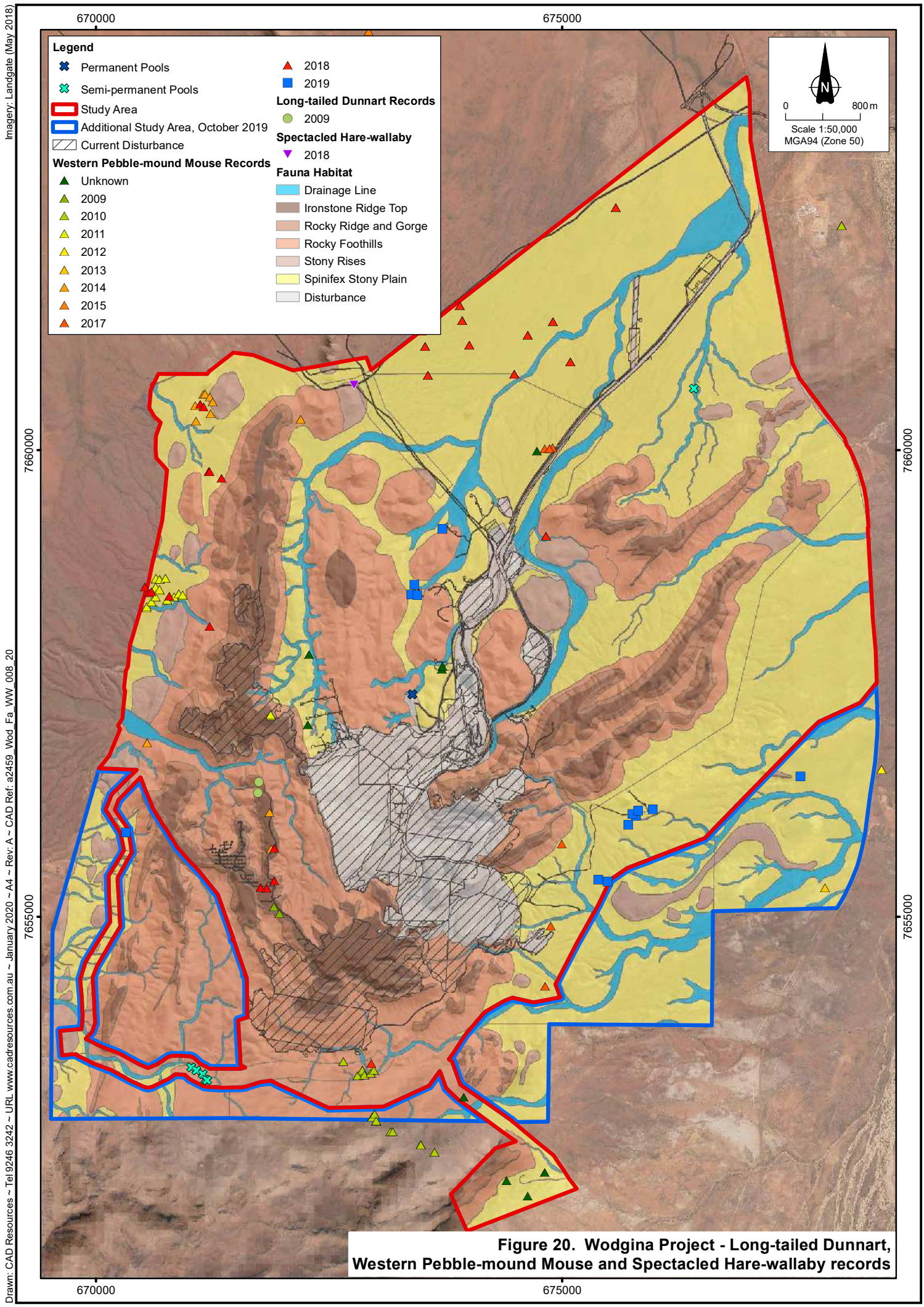

Figure 20. Wodgina Project - Long-tailed Dunnart, Western Pebble-mound Mouse and Spectacled Hare-wallaby records

Plate 19. Feral Cats on camera traps in the Study Area.

The Cat (*Felis catus*), Fox (*Vulpes vulpes*) and Wild Dog (*Canis familiaris*) are feral predators known to prey on native fauna species. 'Predation by Feral Cats' and 'Predation by the European Red Fox' are listed as a key threatening processes under the EPBC Act. Foxes prey on 'critical weight range' mammals (i.e. those between 35g and 5.5kg) and ground-nesting birds (Commonwealth of Australia 2008). Feral Cats have contributed to the extinction of many small to medium sized native mammals and ground-nesting birds in the arid zone (Commonwealth of Australia 2015a). Though mammals tend to be the dominant prey (Commonwealth of Australia 2015a), each Feral Cat in natural environments kills on average 225 reptiles per year, with cats in arid areas taking even more, equating to the predation of about 1.8 million reptiles per day (Woinarski *et al*. 2018).

The relationships between feral predators are complex, as they may compete for prey, prey on each other or kill to remove a competitor. The presence of one predator, such as a wild dog or dingo, may affect the behaviour or suppress the abundance of smaller species, such as Cats (Commonwealth of Australia 2015b). Also, the presence of feral prey species such as Rabbits (*Oryctolagus cuniculus*) can support Fox populations (Commonwealth of Australia 2008). These complex interactions mean that control of these species is not straightforward, as reducing the population of one species may result in the increase in another.

5.5 Freshwater Fish

The freshwater fish fauna of the interior Pilbara region is not diverse. Only eight species are expected to occur in the vicinity of the Study Area (Appendix 9), though most of these are likely to be restricted to the larger rivers (i.e. the Turner River) and any permanent river pools. The species listed in Appendix 9 have mainly been recorded in the Turner River, of which the drainage lines in the Study Area are tributaries, by Morgan and Gill (2004). No freshwater fish were recorded in the Study Area.

6. Survey Adequacy

6.1 Species Accumulation Curves

Species accumulation curves were calculated for reptiles (Figure 19), mammals (Figure 20) and birds (Figure 21) in each habitat. For reptiles and small terrestrial mammals, data from both this survey and the Hercules DSO Project (Outback Ecology 2012) were used, with the number of captures combined for each habitat type. Data from the Wodgina DSO survey (Outback Ecology 2009) was not used, as the data for each habitat were not available. For birds, only the data from this survey was used, and combined for all sites. Raw bird data for previous surveys were not available.

Estimates of species richness for reptiles and mammals are given in Table 12, using the Chao1 estimator for abundance-based trapping data. Species richness estimates for birds in each habitat are given in Table 13, using the ICE estimator for incidence-based bird survey data. These are good indicators of the lower bound of the total species richness with small sample sizes. However, the number of singletons in many samples is high, indicating that the sample size is low and the accuracy of these estimates is likely to be poor. This is a common feature of all Level 2 fauna surveys, with many species represented by a single capture, and is ameliorated by using other survey techniques to increase the number of species recorded across the Study Area as a whole.

When interpreting species accumulation curves and estimators of species richness in the context of a Level 2 fauna survey, it is vital to remember that the data collected is influenced by the sampling methods. All sampling methods have inherent biases that favour the detection of some species over others, i.e. some species will be readily trapped and others may be trapped rarely or not at all. Thus the species accumulation curves and estimates of species richness are that of the 'trappable' component of the fauna only. Species may not be trappable if they are temporarily absent from the site (e.g. migratory, nomadic species or irruptive species), are too large to be targeted by standard trapping techniques (e.g. kangaroos) or are shy of entering traps. Fauna may also be patchy in their distribution within a habitat, and may only be trapped if the trapping site intersects their home-range.

In addition, the trappable component of the fauna is likely to vary due to the prevailing conditions, e.g. frogs may be trappable after heavy rains, but virtually impossible to sample in dry conditions. Long-term drought conditions may reduce some species to undetectable levels, or cool conditions may result in reptiles being inactive.

For both reptiles and mammals, the species accumulation curve did not reach asymptote, suggesting that if trapping had continued, more species would have been recorded in each habitat. However, the level of trapping was consistent with guidance for fauna surveys (EPA and DEC 2010). For mammals, the estimate of species richness for each habitat was only slightly higher than the observed species richness, suggesting few species remained unrecorded. The sample sizes for mammal captures were very low, with most mammals on this survey recorded through other methods such as bat call recording and camera traps.

For birds, the species accumulation curves did not reach asymptote, although it should be noted that many species were observed outside of systematic bird surveys. The estimated species richness was 72.7 species (Table 13) and 76 species were recorded on the current survey (Table 10). Birds are generally more mobile than reptiles and mammals and most species are likely to occur across several habitats.

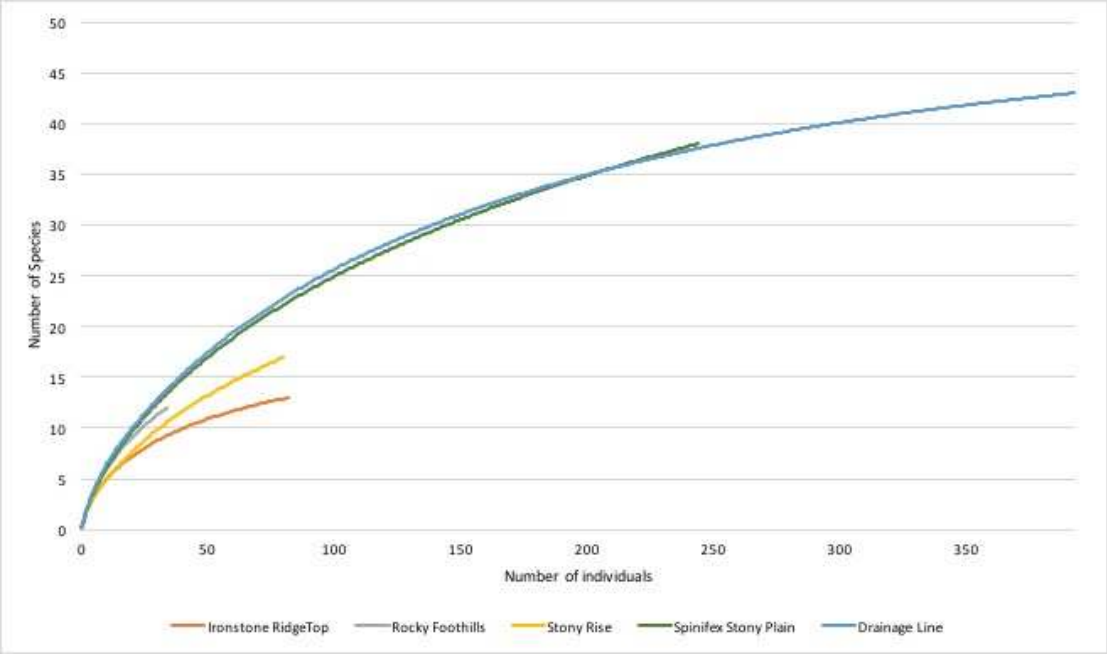

Figure 21. Species accumulation curves for reptiles in each habitat.

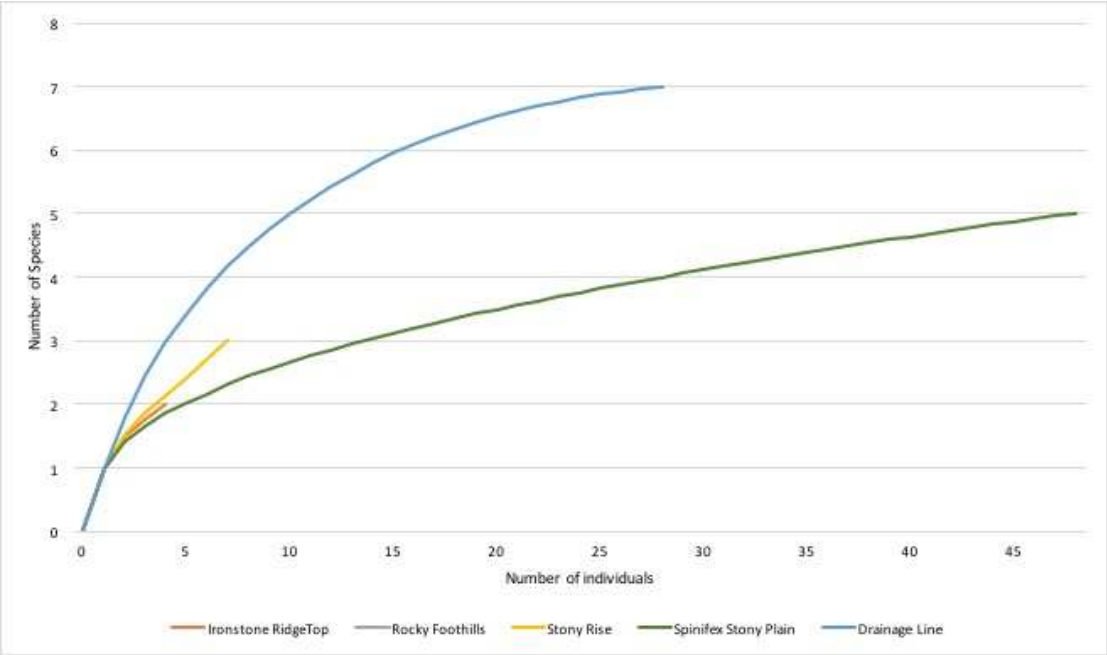

Figure 22. Species accumulation curves for mammals in each habitat.

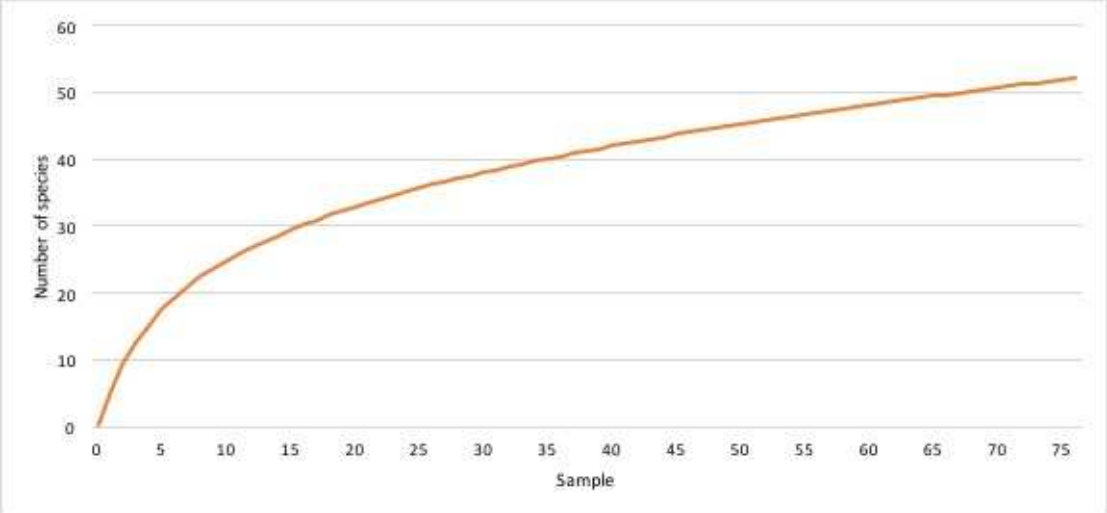

Figure 23. Species accumulation curve for birds in all habitats.

It is important to note that although each habitat supports its own faunal assemblage, individual species can occur across more than one assemblage. This is particularly the case for habitats with similar substrates such as stony plains, stony rises and rocky foothills. Therefore, even if a species has not been recorded in a particular habitat, it may have been recorded in a similar habitat and still be a part of the overall species inventory for the Study Area.

Table 12. Estimated species richness for reptiles and mammals in each habitat.

Species Group	Habitat	Observed species richness	Sample Size (number of individuals)	Number of singletons in the sample	Chao1 Estimate of species richness (± SD)
Reptiles	Ironstone Ridgetop	13	82	4	14.48 ± 2.21
	Rocky Foothills	12	34	6	16.85 ± 5.39
	Stony Rise	17	80	9	28.85 ± 10.65
	Spinifex Stony Plain	38	224	16	52.93 ± 9.94
	Drainage Line	43	393	10	47.98 ± 4.30
Mammals	Ironstone Ridgetop	2	4	1	2.00 ± 0.46
	Rocky Foothills	1	3	0	-
	Stony Rise	3	7	2	3.85 ± 1.84
	Spinifex Stony Plain	5	48	2	5.48 ± 1.27
	Drainage Line	7	28	1	7.00 ± 0.16

Table 13. Estimated species richness for birds in all habitats.

Species Group	Habitat	Observed species richness	Sample Size (number of records)	Number of uniques in the sample	ICE Estimate of species richness (±SD)
Birds	All	52	418	17	72.77 ± 0.01

6.2 Proportion of the Fauna Identified

Species accumulation curves are not the complete picture, as they are based only on the systematically collected trapping and bird survey data. Many species are observed opportunistically or through targeted surveys, and these records often add considerably to the total species inventory of a particular site. The total number of species observed can be compared to the number of species potentially occurring on the site. A total of ten frogs, 108 reptiles, 140 birds, 33 native mammals and eight introduced mammals potentially occur, based on the literature review (Table 7, Appendices 5 - 8). Of these, 50.0% of frogs, 65.7% of reptiles, 63.6% of birds, 75.8% of native mammals and 75.0% of exotic mammals were recorded in the Study Area between 2009 and 2019.

For each species group, at least half the expected species were recorded. As the list of potentially occurring species in Appendices 5 to 8 is relatively conservative, it is quite likely that some of the unrecorded species, though known from the region, do not in fact occur in the Study Area. Bird populations in arid areas are likely to fluctuate markedly in response to local and regional climatic conditions. Potentially occurring species that remain unrecorded include 20 waterbird species and terrestrial species that may move into the area from coastal regions after summer rains or during flowering events.

Of the reptiles that remain unrecorded, many are species that are on the edge of their known range in the Study Area, and it is probable that for at least some of these species, their range does not extend into the Study Area.

It is likely that further work in the Study Area will result in more species being recorded. This is the case with all Level 1 and Level 2 fauna surveys, as the short survey periods only provide a 'snapshot' of the fauna occurring in the Study Area. However, the addition of the current survey to the data collected on previous surveys has resulted in a significant proportion of the fauna being recorded, and field data are supported by a review of the relevant literature.

7. Conclusions

7.1 Faunal Assemblage

The faunal assemblage of the Study Area is likely to be diverse, though many of the species that occur are widely distributed through arid Australia. The predicted faunal assemblage includes up to ten frogs, 108 reptiles, 140 birds, 33 native mammals and eight introduced mammals. The observed assemblage thus far includes five frogs, 71 reptiles, 89 birds, 25 native mammals and six introduced mammals.

7.2 Conservation Significant Fauna

Seventeen conservation significant fauna have been recorded or potentially occur in the Study Area, as summarised in Table 14. The species have been grouped into their conservation significance categories and discussed below.

1. Threatened species.

Six threatened species potentially occur in the Study Area, of which three have been recorded on the current or previous surveys:

- Pilbara Olive Python (*Liasis olivaceus barroni*)
- Grey Falcon (*Falco hypoleucos*)
- Night Parrot (*Pezoporus occidentalis*)
- Northern Quoll (*Dasyurus hallucatus*) **- Recorded**
- Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) **- Recorded**
- Ghost Bat (*Macroderma gigas*) **- Recorded**

Threatened species are those that are considered in danger of extinction as their populations have declined and/or are still declining, and their total population size is small and/or fragmented or geographically restricted. Sites that support these species may be important for their long-term conservation, particularly if the site supports a resident breeding population.

The Northern Quoll, Pilbara Leaf-nosed Bat and Ghost Bat are all known to occur in the Study Area.

The Northern Quoll is likely to be a resident breeding species, albeit one that is less numerous than in previous years, probably due to the impact of bushfires in 2014 and 2016 (Stantec 2017).

The Pilbara Leaf-nosed Bat is known to forage in the Study Area, particularly in the Drainage Line habitat. No permanent diurnal roosts are present or thought likely to be present, though a transitory diurnal roost and nocturnal refuges have been recorded in the western part of the Study Area.

Similarly, the Ghost Bat is likely to forage across the Study Area, with both diurnal roosts and potential maternity roosts recorded in the Study Area. Significant numbers of Ghost Bats (up to 65 bats) have been recorded on occasion.

The status of the Night Parrot in the Study Area is difficult to assess, as this species is represented very few records in the region and/or very few records overall, so its pattern of distribution and abundance are not clear. The Night Parrot was not recorded during the survey, the Study Area lacks the *Triodia longiceps* habitats that this species is associated with at occupied sites and areas with large spinifex hummocks are more wooded than at sites where this species is known to occur.

The Grey Falcon is unlikely to breed in the Study Area but is potentially a foraging visitor if breeding nearby.

2. Migratory species.

Four Migratory species potentially occur in the Study Area, of which none have been recorded in the Study Area:

- Oriental Plover (*Charadrius veredus*)
- Wood Sandpiper (*Tringa glareola*) **- Recorded**
- Common Sandpiper (*Tringa hypoleucos*) **- Recorded**
- Fork-tailed Swift (*Apus pacificus*)

Migratory species are not always present at a site, but a particular site may have significance as a seasonal or ephemeral foraging, breeding or shelter area. Impacts to these sites may then impact the population both within the site and further afield. It is unlikely that the Study Area provides important habitat for migratory species, although low numbers of individuals may occur at times. Both Common and Wood Sandpipers were recorded as individual birds in the Study Area in October 2019.

3. Specially Protected species.

A single Specially Protected species potentially occurs in the Study Area:

- Peregrine Falcon (*Falco peregrinus*)

The Peregrine Falcon potentially occurs as a breeding species or a foraging visitor. Although the Study Area provides habitat for this species, its population is large and secure.

4. Priority species

Six Priority species potentially occur in the Study Area, of which three have been recorded on the current or previous surveys:

- Black-striped Ctenotus (*Ctenotus nigrilineatus*)
- Gane's Blind Snake (*Anilios ganei*)
- Long-tailed Dunnart (*Sminthopsis longicaudata*) – **Recorded**
- Spectacled Hare-wallaby (*Lagorchestes conspicillatus*) – **Recorded**
- Lakeland Downs Mouse (*Leggadina lakedownensis*)
- Western Pebble-mound Mouse (*Pseudomys chapmani*) – **Recorded**

The Black-striped Ctenotus and Gane's Blind Snake are data deficient and known from only a few locations. They have not been recorded in the Study Area, but the habitats present may support these species.

The Long-tailed Dunnart was recorded in 2009 and is likely to be restricted to rocky habitats. The Western Pebble-mound Mouse is likely to be common and widespread within its habitat of Spinifex Stony Plains. The Spectacled Hare-wallaby was recorded in 2018 (Biologic 2018a) and is likely to occur on the Spinifex Stony Plain, favouring long-unburnt areas. Although unrecorded thus far, the Lakeland Downs Mouse may occur, as the Study Area is within its range and potentially suitable habitats are present.

5. Locally Significant Fauna

No locally significant fauna were identified on this survey.

7.3 Important Habitats

All habitats have some importance in that they support native fauna, however, habitats may be of particular importance if they:

- support very diverse or unique faunal assemblages
- are restricted or rare in the region (and thus the faunal assemblages are restricted or rare)
- are refugia (e.g. from drought or fire)
- provide ecological linkage
- support conservation significant fauna

Of the habitats in the Study Area, the Rocky Ridge and Gorge habitat is considered the most important as it provides habitat for several Threatened and Priority fauna species and is limited in extent in the region compared with habitats such as stony plains or sandplain. This habitat provides caves, cracks and crevices for shelter, breeding and roosting sites for a range of native fauna.

The Drainage Line habitat is also important, as though it is widespread in the region, it is likely to support greater abundance and diversity of fauna than surrounding habitats and may provide a corridor for fauna movement. Permanent and semi-permanent pools are likely to provide water for fauna in an otherwise relatively dry landscape.

Table 14. Summary of conservation significant fauna.

Key to status: Cr = Critically Endangered, En = Endangered, Vu = Vulnerable, Mi = Migratory, Sp = Specially Protected, P1 – P4 = Priority 1 – 4, LS = Locally Significant.

Species	Conservation Status				Recorded in Study Area 2009 - 2019	Likelihood of Occurrence	Potential habitat use in the Study Area					
	EPBC Act	BC Act	DBCA Priority	Locally significant			Ironstone Ridgetop	Rocky Ridge and Gorge	Rocky Foothills	Stony Rise	Spinifex Stony Plain	Drainage Line
Threatened Species												
Pezoporus occidentalis **Night Parrot**	En	Cr			-	Low (?)					**?**	
Dasyurus hallucatus **Northern Quoll**	En	En			Yes	Known to occur		**+**				**+**
Rhinonicteris aurantia **Pilbara Leaf-nosed Bat**	Vu	Vu			Yes	Known to occur		**+**				**+**
Macroderma gigas **Ghost Bat**	Vu	Vu			Yes	Known to occur		**+**				
Liasis olivaceus barroni **Pilbara Olive Python**	Vu	Vu			-	High		**+**				**+**
Falco hypoleucos **Grey Falcon**		Vu			-	High	**+**		**+**	**+**	**+**	**+**
Migratory Species												
Charadrius veredus **Oriental Plover**	Mi	Mi			-	Moderate (non-breeding only)						**+**
Tringa glareola **Wood Sandpiper**	Mi	Mi			Yes	Known to occur (non-breeding only)						**+**
Tringa hypoleucos **Common Sandpiper**	Mi	Mi			Yes	Known to occur (non-breeding only)						**+**
Apus pacificus **Fork-tailed Swift**	Mi	Mi			-	High						**+**
Specially Protected												
Falco peregrinus **Peregrine Falcon**		Sp			-	High	**+**	**+**	**+**	**+**	**+**	**+**
Priority Species												
Ctenotus nigrilineatus **Black-lined Ctenotus**			P1		-	Moderate					**?**	
Anilios ganei **Gane's Blind Snake**			P1		-	Moderate		**?**	**?**			

Table 14. (cont.)

Species	Conservation Status				Recorded in Study Area 2009 - 2019	Likelihood of Occurrence	Potential habitat use in the Study Area					
	EPBC Act	BC Act	DBCA Priority	Locally significant			Ironstone Ridgetop	Rocky Ridge and Gorge	Rocky Foothills	Stony Rise	Spinifex Stony Plain	Drainage Line
Lagorchestes conspicillatus **Spectacled Hare-wallaby**			P4		Yes	Known to occur					+	
Sminthopsis longicaudata **Long-tailed Dunnart**			P4		Yes	Known to occur	+	+	+	+	+	
Leggadina lakedownensis **Lakeland Downs Mouse**			P4		-	Moderate					+	+
Pseudomys chapmani **Western Pebble-mound Mouse**			P4		Yes	Known to occur	+				+	

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Appendices.

Appendix 1. Daily weather observations before and during each survey period.

Data after BOM (2019).

Month	Date	Survey Period	Daily Temperature (°C)		Rainfall (mm)
			Minimum	Maximum	
March 2019	20 – 03 – 19		25.5	41	0
	21 – 03 – 19		26.8	37.7	0
	22 – 03 – 19		28	37	0
	23 – 03 – 19		26.8	33.1	0
	24 – 03 – 19		24.9	26.1	16.2
	25 – 03 – 19		22.5	28.2	138
	26 – 03 – 19		22.9	34.2	26.8
	27 – 03 – 19		24.2	36.5	0
	28 – 03 – 19		26	38.6	0
	29 – 03 – 19		27.4	40.2	0
	30 – 03 – 19		26.9	37.8	0
	31 – 03 – 19		22.8	38.3	0
April 2019	1 – 04 - 19		20.7	38.2	0
	2 – 04 – 19		20.5	38.5	0
	3 – 04 – 19		21.4	37.5	0
	4 – 04 – 19		19.1	37.6	0
	5 – 04 – 19		19.4	38	0
	6 – 04 – 19		19.1	38.7	0
	7 – 04 – 19		20.3	39.3	0
	8 – 04 – 19	✓	23.1	37.8	0
	9 – 04 – 19	✓	27.2	36.8	0
	10 – 04 – 19	✓	26.2	38.7	0
	11 – 04 – 19	✓	26.7	38.4	0
	12 – 04 – 19	✓	24.6	31.6	0.4
	13 – 04 – 19	✓	24.6	36.1	0.2
	14 – 04 – 19	✓	26	35.5	0
	15 – 04 – 19	✓	24.9	35.9	0
	16 – 04 – 19	✓	25.8	36.7	0
	17 – 04 – 19	✓	25	37.6	0
	18 – 04 – 19	✓	25.6	39	0
	19 – 04 – 19	✓	24.3	38.2	0

Appendix 1. (cont.)

Month	Date	Survey Period	Daily Temperature (°C)		Rainfall (mm)
			Minimum	Maximum	
September 2019	23 – 03 – 19		17.5	32.7	0
	24 – 03 – 19		16.8	30.7	0
	25 – 03 – 19		14.1	34.1	0
	26 – 03 – 19		16.3	36.8	0
	27 – 03 – 19		17.5	36.0	0
	28 – 03 – 19		16.3	37.1	0
	29 – 03 – 19		16.5	39.0	0
	30 – 03 – 19		18.8	39.9	0
October 2019	1 – 04 - 19		24	41.8	0
	2 – 04 – 19		24.9	42.8	0
	3 – 04 – 19		27.3	42.3	0
	4 – 04 – 19		27.2	42.3	0
	5 – 04 – 19		26.6	40.4	0
	6 – 04 – 19		19.8	41.8	0
	7 – 04 – 19		20.4	42.1	0
	8 – 04 – 19		23.1	42.1	0
	9 – 04 – 19		20.9	42.6	0
	10 – 04 – 19		20.8	42.2	0
	11 – 04 – 19		21.8	43.2	0
	12 – 04 – 19		19.7	42.8	0
	13 – 04 – 19		19.4	39.4	0
	14 – 04 – 19		19.6	38.6	0
	15 – 04 – 19		18.4	38.9	0
	16 – 04 – 19	✓	20.6	40.6	0
	17 – 04 – 19	✓	20.9	40.6	0
	18 – 04 – 19	✓	24.0	42.3	0
	19 – 04 – 19	✓	21.6	42.5	0
	20 – 04 – 19	✓	25.2	42.7	0
	21 – 04 – 19	✓	24.9	42.3	0
	22 – 04 – 19	✓	26.4	42.0	0
	23 – 04 – 19	✓	25.6	42.4	0
	24 – 04 – 19	✓	26.7	42.2	0
	25 – 04 – 19	✓	22.7	41.6	0
	26 – 04 – 19	✓	22.4	40.6	0

Appendix 2. SM4 passive acoustic detector locations.

Site	Zone	Easting	Northing	Start Date	Stop Date	Nights Recording
SM4-01-13-04-19	50	675661	7661841	13/04/2019	18/04/2019	5
SM4-02-13-04-19	50	677061	7656504	13/04/2019	18/04/2019	5
SM4-03-13-04-19	50	674831	7652239	13/04/2019	19/04/2019	6
SM4-04-13-04-19	50	678209	7658527	13/04/2019	18/04/2019	5
SM4-05-13-04-19	50	675335	7655145	13/04/2019	18/04/2019	5
SM4-06-13-04-19	50	676639	7663342	13/04/2019	18/04/2019	5

Appendix 3. Anabat bat detector locations.

Site	Zone	Easting	Northing	Start Date	Stop Date	Nights Recording
BAT_450083_13-04-19	50	675753	7661831	13/04/2019	15/04/2019	2
BAT_450091_13-04-19	50	675675	7656084	13/04/2019	14/04/2019	1
BAT_450091_14-04-19	50	675014	7662359	14/04/2019	15/04/2019	1
BAT_450083_15-04-19	50	673590	7658489	15/04/2019	16/04/2019	1
BAT_450083_16-04-19	50	673405	7657272	16/04/2019	18/04/2019	2
BAT_450091_15-04-19	50	675054	7658545	15/04/2019	18/04/2019	3
Bat 450083 12-04-19	50	678294	7657206	12/04/2019	14/04/2019	2
Bat 450083 19-10-19	50	675010	7662387	19/10/2019	20/10/2019	1
Bat 450085 19-10-19	50	675730	7661821	19/10/2019	20/10/2019	1
Bat 450085 20-10-19	50	675057	7658544	20/10/2019	21/10/2019	1
Bat 450083 20-10-19	50	675880	7656138	20/10/2019	21/10/2019	1
Bat 450083 21-10-19	50	678294	7657206	21/10/2019	22/10/2019	1
Bat 450085 21-10-19	50	673559	7658495	21/10/2019	22/10/2019	1
Bat 450085 22-10-19	50	676597	7661533	22/10/2019	23/10/2019	1
Bat 450083 22-10-19	50	674564	7655664	22/10/2019	24/10/2019	2
Bat 450085 23-10-19	50	673286	7659985	23/10/2019	24/10/2019	1
Bat 450085 24-10-19	50	675480	7660695	24/10/2019	25/10/2019	1
Bat 450083 24-10-19	50	675452	7654878	24/10/2019	25/10/2019	1
Bat 450085 25-10-19	50	676934	7662466	25/10/2019	26/10/2019	1
Bat 450083 25-10-19	50	677265	7656436	25/10/2019	26/10/2019	1

Appendix 4. Camera trap locations.

Site	Zone	Easting	Northing	Start Date	Stop Date	Habitat	Nights recording
Cam WL40	50	673975	7658159	15/04/2019	19/04/2019	Drainage near camp	4
Cam WL41	50	672227	7656863	15/04/2019	19/04/2019	Gully	4
Cam WL42	50	673400	7657371	15/04/2019	19/04/2019	Breakaway	4
Cam WL43	50	673139	7658456	15/04/2019	19/04/2019	Rockface	4
Cam WL47	50	675071	7658584	15/04/2019	19/04/2019	Drainage Line	4
Cam WL48	50	675092	7658141	15/04/2019	19/04/2019	Drainage Line	4
Cam WL49	50	673414	7657419	15/04/2019	19/04/2019	Gorge/Gully	4
Cam WL19	50	672672	7661573	14/04/2019	18/04/2019	Breakaway	4
Cam WL20	50	672709	7662218	14/04/2019	18/04/2019	Breakaway	4
Cam WL21	50	672573	7662126	14/04/2019	18/04/2019	Breakaway	4
Cam WL22	50	673099	7658414	15/04/2019	19/04/2019	Gully/Breakaway	4
Cam WL23	50	673219	7658555	15/04/2019	19/04/2019	Breakaway	4
Cam WL24	50	672630	7661578	14/04/2019	18/04/2019	Gully	4
Cam WL27	50	672213	7656958	15/04/2019	19/04/2019	Breakaway	4
Cam WL28	50	671916	7664794	14/04/2019	18/04/2019	Breakaway	4
Cam WL29	50	671897	7664826	14/04/2019	18/04/2019	Breakaway	4
Cam WL45	50	673219	7658636	15/04/2019	19/04/2019	Breakaway	4
Cam WL31	50	673441	7659154	14/04/2019	18/04/2019	Rockpile	4
Cam WL02	50	674946	7656138	13/04/2019	18/04/2019	Gorge	5
Cam WL30	50	675007	7656188	13/04/2019	18/04/2019	Gorge	5
Cam WL10	50	675831	7655244	14/04/2019	18/04/2019	Ironstone ridgetop	4
Cam WL09	50	675938	7655243	14/04/2019	18/04/2019	Ironstone ridgetop	4
Cam WL04	50	675260	7655137	14/04/2019	18/04/2019	Drainage line	4
Cam WL06	50	678175	7657194	14/04/2019	18/04/2019	Drainage line	4
Cam WL50	50	674348	7652064	14/04/2019	19/04/2019	Drainage line	5
Cam WL18	50	674026	7652014	14/04/2019	19/04/2019	Rocky hill slope	5
Cam WL44	50	678201	7655881	15/04/2019	19/04/2019	Drainage line	4
Cam WL46	50	676737	7653345	15/04/2019	19/04/2019	Drainage line	4
Cam WL25	50	673526	7652144	15/04/2019	19/04/2019	Rocky hill slope	4
Cam WL15	50	673540	7652415	15/04/2019	19/04/2019	Drainage line	4
Cam WL26	50	677397	7655532	15/04/2019	19/04/2019	Rocky hill slope	4
Cam WL03	50	677279	7656527	13/04/2019	18/04/2019	Rocky Foothills	5
Cam WL07	50	677173	7656569	13/04/2019	18/04/2019	Rocky Foothills	5
Cam WL08	50	675293	7656360	13/04/2019	18/04/2019	Rocky Foothills	5
Cam WL17	50	675333	7656434	13/04/2019	18/04/2019	Rocky Foothills	5
Cam WL35	50	675571	7655103	14/04/2019	18/04/2019	Rocky Foothills	4
Cam WL16	50	677457	7660434	14/04/2019	18/04/2019	Rocky Foothills	4
Cam WL05	50	674408	7652348	14/04/2019	19/04/2019	Rocky Foothills	5
Cam WL13	50	677457	7660434	15/04/2019	19/04/2019	Rocky Foothills	4
Cam WL32	50	677583	7660442	15/04/2019	19/04/2019	Rocky Foothills	4
Cam WL02-2	50	675612	7661748	19/10/2019	24/10/2019	Drainage line	5
Cam WL03-2	50	676804	7662309	19/10/2019	24/10/2019	Drainage line	5
Cam WL06-2	50	673368	7661159	19/10/2019	24/10/2019	Spinifex stony plain	5
Cam WL26-2	50	672360	7660459	19/10/2019	24/10/2019	Rocky outcrop in hills	5
Cam WL28-2	50	673559	7658530	19/10/2019	24/10/2019	Drainage line	5

Appendix 4. (cont.)

Site	Zone	Easting	Northing	Start Date	Stop Date	Habitat	Nights recording
Cam WL46-2	50	672472	7660413	19/10/2019	24/10/2019	Rocky outcrop in hills	5
Cam WL08-2	50	673919	7659368	19/10/2019	24/10/2019	Spinifex stony plain	5
Cam WL35-2	50	676704	7663129	19/10/2019	24/10/2019	Spinifex stony plain	5
Cam WLB37	50	677887	7659739	19/10/2019	24/10/2019	Spinifex stony plain	5
Cam WLB41	50	675099	7658579	19/10/2019	24/10/2019	Drainage line	5
Cam WLB43	50	673391	7657393	19/10/2019	24/10/2019	Drainage line	5
Cam WLB44	50	677714	7659621	19/10/2019	24/10/2019	Rocky Ridge	5
Cam WLB48	50	673399	7657404	19/10/2019	24/10/2019	Drainage line	5
Cam WLB50	50	677653	7659621	19/10/2019	24/10/2019	Rocky Ridge	5
Cam WLB27	50	677885	7659739	19/10/2019	24/10/2019	Low spinifex foothills	5
Cam WLB44	50	677704	7659620	19/10/2019	24/10/2019	Rocky hill slope	5
Cam WLB40	50	678097	7655845	19/10/2019	24/10/2019	Drainage line	5
Cam WLB24	50	675495	7656455	19/10/2019	24/10/2019	Rockface	5
CamWL09-2	50	672009	7660459	19/10/2019	24/10/2019	Rocky hilltop	5
CamWL05-2	50	672004	7660496	19/10/2019	24/10/2019	Rocky hilltop	5
Cam WL04-2	50	672920	7658853	20/10/2019	25/10/2019	Rocky gully	5
Cam WL10-2	50	673888	7656621	20/10/2019	25/10/2019	Drainage line	5
Cam WL20-2	50	676027	7661924	20/10/2019	25/10/2019	Drainage line	5
Cam WL21-2	50	673482	7659460	20/10/2019	25/10/2019	Rocky gully	5
Cam WL25-2	50	673301	7659963	20/10/2019	25/10/2019	Rocky Ridge	5
Cam WL30-2	50	673201	7658634	20/10/2019	25/10/2019	Rocky Ridge	5
Cam WL32-2	50	673020	7658957	20/10/2019	25/10/2019	Rocky Ridge	5
Cam WL18-2	50	673419	7659415	20/10/2019	25/10/2019	Rocky gully.	5
Cam WLB13	50	670101	7653442	20/10/2019	25/10/2019	Rocky Ridge	5
Cam WLB16	50	670276	7656033	20/10/2019	25/10/2019	Drainage line	5
Cam WLB22	50	670222	7654373	20/10/2019	25/10/2019	Rocky Ridge	5
Cam WLB23	50	675567	7656644	20/10/2019	25/10/2019	Rocky Ridge	5
Cam WLB31	50	670539	7655945	20/10/2019	25/10/2019	Rocky Ridge	5
Cam WLB45	50	675955	7654785	20/10/2019	25/10/2019	Drainage line	5
Cam WLB17	50	670067	7655823	20/10/2019	25/10/2019	Breakaway	5
Cam WLB15	50	670415	7655690	20/10/2019	25/10/2019	Rocky foothills	5
Cam WLB49	50	675566	7655233	20/10/2019	25/10/2019	Low Breakaway	5
Cam WLB29	50	670102	7654098	20/10/2019	25/10/2019	Rocky Ridge	5
Cam WLB47	50	670070	7653606	20/10/2019	25/10/2019	Rocky Ridge	5
Cam WLB19	50	675262	7655139	20/10/2019	25/10/2019	Drainage line	5
Cam WL07-2	50	674270	7655307	21/10/2019	25/10/2019	Rocky Ridge	4
Cam WL42-2	50	674290	7655340	21/10/2019	25/10/2019	Rocky Ridge	4

Appendix 5. Amphibians potentially occurring in the Study Area.

Key to records:

2019 = species recorded in this survey, April or October 2019.
2018 = species recorded on the Level 1 and targeted survey, July 2018 (Stantec 2018b).
2017 = species recorded on the Wodjina Mine/Airstrip Level 1 fauna survey, December 2017 (360 Environmental 2018a).
2011 = species recorded on the Hercules DSO Level 2 fauna survey, March 2011 (Outback Ecology 2012).
2009 = species recorded on the Wodgina DSO Level 2 fauna survey, March 2009 (Outback Ecology 2009).
EPBC = modelled occurrence of species or species habitat in the area on the EPBC Protected Matters Search Tool.
DBCA = species recorded in the area on DBCA's Threatened and Priority Fauna Database.
NatureMap = species recorded within 40km on NatureMap (DBCA 2007-).

Species	Conservation Status	Records							
		At Wodgina					Databases		
		2019	2018	2017	2011	2009	EPBC	DBCA	NatureMap
Pelodraydidae (tree frogs and water-holding frogs)									
Giant Frog *Cyclorana australis*									+
Main's Frog *Cyclorana maini*		+			+	+			+
Desert Tree Frog *Litoria rubella*		+			+	+			+
Limnodynastidae (burrowing frogs)									
Centralian Burrowing Frog *Platyplectrum spenceri*									+
Northern Burrowing Frog *Neobatrachus aquilonius*									+
Shoemaker Frog *Neobatrachus sutor*									+
Desert Spadefoot *Notaden nichollsi*		+							+
Myobatrachidae (ground frogs)									
Glandular Toadlet *Uperoleia glandulosa*									+
Pilbara Toadlet *Uperoleia saxatilis*		+			?	?			+
Ratcheting Toadlet *Uperoleia talpa*									
# frog species expected:	**10**								

Appendix 6. Reptiles potentially occurring in the Study Area.

Key to records:

2019 = species recorded in this survey, April or October 2019.
2018 = species recorded on the Level 1 and targeted survey, July 2018 (Stantec 2018b).
2017 = species recorded on the Wodjina Mine/Airstrip Level 1 fauna survey, December 2017 (360 Environmental 2018a) or during Wodgina DSO Northern Quoll monitoring (Stantec 2017).
2011 = species recorded on the Hercules DSO Level 2 fauna survey, March 2011 (Outback Ecology 2012).
2009 = species recorded on the Wodgina DSO Level 2 fauna survey, March 2009 (Outback Ecology 2009).
EPBC = modelled occurrence of species or species habitat in the area on the EPBC Protected Matters Search Tool.
DBCA = species recorded in the area on DBCA's Threatened and Priority Fauna Database.
NatureMap = species recorded within 40km on NatureMap (DBCA 2007-).

Species		Conservation Status	Records							
			At Wodgina					Database		
			This survey	2018	2017	2011	2009	EPBC	DBCA	NatureMap
Cheloniidae										
Flat-shelled Turtle	*Chelodina steindachneri*									+
Carphodactylidae (knob-tailed geckoes)										
Smooth Knob-tailed Gecko	*Nephrurus levis*		+							+
	Nephrurus wheeleri									+
Diplodactylidae (ground geckoes)										
Clawless Gecko	*Crenadactylus pilbarensis*									+
Western Fat-tailed Gecko	*Diplodactylus bilybara*		+							
Fat-tailed Gecko	*Diplodactylus conspicillatus*		+			+				+
Northern Pilbara Beak-faced Gecko	*Diplodactylus galaxias*		+							+
Southern Pilbara Beak-faced Gecko	*Diplodactylus savagei*					+	+			+
	Lucasium stenodactylum		+			+	+			+
	Lucasium wombeyi		+			+				+
Western Marbled Velvet Gecko	*Oedura fimbria*					+				?
Beaked Gecko	*Rhynchoedura ornata*		+							+
Northern Spiny-tailed Gecko	*Strophurus ciliaris*									
Jewelled Gecko	*Strophurus elderi*		+			+				+
	Strophurus jeanae									+
Gekkonidae (geckoes)										
Robust Termitaria Gecko	*Gehyra kimberleyi*		+							
Large Pilbara Rock Gehyra	*Gehyra macra*									
Medium Pilbara Spotted Rock Gehyra	*Gehyra media*									
Small Pilbara Spotted Rock Gehyra	*Gehyra micra*									
Pilbara Dtella	*Gehyra pilbara*					+				+
Spotted Dtella	*Gehyra punctata*		+			+				+
Variegated Dtella	*Gehyra variegata*		+			+	+			+
Bynoe's Gecko	*Heteronotia binoei*		+			+	+			+
Pilbara Cave Gecko	*Heteronotia spelea*		+			+	+			+
Asian House Gecko	*Hemidactylus frenatus*	Int.								

Appendix 6. (cont.)

Species		Conservation Status	Records							
			At Wodgina					Database		
			2019	2018	2017	2011	2009	EPBC	DBCA	NatureMap
Pygopodidae (legless lizards)										
	Delma butleri						+			+
	Delma elegans									+
	Delma nasuta		+			+	+			+
	Delma pax		+			+	+			+
	Delma tincta		+							+
Burton's Legless Lizard	*Lialis burtonis*		+							+
Hooded Scaly-foot	*Pygopus nigriceps*									+
Agamidae (dragon lizards)										
Western Ring-tailed Dragon	*Ctenophorus caudicinctus*		+	+	+	+	+			+
Military Dragon	*Ctenophorus isolepis*		+	+	+					+
Central Netted Dragon	*Ctenophorus nuchalis*									+
Western Netted Dragon	*Ctenophorus reticulatus*									+
Southern Pilbara Tree Dragon	*Diporiphora valens*				+					+
Northern Pilbara Tree Dragon	*Diporiphora vescus*									+
Long-nosed Dragon	*Gowidon longirostris*		+		+	+	+			+
Bearded Dragon	*Pogona minor*		+							+
Pebble Dragon	*Tympanocryptis cephalus*									+
Scincidae (skink lizards)										
	Carlia munda		+			+	+			+
	Carlia triacantha		+			+	+			+
	Cryptoblepharus buchananii									
	Cryptoblepharus ustulatus									+
	Ctenotus duricola		+							+
	Ctenotus grandis		+			+				+
	Ctenotus hanloni		+							+
	Ctenotus helenae		+							+
	Ctenotus leonhardii					+				+
Black-lined Ctenotus	*Ctenotus nigrilineatus*	P								+
	Ctenotus pallasotus									
	Ctenotus pantherinus		+							+
	Ctenotus piankai									+
	Ctenotus rubicundus						+			+
Rock Ctenotus	*Ctenotus saxatilis*		+		+	+	+			+
	Ctenotus schomburgkii									+
	Ctenotus serventyi									+
Sharp-browed Ctenotus	*Ctentotus superciliaris*									+

Appendix 6. (cont.)

Species		Conservation Status	Records							
			At Wodgina					Database		
			This survey	2018	2017	2011	2009	EPBC	DBCA	NatureMap
Scincidae (cont.)										
Slender Blue-tongue	*Cyclodomorphus melanops*		+				+			+
Western Pilbara Spiny-tailed Skink	*Egernia cygnitos*		+							+
Eastern Pilbara Spiny-tailed Skink	*Egernia epsisolus*				+					+
	Egernia formosa									+
Pilbara Skink	*Egernia pilbarensis*				+					
Western Narrow-banded Skink	*Eremiascincus pallidus*					?				?
Broad-banded Sand Swimmer	*Eremiascincus richardsonii*									+
	Lerista bipes		+							+
	Lerista clara									+
	Lerista jacksoni		+			+				+
	Lerista labialis									+
	Lerista muelleri					+	+			+
	Lerista verhmens									+
Night Skink	*Liopholis striata*									+
Dwarf Skink	*Menetia greyii*		+							+
	Menetia surda		+							+
	Morethia ruficauda		+	+		+	+			+
	Notoscincus ornatus									+
	Proablepharus reginae									+
Central Blue-tongue	*Tiliqua multifasciata*		+			+				+
Varanidae (goanna or monitor lizards)										
Spiny-tailed Goanna	*Varanus acanthurus*		+			+	+			+
Short-tailed Pygmy Goanna	*Varanus brevicauda*		+			+				+
	Varanus caudolineatus									
Pygmy Desert Goanna	*Varanus eremius*		+							+
Perentie	*Varanus giganteus*		+	+	+		+			+
Sand Goanna	*Varanus gouldii*		+		+					+
	Varanus panoptes		+		+		+			+
Northern Pilbara Rock Monitor	*Varanus pilbarensis*		+		+					+
Black-tailed Monitor	*Varanus tristis*									+
Typhlopidae (blind snakes)										
	Anilios ammodytes		+							+
Gane's Blind Snake	*Anilios ganei*	P								+
Beaked Blind Snake	*Anilios grypus*		+			+	+			+
Pilbara Blind Snake	*Anilios pilbarensis*					+				+

Appendix 6. (cont.)

Species		Conservation Status	Records							
			At Wodgina					Database		
			2019	2018	2017	2011	2009	EPBC	DBCA	NatureMap
Boidae (pythons)										
Pygmy Python	*Antaresia perthensis*		+							+
Stimson's Python	*Antaresia stimsoni*		+			+	+			+
Black-headed Python	*Aspidites melanocephalus*		+							+
Pilbara Olive Python	*Liasis olivaceus barroni*	T						+	+	+
Elapidae (front-fanged snakes)										
Pilbara Death Adder	*Acanthophis wellsi*									+
Northwestern Shovel-nosed Snake	*Brachyurophis approximans*		+			+				+
Narrow-banded Shovel-nosed Snake	*Brachyurophis fasciolatus*		+							+
Yellow-faced Whipsnake	*Demansia psammophis*		+							+
Rufous Whipsnake	*Demansia rufescens*		+			+	+			+
Moon Snake	*Furina ornata*		+				+			+
Mulga Snake	*Pseudechis australis*		+		+					+
Ringed Brown Snake	*Pseudonaja modesta*									+
Gwardar	*Pseudonaja mengdeni*		+							+
Rosen's Snake	*Suta fasciata*					+				+
Spotted Snake	*Suta punctata*									+
Pilbara Bandy-bandy	*Vermicella snelli*									+
# reptile species expected:			**108 (107 native)**							

Appendix 7. Birds potentially occurring in the Study Area.

Key to records:

2019 = species recorded in this survey, April and October 2019.
2018 = species recorded on the Level 1 and targeted survey, July 2018 (Stantec 2018b).
2017 = species recorded on the Wodjina Mine/Airstrip Level 1 fauna survey, December 2017 (360 Environmental 2018a).
2011 = species recorded on the Hercules DSO Level 2 fauna survey, March 2011 (Outback Ecology 2012).
2009 = species recorded on the Wodgina DSO Level 2 fauna survey, March 2009 (Outback Ecology 2009).
EPBC = modelled occurrence of species or species habitat in the area on the EPBC Protected Matters Search Tool.
DBCA = species recorded in the area on DBCA's Threatened and Priority Fauna Database.
NatureMap = species recorded within 15km on NatureMap (DBCA 2007-).

Species	Conservation Status	Records							
		At Wodgina					Database		
		2019	2018	2017	2011	2009	EPBC	DBCA	NatureMap
Dromaiidae (emus)									
Emu *Dromaius novaehollandiae*									+
Anatidae (ducks & swans)									
Grey Teal *Anas gracilis*		+							+
Pacific Black Duck *Anas superciliosus*		+							+
Hardhead *Aythya australis*		+							+
Australian Wood Duck *Chenonetta jubata*									+
Phasianidae (quails)									
Brown Quail *Coturnix ypsilophora*									+
Pelecanidae (pelicans)									
Australian Pelican *Pelecanus conspicillatus*									+
Podicipedidae (grebes)									
Hoary-headed Grebe *Poliocephalus poliocephalus*									+
Australasian Grebe *Tachybabtus navaehollandiae*		+			+				+
Ciconiidae (storks)									
Black-necked Stork *Ephippiorhynchus asiaticus*						+			+
Threskiornithidae (ibis & spoonbills)									
Yellow-billed Spoonbill *Platalea flavipes*									
Royal Spoonbill *Platalea regis*									+
Australian White Ibis *Threskiornis moluccus*									+
Straw-necked Ibis *Threskiornis spinicollis*									+
Ardeidae (herons, egrets, bitterns & night-herons)									
Little Egret *Ardea garzetta*									+
Eastern Great Egret *Ardea modesta*									+
White-faced Heron *Ardea novaehollandiae*									+
White-necked Heron *Ardea pacifica*		+	+						+
Rufous Night-heron *Nycticorax caledonicus*									+
Phalacrocoracidae (cormorants)									
Little Black Cormorant *Phalacrocorax sulcirostris*									+
Little Pied Cormorant *Phalacrocorax melanoleucos*									+

Appendix 7. (cont.)

Species	Conservation Status	Records							
		At Wodgina					Database		
		2019	2018	2017	2011	2009	EPBC	DBCA	NatureMap
Anhingidae (darter)									
Australasian Darter *Anhinga novaehollandiae*									+
Accipitridae (osprey, hawks, eagles & harriers)									
Black-shouldered Kite *Elanus caeruleus*		+							+
Square-tailed Kite *Hamirostra isura*									+
Black-breasted Buzzard *Hamirostra melanosternon*			+						
Black Kite *Milvus migrans*		+	+			+			+
Whistling Kite *Haliastur sphenurus*		+	+	+	+				+
Brown Goshawk *Accipiter fasciatus*		+		+		+			+
Collared Sparrowhawk *Accipiter cirrocephalus*									+
Little Eagle *Hieraaetus morphnoides*									+
Wedge-tailed Eagle *Aquila audax*		+	+						+
Spotted Harrier *Circus assimilis*		+		+					+
Otididae (bustard)									
Australian Bustard *Ardeotis australis*		+		+					+
Rallidae (crakes, rails and gallinules)									
Eurasian Coot *Fulica atra*		+							+
Buff-banded Rail *Gallirallus philippensis*									+
Purple Swamp Hen *Porphyrio porphyrio*		+							
Spotless Crake *Porzana tabuensis*									
Black-tailed Native-hen *Tribonyx ventralis*									+
Turnicidae (button-quails)									
Little Button-Quail *Turnix velox*		+	+	+	+	+			+
Burhinidae (stone-curlews)									
Bush Stone-Curlew *Burhinus grallarius*		+		+					+
Recurvirostridae (stilts & avocets)									
Black-winged Stilt *Himantopus himantopus*									+
Charadriidae (plovers, dotterels & lapwings)									
Oriental Plover *Charadrius veredus*	Mi						+		+
Black-fronted Dotterel *Elseyornis melanops*		+			+	+			+
Red-kneed Dotterel *Erythrogonys cinctus*									+
Scolopacidae (sandpipers, tattlers, godwits & allies)									
Common Sandpiper *Tringa hypoleucos*	Mi	+					+		+
Wood Sandpiper *Tringa glareola*	Mi	+							+
Glareolidae (pratincoles)									
Australian Pratincole *Stiltia isabella*									+
Laridae (noddies, gulls & terns)									
Whiskered Tern *Sterna hybrida*									+

Appendix 7. (cont.)

Species		Conservation Status	Records							
			At Wodgina					Database		
			2019	2018	2017	2011	2009	EPBC	DBCA	NatureMap
Columbidae (pigeons and doves)										
Common Bronzewing	*Phaps chalcoptera*		+							+
Flock Bronzewing	*Phaps histrionica*									+
Crested Pigeon	*Ocyphaps lophotes*		+	+	+	+				+
Spinifex Pigeon	*Geophaps plumifera*		+	+	+	+	+			+
Diamond Dove	*Geopelia cuneata*		+	+	+	+	+			+
Peaceful Dove	*Geopelia striata*		+							+
Cuculidae (cuckoos)										
Pheasant-Coucal	*Centropus phasianinus*									+
Pallid Cuckoo	*Cacomantis pallidus*						+			+
Black-eared Cuckoo	*Chrysococcyx osculans*									
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*		+							+
Tytonidae (barn owls)										
Barn Owl	*Tyto alba*									+
Strigidae (hawk owls)										
Barking Owl	*Ninox connivens*									+
Southern Boobook	*Ninox boobook*			+						+
Podargidae (frogmouths)										
Tawny Frogmouth	*Podargus strigoides*		+							+
Caprimulgidae (nightjars)										
Spotted Nightjar	*Eurostopodus argus*		+	+		+	+			+
Aegothelidae (owlet-nightjars)										
Australian Owlet-Nightjar	*Aegotheles cristatus*		+		+		+			+
Apodidae (swifts)										
Fork-tailed Swift	*Apus pacificus*	Mi						+	+	+
Alcedinidae (kingfishers)										
Blue-winged Kookaburra	*Dacelo leachii*		+	+						+
Red-backed Kingfisher	*Todiramphus pyrrhopygius*		+	+	+					+
Sacred Kingfisher	*Todiramphus sanctus*						+			+
Meropidae (bee-eaters)										
Rainbow Bee-eater	*Merops ornatus*		+	+	+	+	+			+
Falconidae (falcons)										
Brown Falcon	*Falco berigora*		+				+			+
Australian Kestrel	*Falco cenchroides*		+	+	+	+	+			+
Australian Hobby	*Falco longipennis*		+		+		+			+
Grey Falcon	*Falco hypoleucos*	T							+	+
Peregrine Falcon	*Falco peregrinus*	OS							+	+
Black Falcon	*Falco subniger*						+			+

Appendix 7. (cont.)

Species	Conservation Status	Records							
		At Wodgina					Database		
		2019	2018	2017	2011	2009	EPBC	DBCA	NatureMap
Cacatuidae (cockatoos)									
Galah *Cacatua roseicapilla*		+	+	+	+	+			+
Little Corella *Cacatua sanguinea*		+	+	+		+			+
Cockatiel *Nymphicus hollandicus*		+		+	+	+			+
Psittacidae (parrots, lorikeets and rosellas)									
Australian Ringneck *Platycercus zonarius*		+							+
Budgerigar *Melopsittacus undulatus*		+	+		+	+			+
Night Parrot *Pezoporus occidentalis*	T						+		
Ptilonorhynchidae (bowerbirds)									
Western Bowerbird *Ptilonorhynchus maculatus guttatus*		+			+	+			+
Climacteridae (treecreepers)									
Black-tailed Treecreeper *Climacteris melanurus*									+
Maluridae (fairy-wrens, grasswrens and emu-wrens)									
Striated Grasswren *Amytornis striatus*		+			+	+			+
Variegated Fairy-wren *Malurus lamberti*		+			+	+			+
White-winged Fairy-wren *Malurus leucopterus*		+		+					+
Rufous-crowned Emu-wren *Stipiturus ruficeps*									+
Meliphagidae (honeyeaters and chats)									
Brown Honeyeater *Lichmera indistincta*		+	+	+	+	+			+
Black Honeyeater *Sugomel niger*						+			+
Pied Honeyeater *Certhionyx variegatus*		+				+			+
Singing Honeyeater *Gavicalis virescens*		+	+	+	+	+			+
Grey Honeyeater *Lacustroica whitei*						+			
Grey-headed Honeyeater *Ptilotula keartlandi*		+	+	+	+	+			+
White-plumed Honeyeater *Ptilotula penicillata*		+	+	+					+
Grey-fronted Honeyeater *Ptilotula plumulus*					+	+			+
Black-chinned Honeyeater *Melithreptus gularis*									+
White-fronted Honeyeater *Purnella albifrons*									
Yellow-throated Miner *Manorina flavigula*		+	+	+	+	+			+
Spiny-cheeked Honeyeater *Acanthagenys rufogularis*		+							+
Crimson Chat *Epthianura tricolor*		+		+					+
Pardalotidae (pardalotes)									
Red-browed Pardalote *Pardalotus rubricatus*		+							+
Striated Pardalote *Pardalotus striatus*						+			+
Acanthizidae (thornbills, gerygones & allies)									
Weebill *Smicrornis brevirostris*									+
Western Gerygone *Gerygone fusca*				+					+
Pomatostomidae (babblers)									
Grey-crowned Babbler *Pomatostomus temporalis*		+	+						+

Appendix 7. (cont.)

Species	Conservation Status	Records							
		At Wodgina					Database		
		2019	2018	2017	2011	2009	EPBC	DBCA	NatureMap
Artamidae (woodswallows)									
White-breasted Woodswallow *Artamus leucorynchus*									+
Masked Woodswallow *Artamus personatus*									+
Black-faced Woodswallow *Artamus cinereus*		+	+	+	+	+			+
Little Woodswallow *Artamus minor*		+		+	+	+			+
Cracticidae (butcherbirds & magpie)									
Grey Butcherbird *Cracticus torquatus*		+							+
Pied Butcherbird *Cracticus nigrogularis*		+		+	+	+			+
Australian Magpie *Cracticus tibicen*					+				+
Campephagidae (cuckoo-shrikes and trillers)									
Ground Cuckoo-shrike *Coracina maxima*									+
Black-faced Cuckoo-Shrike *Coracina novaehollandiae*		+	+	+	+	+			+
White-winged Triller *Lalage tricolor*		+				+			+
Oreoicidae (bellbirds)									
Crested Bellbird *Oreoica gutturalis*		+							+
Pachycephalidae (shrike-tits, whistlers and allies)									
Rufous Whistler *Pachycephala rufiventris*		+							+
Grey Shrike-thrush *Colluricincla harmonica*		+		+	+	+			+
Rhipiduridae (fantails)									
Grey Fantail *Rhipidura albiscapa*									+
Willie Wagtail *Rhipidura leucophrys*		+	+	+	+	+			+
Monarchidae (flycatchers, monarchs and magpie-lark)									
Magpie-Lark *Grallina cyanoleuca*		+	+	+	+	+			+
Corvidae (ravens and crows)									
Torresian Crow *Corvus orru*		+	+	+	+	+			+
Little Crow *Corvus bennetti*		+							+
Petroicidae (robins)									
Red-capped Robin *Petroica goodenovii*									+
Hooded Robin *Melanodryas cucullata*									+
Alaudidae (larks)									
Horsfield's Bushlark *Mirafra javanica*									+
Hirundinidae (swallows and martins)									
White-backed Swallow *Cheramoeca leucosterna*									
Welcome Swallow *Hirundo neoxena*					+				+
Tree Martin *Petrochelidon nigricans*		+		+	+	+			+
Fairy Martin *Petrochelidon ariel*		+			+	+			+
Acrocephalidae (reed warblers)									
Australian Reed Warbler *Acrocephalus australis*					+				+

Appendix 7. (cont.)

Species	Conservation Status	Records							
		At Wodgina					Database		
		2019	2018	2017	2011	2009	EPBC	DBCA	NatureMap
Locustellidae (warblers, songlarks and grassbirds)									
Little Grassbird *Megalurus gramineus*									
Spinifexbird *Eremiornis carteri*		+	+		+	+			+
Rufous Songlark *Megalurus mathewsi*		+	+	+	+				+
Brown Songlark *Megalurus cruralis*		+							+
Dicaeidae (flowerpeckers)									
Mistletoebird *Dicaeum hirundinaceum*									+
Estrildidae (grassfinches, sparrows and allies)									
Zebra Finch *Taeniopygia guttata*		+	+	+	+	+			+
Star Finch *Neochmia ruficauda*		+							+
Painted Finch *Emblema pictum*		+	+	+	+	+			+
Motacillidae (pipits and wagtails)									
Australian Pipit *Anthus australis*		+			+				+
# bird species expected:		**140**							

Appendix 8. Mammals potentially occurring in the Study Area.

Key to records:

2019 = species recorded in this survey, April or October 2019.
2018 = species recorded on the Level 1 and targeted survey, July 2018 (Stantec 2018b) or targeted Northern Quoll Monitoring (Biologic 2018a).
2017 = species recorded on the Wodjina Mine/Airstrip Level 1 fauna survey, December 2017 (360 Environmental 2018a).
2011 = species recorded on the Hercules DSO Level 2 fauna survey, March 2011 (Outback Ecology 2012).
2009 = species recorded on the Wodgina DSO Level 2 fauna survey, March 2009 (Outback Ecology 2009).
EPBC = modelled occurrence of species or species habitat in the area on the EPBC Protected Matters Search Tool.
DBCA = species recorded in the area on DBCA's Threatened and Priority Fauna Database.
NatureMap = species recorded within 40km on NatureMap (DBCA 2007-).

Species		Conservation Status	Records							
			At Wodgina					Database		
			2019	2018	**2017**	2011	2009	**EPBC**	**DBCA**	**NatureMap**
Tachyglossidae (echidnas)										
Echidna	*Tachyglossus aculeatus*		+	+	+					+
Dasyuridae (dasyurid marsupials)										
Little Red Kaluta	*Dasykaluta rosamondae*		+	+						+
Northern Quoll	*Dasyurus hallucatus*	T	+	+	+	+	+	+	+	+
Woolley's Pseudantechinus	*Pseudantechinus woolleyae*		+				+			+
Pilbara Ninguai	*Ningaui timealeyi*		+							+
Common Planigale	*Planigale maculata*									+
Pilbara Planigale	*Planigale sp 1*		+			?	?			+
Long-tailed Dunnart	*Sminthopsis longicaudata*	P					+		+	+
Striped-faced Dunnart	*Sminthopsis macroura*			+						+
Ooldea Dunnart	*Sminthopsis ooldea*									+
Lesser Hairy-footed Dunnart	*Sminthopsis youngsoni*									+
Macropodidae (kangaroos and wallabies)										
Spectacled Hare-Wallaby	*Lagorchestes conspicillatus*	P		+					+	+
Euro	*Osphranter robustus*		+	+		+	+			+
Red Kangaroo	*Osphranter rufus*									+
Rothschild's Rock-Wallaby	*Petrogale rothschildi*		+	+	+		+			+
Muridae (rats and mice)										
Lakeland Downs Mouse	*Leggadina lakedownensis*	P								+
House Mouse	*Mus musculus*	Int.	+							+
Spinifex Hopping Mouse	*Notomys alexis*		+	+	+					+
Western Pebble-mound Mouse	*Pseudomys chapmani*	P	+	+	+	+	+		+	+
Delicate Mouse	*Pseudomys delicatulus*									+
Desert Mouse	*Pseudomys desertor*		+							+
Sandy Inland Mouse	*Pseudomys hermannsburgensis*		+							+
Common Rock-Rat	*Zyzomys argurus*		+	+	+		+			+

Appendix 8. (cont.)

Species		Conservation Status	Records							
			At Wodgina					Database		
			2019	2018	2017	2011	2009	EPBC	DBCA	NatureMap
Rhinonicteridae (leaf-nosed bats)										
Pilbara Leaf-nosed Bat	*Rhinonicteris aurantia* (Pilbara)	T	+	+		+	+	+	+	+
Megadermatidae (ghost bat)										
Ghost Bat	*Macroderma gigas*	T		+		+	+	+	+	+
Emballonuridae (sheathtail bats)										
Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*		+			+	+			+
Common Sheathtail Bat	*Taphozous georgianus*		+	+		+	+			+
Molossidae (freetail bats)										
Greater Northern Freetail Bat	*Chaerephon jobensis*		+				+			+
Northern Freetail Bat	*Ozimops lumsdenae*									+
White-striped Freetail Bat	*Austronomus australis*		+	+			+			+
Vespertilionidae (ordinary bats)										
Gould's Wattled Bat	*Chalinolobus gouldii*		+	+		+	+			+
Lesser Long-eared Bat	*Nyctophilus geoffroyi*									+
Little Broad-nosed Bat	*Scotorepens greyii*		+	+		+	+			+
Finlayson's Cave Bat	*Vespadelus finlaysoni*		+	+		+	+			+
Canidae (dogs and foxes)										
Dog / Dingo	*Canis familiaris*	Int.	+	+	+					+
Fox	*Vulpes vulpes*	Int.		+	+					+
Felidae (cats)										
Feral / House Cat	*Felis catus*	Int.	+	+	+		+			+
Equidae (horses)										
Donkey	*Equus asinus*	Int.								+
Horse	*Equus caballus*	Int.			+					+
Camelidae (camels)										
Camel	*Camelus dromedarius*	Int.								+
Bovidae (horned ruminants)										
Cow	*Bos taurus*	Int.	+	+	+	+	+			+
Number of species expected:			**41 (33 native)**							

Appendix 9. Freshwater Fish potentially occurring in the Study Area.

Key to records:

2019 = species recorded in this survey, April and October 2019.
2018 = species recorded on the Level 1 and targeted survey, July 2018 (Stantec 2018b).
2017 = species recorded on the Wodjina Mine/Airstrip Level 1 fauna survey, December 2017 (360 Environmental 2018a).
2011 = species recorded on the Hercules DSO Level 2 fauna survey, March 2011 (Outback Ecology 2012).
2009 = species recorded on the Wodgina DSO Level 2 fauna survey, March 2009 (Outback Ecology 2009).
EPBC = modelled occurrence of species or species habitat in the area on the EPBC Protected Matters Search Tool.
DBCA = species recorded in the area on DBCA's Threatened and Priority Fauna Database.
NatureMap = species recorded within 40km on NatureMap (DBCA 2007-).

Species	Conservation Status	Records							
		At Wodgina					Database		
		2019	2018	**2017**	2011	2009	**EPBC**	**DBCA**	**NatureMap**
Clupidae (herrings)									
Bony Bream *Nematalosa erebi*									
Ariidae (fork-tailed catfishes)									
Lesser Salmon Catfish *Arius graeffei*									
Plotosidae (eel-tailed catfishes)									
Hyrtl's Tandan *Neosilurus hyrtlii*									
Melanotaeniidae (Rainbowfishes)									
Western Rainbowfish *Melanotaenia australis*									+
Terapontidae (grunters)									
Spangled Perch *Leiopotherapon unicolor*									+
Eleotridae (gudgeons)									
Empire Gudgeon *Hypseleotris compressus*									
# fish species expected:		**6**							

Appendix 10. EPBC Protected Matters Search Tool results.

Species listed for the area 10km in radius from 21.173ºS, 118.680ºE on the EPBC Act Protected Matters Search Tool.

Australian Government
Department of the Environment and Energy

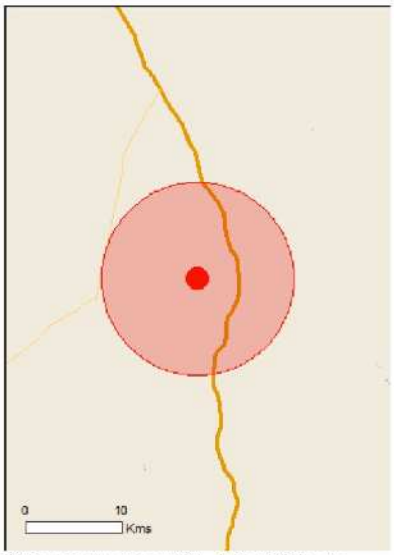
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 01/04/19 17:28:24



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates
Buffer: 10.0Km

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	9
Listed Migratory Species:	11

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	17
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	8
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species habitat likely to occur within area
Rhinonicteris aurantia (Pilbara form) Pilbara Leaf-nosed Bat [82790]	Vulnerable	Species or species habitat known to occur within area
Reptiles		
Liasis olivaceus barroni Olive Python (Pilbara subspecies) [66699]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		

Name	Threatened	Type of Presence
Hirundo rustica		
Barn Swallow [662]		Species or species habitat may occur within area
Motacilla cinerea		
Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava		
Yellow Wagtail [644]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius veredus		
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum		
Oriental Pratincole [840]		Species or species habitat may occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat may occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Extra Information

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Mammals		
Camelus dromedarius Dromedary, Camel [7]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area

Appendix 11. Conservation Significant Fauna Records in the Study Area.

Zone	Easting	Northing	Species	Site	Status	Record Type	Date
50	672573	7662126	*Dasyurus hallucatus*	Cam WL21	En	Camera image	14/04/2019
50	671916	7664794	*Dasyurus hallucatus*	Cam WL28	En	Camera image	14/04/2019
50	672227	7656863	*Dasyurus hallucatus*	Cam WL41	En	Camera image	14/04/2019
50	675445	7657491	*Dasyurus hallucatus*	Quoll 2	En	Large Elliott trap	16/04/2019
50	675791	7656078	*Pseudomys chapmani*	WL Site 04	P4	Active pebble mound	11/04/2019
50	675972	7656149	*Pseudomys chapmani*	WL Site 04	P4	Inactive pebble mound	11/04/2019
50	646020	7656128	*Pseudomys chapmani*	WL Site 04	P4	Inactive pebble mound	11/04/2019
50	675754	7656100	*Pseudomys chapmani*	WL Site 04	P4	Inactive pebble mound	11/04/2019
50	675712	7655984	*Pseudomys chapmani*	WL Site 04	P4	Inactive pebble mound	12/04/2019
50	675818	7656131	*Pseudomys chapmani*	WL Site 04	P4	Inactive pebble mound	12/04/2019
50	677558	7656503	*Pseudomys chapmani*	No Site	P4	Inactive pebble mound	14/04/2019
50	673719	7659154	*Pseudomys chapmani*	No Site	P4	Inactive pebble mound	14/04/2019
50	673419	7658557	*Pseudomys chapmani*	No Site	P4	Inactive pebble mound	15/04/2019
50	673386	7658450	*Pseudomys chapmani*	No Site	P4	Active pebble mound	15/04/2019
50	675492	7655377	*Pseudomys chapmani*	No Site	P4	Active pebble mound	18/04/2019
50	675389	7655392	*Pseudomys chapmani*	No Site	P4	Inactive pebble mound	18/04/2019
50	673451	7658444	*Pseudomys chapmani*	No Site	P4	Inactive pebble mound	19/04/2019
50	678294	7657206	*Rhinonicteris aurantia*	Bat 450083 12-04-19	Vu	Bat call recording	12/04/2019
50	675753	7661831	*Rhinonicteris aurantia*	BAT_450083_13-04-19	Vu	Bat call recording	13/04/2019
50	675753	7661831	*Rhinonicteris aurantia*	BAT_450083_13-04-19	Vu	Bat call recording	14/04/2019
50	675054	7658545	*Rhinonicteris aurantia*	BAT_450091_15-04-19	Vu	Bat call recording	15/04/2019
50	673405	7657272	*Rhinonicteris aurantia*	BAT_450083_16-04-19	Vu	Bat call recording	16/04/2019
50	675054	7658545	*Rhinonicteris aurantia*	BAT_450091_15-04-19	Vu	Bat call recording	16/04/2019
50	673405	7657272	*Rhinonicteris aurantia*	BAT_450083_16-04-19	Vu	Bat call recording	17/04/2019
50	675054	7658545	*Rhinonicteris aurantia*	BAT_450091_15-04-19	Vu	Bat call recording	17/04/2019
50	675730	7661821	*Rhinonicteris aurantia*	Bat 450085 19-10-19	Vu	Bat call recording	19/10/2019
50	675057	7658544	*Rhinonicteris aurantia*	Bat 450085 20-10-19	Vu	Bat call recording	20/10/2019
50	674564	7655664	*Rhinonicteris aurantia*	Bat 450083 22-10-19	Vu	Bat call recording	22/10/2019
50	676597	7661533	*Rhinonicteris aurantia*	Bat 450085 22-10-19	Vu	Bat call recording	22/10/2019
50	674564	7655664	*Rhinonicteris aurantia*	Bat 450083 22-10-19	Vu	Bat call recording	23/10/2019
50	673286	7659985	*Rhinonicteris aurantia*	Bat 450085 23-10-19	Vu	Bat call recording	23/10/2019
50	675452	7654878	*Rhinonicteris aurantia*	Bat 450083 24-10-19	Vu	Bat call recording	24/10/2019
50	675480	7660695	*Rhinonicteris aurantia*	Bat 450085 24-10-19	Vu	Bat call recording	24/10/2019
50	678294	7657206	*Rhinonicteris aurantia*	Bat 450083 21-10-19	Vu	Bat call recording	25/10/2019
50	673559	7658495	*Rhinonicteris aurantia*	Bat 450085 21-10-19	Vu	Bat call recording	25/10/2019
50	676934	7662466	*Rhinonicteris aurantia*	Bat 450085 25-10-19	Vu	Bat call recording	25/10/2019

Appendix 12. Bat Call Analysis

Specialised Zoological

Bat call identification from Wodgina, Western Australia

Type:	Acoustic analysis
Prepared for:	Western Wildlife
Date:	6 May 2019
Job No.:	SZ491
Prepared by:	Dr Kyle Armstrong and Yuki Konishi Specialised Zoological ABN 92 265 437 422 Tel 0404 423 264 kyle.n.armstrong@gmail.com http://szool.com.au

This report should be included as an appendix in any larger submission to Government, and cited as:

Specialised Zoological (2019). Bat call identification from Wodgina, Western Australia. Acoustic analysis. Unpublished report by Specialised Zoological for Western Wildlife, 6 May 2019, Job number SZ491.

Summary

Bat identifications from acoustic recordings are provided from the Wodgina area, in the Pilbara region of Western Australia. The identification of bat species from full spectrum WAV-format recordings of their echolocation calls was based on measurements of characteristic frequency, observation of pulse shape, and the pattern of harmonics. Eight species of bat were identified unambiguously as being present (**Tables 1** and **2**). The Pilbara Leaf-nosed Bat *Rhinonicteris aurantia* (Rhinonycteridae) was detected, but the Ghost Bat *Macroderma gigas* (Megadermatidae) was not. Representative echolocation calls for each identification are illustrated (**Figure 1**), as recommended by the Australasian Bat Society (ABS 2006). Further details are available should verification be required.

Methods

The data provided were recorded in full spectrum WAV format with Titley Scientific AnaBat Swift bat detectors (sampling rate 500 kHz, set to turn on automatically at sunset and off at sunrise).

A multi-step acoustic analysis procedure developed to process large full spectrum echolocation recording datasets from insectivorous bats (Armstrong and Aplin 2014; Armstrong et al. 2016) was applied to the recordings made on the survey. Firstly, the WAV files were scanned for bat echolocation calls using several parameter sets in the software SCAN'R version 1.8.3 (Binary Acoustic Technology), which also provides measurements (SCAN'R parameters) from each putative bat pulse. The outputs were then used to determine if putative bat pulses measured in SCAN'R could be identified to species. This was done using a custom [R] language script that performed three tasks: 1. undertook a Discriminant Function Analysis on training data from representative calls from the Pilbara; 2. from the measurements of each putative bat pulse from SCAN'R, calculated values for the first two Discriminant Functions that could separate the echolocation call types derived from the analysis of training data, and plotted these resulting coordinates over confidence regions for the defined call types; and 3. facilitated an inspection in a spectrogram of multiple examples of each call type for each recording night by opening the original WAV files containing pulses of interest in Adobe Audition CS6 version 5.0.2. The [R] language script also included a separate process that repeated the above steps using training data that included signals from Pilbara cave roosting bat species to assist with the detection of echolocation calls of the Ghost Bat *Macroderma gigas*.

Species were identified based on information in McKenzie and Bullen (2009) and the author's own unpublished material; and nomenclature follows Jackson and Groves (2015).

References

ABS (2006). Recommendations of the Australasian Bat Society Inc for reporting standards for insectivorous bat surveys using bat detectors. *The Australasian Bat Society Newsletter* 27: 6–9. [ISSN 1448-5877]

Armstrong, K.N. and Aplin, K.P. (2014). Identifying bats in an unknown acoustic realm using a semi-automated approach to the analysis of large full spectrum datasets. Oral presentation at the 16th Australasian Bat Society Conference 22–25 April 2014, Townsville, Queensland. *The Australasian Bat Society Newsletter* 42: 35–36.

Armstrong, K.N., Aplin, K.P. and Crotty, S. (2016). A pipeline and app for massive filtering, and assisted inspection of enormous acoustic datasets. Poster presentation at the 17th Australasian Bat Society Conference, 29 March-1 April 2016, Hobart, Tasmania, Australia. *The Australasian Bat Society Newsletter* 46: 51.

Jackson, S.M. and Groves, C.P. (2015). *Taxonomy of Australian mammals*. CSIRO Publishing, Victoria.

McKenzie, N.L. and Bullen, R.D. (2009). The echolocation calls, habitat relationships, foraging niches and communities of Pilbara microbats. *Records of the Western Australian Museum* Supplement 78: 123–155.

Table 1. Species identified in the present survey from all sites combined.

RHINONYCTERIDAE	
Pilbara Leaf-nosed Bat	*Rhinonicteris aurantia*
EMBALLONURIDAE	
Yellow-bellied Sheath-tailed Bat	*Saccolaimus flaviventris*
Common Sheath-tailed Bat	*Taphozous georgianus*
VESPERTILIONIDAE	
Gould's Wattled Bat	*Chalinolobus gouldii*
Little Broad-nosed Bat	*Scotorepens greyii*
Finlayson's Cave Bat	*Vespadelus finlaysoni*
MOLOSSIDAE	
White-striped Free-tailed Bat	*Austronomus* (=*Tadarida*) *australis*
Greater Northern Free-tailed Bat	*Chaerephon jobensis*

Table 2. Species identifications, with the degree of confidence indicated by a code. Date and serial/unit number correlates with site; see Table 1 for full species names.

	A. australis	*C. gouldii*	*C. jobensis*	*R. aurantia*	*S. flaviventris*	*S. greyii*	*T. georgianus*	*V. finlaysoni*
Swift 450083								
12/04/2019	—	◆	◆	◆	◆	◆	◆	◆
13/04/2019	—	◆	◆	◆	—	◆	—	◆
14/04/2019	—	◆	◆	◆	—	◆	◆	◆
15/04/2019	—	—	◆	—	—	—	◆	◆
16/04/2019	—	◆	—	◆	—	—	◆	◆
17/04/2019	◆	—	◆	◆	—	—	◆	◆
Swift 450091								
13/04/2019	—	—	◆	—	◆	—	◆	◆
14/04/2019	—	◆	◆	—	—	—	◆	—
15/04/2019	—	◆	◆	◆	—	◆	◆	◆
16/04/2019	—	◆	◆	◆	◆	◆	◆	◆
17/04/2019	—	◆	◆	◆	—	◆	◆	◆

Definition of confidence level codes:

— Not detected.

◆ Unambiguous identification of the species at the site based on measured call characteristics and comparison with available reference material. Greater confidence in this ID would come only after capture and supported by morphological measurements or a DNA sequence.

NC Needs Confirmation. Either call quality was poor, or the species cannot be distinguished reliably from another that makes similar calls. Alternative identifications are indicated in the *Comments on identifications* section of this report. If this is a species of conservation significance, further survey work might be required to confirm the record.

Table 2. Summary of detections of the Pilbara Leaf-nosed Bat (blue shading designates different units for ease of inspection; a 'pass' is one sequence of calls in a single WAV file).

Unit	Night-of date	Sunrise date	Sunset time	Civil twilight end time	Civil twilight start time	Sunrise time	First detection	Time since sunset	Last detection	Time before sunrise	No. passes
450083	12/04/2019	13/04/2019	17:57:48	18:20:07	05:54:45	06:17:08	21:06:31	3H 8M 45S	23:01:53	7H 15M 15S	6
450083	13/04/2019	14/04/2019	17:56:55	18:19:18	05:55:03	06:17:27	18:57:10	1H 0M 15S	00:45:32	5H 31M 55S	7
450083	14/04/2019	15/04/2019	17:56:05	18:18:30	05:55:21	06:17:47	19:02:58	1H 6M 52S	19:02:58	11H 14M 49S	1
450083	16/04/2019	17/04/2019	17:54:28	18:16:56	05:55:57	06:18:26	22:12:38	4H 18M 11S	03:08:07	3H 10M 19S	2
450083	17/04/2019	18/04/2019	17:53:41	18:16:09	05:56:16	06:18:46	19:31:04	1H 37M 23S	20:41:03	9H 37M 43S	2
450091	15/04/2019	16/04/2019	17:55:17	18:17:43	05:55:39	06:18:06	19:26:42	1H 33M 25S	22:22:16	7H 55M 50S	3
450091	16/04/2019	17/04/2019	17:54:28	18:16:56	05:55:57	06:18:26	01:18:12	7H 23M 44S	01:18:12	5H 0M 14S	1
450091	17/04/2019	18/04/2019	17:53:41	18:16:09	05:56:16	06:18:46	23:11:13	5H 17M 32S	23:11:13	7H 7M 33S	1

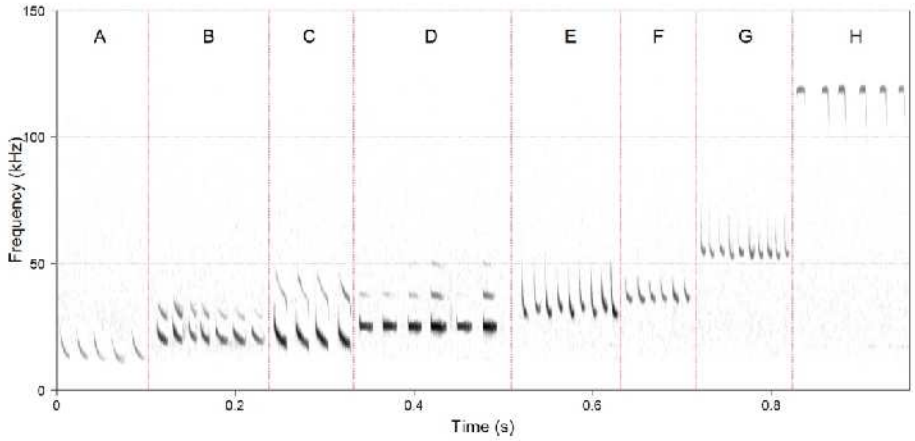


Figure 1. Representative echolocation call sequence portions of the species identified (**A**: *Austronomus australis*; **B**: *Saccolaimus flaviventris*; **C**: *Chaerephon jobensis*; **D**: *Taphozous georgianus*; **E**: *Chalinolobus gouldii*; **F**: *Scotorepens greyii*; **G**: *Vespadelus finlaysoni*; **H**: *Rhinonicteris aurantia*; time between pulses has been compressed).

Specialised Zoological

Acoustic analysis and bat call identification from Wodgina, Western Australia

Prepared for **Western Wildlife**

Version **16 January 2020**

SZ project reference **SZ509**

Prepared by **Dr Kyle Armstrong and Yuki Konishi**

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This report should be included as an appendix in any larger submission to Government, and cited as:

Specialised Zoological (2020). Acoustic analysis and bat call identification from Wodgina, Western Australia. Unpublished report by Specialised Zoological for Western Wildlife, 16 January 2020, project reference SZ509.

Summary

Bat identifications from acoustic recordings are provided from Wodgina, in the Pilbara region of Western Australia. The identification of bat species from full spectrum WAV-format recordings of their echolocation calls was based on measurements of characteristic frequency, observation of pulse shape, and the pattern of harmonics. Seven species of bat were identified unambiguously as being present (**Tables 1** and **2**). The Pilbara Leaf-nosed Bat *Rhinonicteris aurantia* (Rhinonycteridae) was detected. Representative echolocation calls for each identification are illustrated (**Figure 1**), as recommended by the Australasian Bat Society (ABS 2006). Further details are available should verification be required.

Methods

The data provided were recorded in full spectrum WAV format with Titley Scientific Anabat Swift bat detectors (sampling rate 500 kHz, set to turn on automatically at sunset and off at sunrise).

A multi-step acoustic analysis procedure developed to process large full spectrum echolocation recording datasets from insectivorous bats (Armstrong and Aplin 2014; Armstrong et al. 2016) was applied to the recordings made on the survey. Firstly, the WAV files were scanned for bat echolocation calls using several parameter sets in the software SCAN'R version 1.8.3 (Binary Acoustic Technology), which also provides measurements (SCAN'R parameters) from each putative bat pulse. The outputs were then used to determine if putative bat pulses measured in SCAN'R could be identified to species. This was done using a custom [R] language script that performed three tasks: 1. undertook a Discriminant Function Analysis on training data from representative calls from the Pilbara; 2. from the measurements of each putative bat pulse from SCAN'R, calculated values for the first two Discriminant Functions that could separate the echolocation call types derived from the analysis of training data, and plotted these resulting coordinates over confidence regions for the defined call types; and 3. facilitated an inspection in a spectrogram of multiple examples of each call type for each recording night by opening the original WAV files containing pulses of interest in Adobe Audition CS6 version 5.0.2.

Species were identified based on information in McKenzie and Bullen (2009) and the author's own unpublished material; and nomenclature follows Jackson and Groves (2015).

Limitations

The identifications presented in this report have been made within the following context:

1. The identifications made herein were based on the ultrasonic acoustic data recorded and provided by a 'third party' (the client named on the front of this report).
2. The scope of this report extended to providing information on the identification of bat species in bulk ultrasonic recordings. Further comment on these species and the possible impacts of a planned project on bat species were not part of the scope.
3. In the case of the present report, the recording equipment was set up and supplied by Specialised Zoological. The equipment was operated by the third party during the survey.
4. Other than the general location of the study area, Specialised Zoological has not been provided with detailed information of the survey area, has not made a visit to observe the habitats available for bats, nor have we visited the specific project areas on a previous occasion.
5. Specialised Zoological has had no input into the overall design and timing of this bat survey, recording site placement, nor the degree of recording site replication.
6. While Specialised Zoological has made identifications to the best of our ability given the available materials, and reserves the right to re-examine the data and revise any identification following a query, it is the client's and / or proponent's responsibility to provide supporting evidence for any identification, which might require follow-up trapping effort or non-invasive methods such as video recordings. Specialised Zoological bears no liability for any follow-up work that may be required to support an identification based initially on the analysis of acoustic recordings undertaken and reported on here.
7. There are a variety of factors that affect the 'detectability' of each bat species, given the frequency, power and shape characteristics of their calls. Further information on the analysis and the various factors that can impinge on the reliability of identifications can be provided upon request.
8. The analysis of ultrasonic recordings is one of several methods that can be used to survey for bats, and comprehensive surveys typically employ more than one method. If an identification in the present report is ambiguous or in question, a trapping programme would help to resolve the presence of the possibilities in the project area.

References

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Table 1. Species identified in the present survey from all sites combined.

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VESPERTILIONIDAE	
Gould's Wattled Bat	*Chalinolobus gouldii*
Little Broad-nosed Bat	*Scotorepens greyii*
Finlayson's Cave Bat	*Vespadelus finlaysoni*
MOLOSSIDAE	
Greater Northern Free-tailed Bat	*Chaerephon jobensis*

Table 2. Species identifications, with the degree of confidence indicated by a code. Date and recording unit number correlates with site; see *Table 1* for full species names.

	C. gouldii	*C. jobensis*	*R. aurantia*	*S. flaviventris*	*S. greyii*	*T. georgianus*	*V. finlaysoni*
Swift 450083							
19/10/2019	—	◆	—	—	—	◆	—
20/10/2019	—	◆	—	—	—	—	◆
21/10/2019	—	—	◆	◆	◆	—	◆
22/10/2019	—	◆	◆	—	—	◆	◆
23/10/2019	—	◆	◆	—	—	◆	◆
24/10/2019	◆	—	◆	—	—	—	◆
25/10/2019	—	—	—	—	◆	—	—
Swift 450085							
19/10/2019	—	◆	◆	—	◆	—	◆
20/10/2019	—	◆	◆	—	—	◆	◆
21/10/2019	◆	◆	◆	—	—	◆	—
22/10/2019	—	—	◆	◆	◆	—	—
23/10/2019	—	◆	◆	—	—	◆	◆
24/10/2019	—	◆	◆	—	—	—	◆
25/10/2019	—	◆	◆	◆	◆	—	◆

Definition of confidence level codes

— Not detected.

◆ Unambiguous identification of the species at the site based on measured call characteristics and comparison with available reference material. Greater confidence in this ID would come only after capture and supported by morphological measurements or a DNA sequence.

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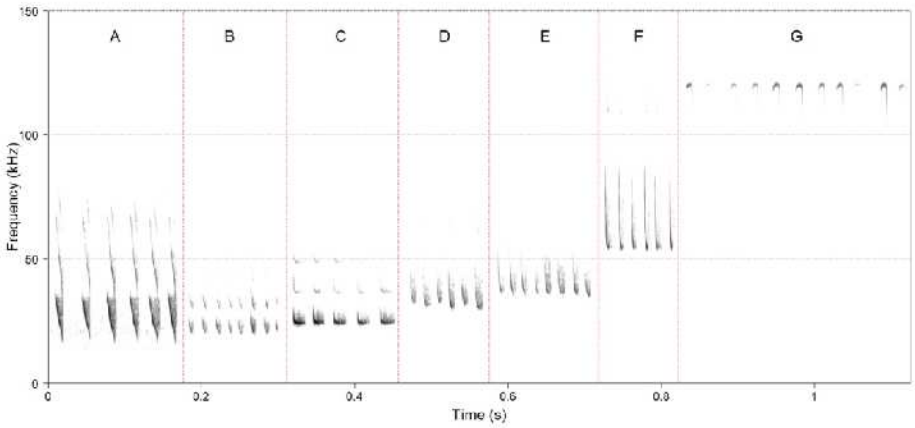

Figure 1. Representative echolocation call sequence portions of the species identified (**A**: *Chaerephon jobensis*; **B**: *Saccolaimus flaviventris*; **C**: *Taphozous georgianus*; **D**: *Chalinolobus gouldii*; **E**: *Scotorepens greyii*; **F**: *Vespadelus finlaysoni*; **G**: *Rhinonicteris aurantia*; time between pulses has been compressed).